APPENDIX IV

Translation of "Avances en la Investigación Productiva de Grana - Cochinilla"

Research Advances in the Productivity of Grana[1]-Cochinilla[2]

Translated by Stephanie Stoermer Strickland

Introduction (p. 1)

There are many natural resources in Mexico which can be exploited by man. Nevertheless, the serious problems that confront agriculture are more accentuated in the areas where extreme ecological and climatic conditions exist and only certain plants can grow. Approximately 60 per cent of the area of the national territory [of Mexico] is occupied by arid zones.

The State of Oaxaca is probably one of the most complex physiographic zones in the country--the extreme variation of its orothography has resulted in a great diversity of climatic zones.

Due to the poverty of its soils, scarcity of water and irregular rainfall, etc., a search for alternative crops for such conditions has been undertaken. The **nopal** plant family (***Opuntia*** sp.) represents one of these alternatives and has acquired significance because the nopal is a resistant cactus, a good "fixer" of soils and protects against soil erosion. The fruits[3] of nopal are utilized as food, the tender pads[4] are eaten as a vegetable and used for animal fodder and the plant is the principal host of

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[1] Grana - the cochineal "grain" from which cochineal dye is derived.
[2]Cochinilla - the cochineal insect; also the cochineal dye.
[3]Frutas - "fruits", that is the part of the cactus which produces a blossom; the portion of the prickly pear known in the Southwestern U.S. and Northern Mexico as "tunas".
[4]Cladodios tiernos - "tender pads"; the portion of the prickly pear known in the Southwestern U.S. and Northern Mexico as "nopal".

the **cochinilla** (*Dactylopius coccus*, Costa), the insect that is the source for natural coloring.

Background (p. 2)

The cultivation of the **cochinilla** originated in Mexico, and is concentrated in the State of Oaxaca. It has been cultivated since remote times by the indigenous peoples, who, with ingenuity and effort, developed a suitable technology and took upon themselves the risks of production.

During the colonial epoch, **cochinilla** was produced in more than one hundred towns in Oaxaca. In 1774, 716 metric tons[5] of the insect were exported, occupying third place (after gold and silver) in exported products.

The appearance of aniline dyes and other synthetic coloring agents, produced at much lower costs, caused a displacement in the market for natural coloring agents, ending an important source for work for the rural population. However, the realization that synthetic coloring agents (such as Red Dye #2) were potential carcinogens and caused allergic skin reactions (on occasion) was the reason for the return of cultivation of **cochinilla** as an important crop because it constitutes a viable alternative for obtaining natural coloring agents.

In the past few years the worldwide production of **cochinilla** has been from 200 to 270 metric tons per year. Peru, the principal producer, exports approximately 211 metric tons, which represents approximately 85 percent of the worldwide production; other countries, such as Argelia [no

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[5]tonelada metrica = 2,200 English pounds

translation available], Java and the Canary Islands produce this insect, but in small quantities.

With the objective of reviving the cultivation of **cochinilla** in Oaxaca, the ITA#23, in coordination with the Secretariat of Rural Development, is promoting the production of the cochinilla, generating a source of employment and to raise the socioeconomic level of the rural population.

Description and Use of the Product (p. 3)

The **cochinilla** is a parasitic insect, whose product is formed by the dried bodies of the adult females. These bodies are grainy, oval shaped and vary in color from black to gray at the time when the waxy mantle which covers the insect has been grown or shed.

The principal constituent of **cochinilla** is carminic acid, with a concentration of between approximately 15 percent to 20 percent.

An intense red is obtained from this insect, a natural coloring agent that has a multitude of applications in different industries (food coloring, cosmetics, pharmaceuticals, textiles, etc.); it is also used in the preparation of paints, as a chemical reactant , a histological stain, and, in our state of Oaxaca, it is extensively used in crafts.

Presentations (p. 3)

(a) **grana**
  (1) **grana negra** (black): the bodies of the adult female insects without wax.
  (2) **grana blanca o plateada** (white or silvery gray): the bodies of the adult insects that have not yet laid eggs.

(b) **extracto de cochinilla** (cochineal extract): derived from **grana negra** and used as a colorant for food and medicines.

(c) **acido carminico** (carminic acid): used in color photographs, as an artist pigment, as a chemical reactant, etc.

Host Species (p. 4-5)

The **cochinilla** or **grana del carmin** (***Dactylopius coccus***, Costa), is a little insect that lives as a parasite on various species of nopal (cactus), particularly on those of the genera ***Opuntia*** and ***Nopalea***.

The ITA # 23 of Oaxaca has completed its investigations to determine the species most productive and susceptible to the cultivation of the **cochinilla** insect, succeeding in evaluating the most promising materials of the region of the state of Oaxaca.

The genera of ***Opuntia*** evaluated were the San Gabriel nopal (***Opuntia tomentosa***), the Castilla nopal (***Opuntia ficus-indica***), the San Cristobal nopal (***Opuntia pilifera***), ***Opuntia Zarca***, ***Opuntia amyclaea*** and the ***Opuntia ficus indica*** variety of vegetable[6]; of the genus ***Nopalea***, only one ***Nopalea karwiskiana*** was evaluated.

As a result of the investigation, it was determined that the most productive species for the production of **cochinilla** are the San Gabriel nopal and the Castilla nopal. The first of these is characterized by its proliferation[7] and its lustrous and pliant fleshiness, making it one of the the preferred host species for the cultivation of the **cochinilla** insect. Nevertheless, the San Gabriel nopal is much more demanding in its water and nutrient requirements in comparison with the Castilla nopal, which has

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6 "verdura": literally a plant that is consumed as a leafy vegetable.

7 literally, its high rate of reproduction.

a great affinity for the **cochinilla** insect and is more tolerant of dryness and poor soils.

With respect to the ***Opuntia Zarca***, ***Opuntia pilifera*** and ***Opuntia amyclaea*** varieties, although they are susceptible to the **cochinilla** insect, there is a high mortality rate for the insect in the early stages of development.

For dual purposes (i.e. **cochinilla** cultivation and fruit/vegetable[8] production), the recommended species are the Alfayucan nopal (***Opuntia amyclaea***) for the production of **cochinilla** and and fruits and the Castilla nopal variety "Verdulera" for the production of pads and **cochinilla**. For dual purpose nopal production, it is recommended that these activities be alternated.

With respect to ***Nopalea karwiskiana***, it is not susceptible to the cultivation of the **cochinilla** because of the thick mantle of wax that this species possesses. Nevertheless, it is recommended for the production of vegetables.

Manner of Planting (p. 6-7)

The nopal is a plant resistant to extreme conditions such as aridity and dryness; however, it requires care like any other crop in order to obtain a planting in good condition, and in our case, for the production of **cochinilla**. For this reason, the following duties must be accomplished:

> (1) Control of weed growth and weeding
> Weeding should be accomplished so that there will be no competition between the nopal and the weeds for light, humidity and nutrients--principally in the rainy season. As

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8 again, "vegetable": means edible nopal pads consumed as a leafy vegetable.

long as the weeding and the loosening of the soil around the plant is accomplished without damaging the "foot" of the plant and the rootlets, the capture and utilization of the rainwater is permitted and can be maintained during the dry season. Furthermore, when weeding is accomplished, the potential for infestations and diseases is diminished.

(2) Pruning

With pruning, more vigorous plants are obtained and the growth of new pulpy leaves is promoted, making handling easier. There are different types of pruning:

(a) pruning of the formation: performed on plantings of more that two years of age and consists of eliminating poorly oriented branches, resulting in easier labor and other activities. The material cut in this manner can be used to produce **cochinilla** on cut "leaves" [pads] or to establish new plantings.

(b) sanitary pruning: consists of the elimination of branches that have been attacked buy pathogens or are malformed, with the objective of guaranteeing the vigor of the plant, a sanitary state, and increased production; the eliminated material is gathered, dried, burned and buried in order to prevent the spread of the pathogens to other plants or plantations

(3) control of nopal diseases/infestations: the control of diseases in plantations of nopal intended to produce cochineal can be divided into two stages.

(a) growth stage: from the planting of the nopal until it is infested with the **cochinilla** insect. If a disease or pest manifests itself at this time, chemical products can be applied to control it.

(b) production stage: commences from the establishment of the cochineal insect until harvest time. If disease manifests in this stage, chemicals cannot be applied because the insect is very delicate and could be injured. For this reason, the control must be manual.

Principal Pests [9] of the Nopal Plant (p. 8)

(a) **grana corriente**[10] : a pest of great importance, with reprecussions in the production of quality cochineal. It can finish off a nopal plantation if it is not controlled in time. When **grana corriente** is present, it can be observed as little cottony balls covering the body of an insect that sucks the juice of the nopal and rapidly reproducing, causing the yellowing and rapid demise of the plant.
(b) **gusano cebra**[11]: a worm with dark blue stripes that penetrates the plant and creates cavities. It lives in the interior of the plant and destroys the internal structure of the nopal pads.
(c) **gusano blanco**[12]: as its name indicates is transparent and crystal white in color. It creates cavities within the pith of the plant and at its strongest, clogs the interior of the plant and dries it out. The most observable manifestation of **gusano blanco** infestation is at the point of entry of the pest where each larvae leaves its grey or white excrement.
(d) **picudo barrendor**[13]: the larva penetrates though the woody portion of the plant, destroying and opening cavities. A yellowish-brown (later blackish) secretion may be noticed on the affected part of the plant.

These pests are the most important and their control should be part of the immediate preventive maintenance and the management of the plantation.

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[9] "plagas": used in the original text, means literally diseases or plagues. The English "pest" is used here to distinguish the insects, etc. which prey on the nopal plants from the diseases (enfermedades) discussed in the next section of the text.
[10] "running grain"
[11] "zebra worm"
[12] "white worm"
[13] "beaked borer"

Description and Control of Nopal Diseases (p. 9)

The incidence of diseases in nopal can be of prime importance in the production of branches, fruits as well as the **cochinilla**. The principal diseases are:

> (a) **roya**[14]: Can be identified by the yellowish-orange coloration of the pustules which stand out on the the afffected pad[15], taking the form of circles of approximately five centimeters in diameter. Should be controlled through the immediate cutting, burning and burial of the affected leaves. Chemical control is very costly.
> (b) **podredumbre en el tallo**[16]: light purple in color with a disagreeable odor. Apparently consumes the fleshy part of the stalk and some leaves until it interfers with the process that sustains the plant. The most obvious symptom is the wrinkling and doubling of the bottom leaves. It is possible to cut off all affected parts if the case is not very advanced and the plant may recuperate. Otherwise, the plant should be removed and replaced with a clean and healthy one.
> (c) **mancha negra**[17]: causes dark purple circular spots , approximately fifteen mm. in diameter.

Techniques for Cultivating the Cochineal Insect (p. 10)

The cultivation of the cochineal insect is very simple; nevertheless, the insect is very affected by environmental conditions. For this reason, its production requires places covered with cane, plastic, palm, or other materials obtainable locally. in the region.

The insect will be seriously affected in its growth by non-biological factors; the temperature factor is going to be one of the most important

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14 No literal translation; however, the name may be derived from the verb "roer" meaning to rot.
15"penca"- cactus pad or leaf
16 "decay in the stem or stalk"
17"black spot"

influences upon the development of the insect. As long as the temperature is greater than 30 degrees C., the biological cycle of the insect will be shortened (less than 90 days) and at lower temperatures (less than 15 degrees C., the cycle of the insect will be longer (more than 120 days).

Selection of the Cochinilla Stock[18] (p. 10)

The selection should take place when the insect has completed its total development (90 to 120 days); the period when the insect has initiated its egg laying, with each female laying an average of 200 to 500 tiny eggs.

Infestation (p. 11)

The infestation consists of placing the mother cochineal insects at the base of the nopal plant by means of nests of straw or gauze. It is recommended that the nest remain fixed for a period of 15 to 20 days, during the time each female is laying eggs; it is also recommended that the nests be rotated towards the parts of the plant that have inadequate infestations so that the final result will be a more homogenous distribution of insects.

The number of egg-bearing females placed in the nests depends on the species of nopal under cultivation; in a San Gabriel nopal with 5-6 branches and of an age between 12 to 18 months, 80 insects per nest is recommended for only one cycle. Because of the extreme dehydration caused in the plant, it is necessary to either change plantations or give the plants rest and care to insure their recuperation.

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18 "la semilla" - literally "seed"

For the Castilla nopal, 80 egg-bearing females per nest is also recommended, the difference being that in this species the infestation can be repeated for two or three cycles.

Forms of Production (p.12)

There are two forms of cochineal production:

1. **a planta sembrada**[19], which has already been discussed.
2. **a penca cortada**[20]

The last way is highly recommended because it can provide sufficient vegetative material without requiring that one have the means to maintain a plantation of healthy nopal plants; the said material can be placed in in small areas, takes up very little space and has a high capacity to produce. In this manner, the yield is greater, on a better surface and without the risks of adverse factors to the growth medium.

The pad can last for two harvests[21]when it is from the Castilla nopal and is well taken care of.

Manual Care Techniques[22] (p. 12)

During the early stages of the cochineal insect's life cycle, care is required to control certain pests of economic importance.

Among the principal pests or natural enemies of the cochineal insect we find the **gusano telero** (***Laelia coccidivora***) of the order

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19 cultivated on plants - literally "sowed on plants"

20 on leaves (pads) that have been cut off

21 "la cosecha" - literally harvest or crop

22"labores culturales" - there is no exact translation for this; however it refers to labor-intensive, manual techniques that must be used during the infancy and development of the insect when chemicals, etc., cannot be safely used.

Leppidoptera and the family Phiticidae and the **gusano tambor**[23] (***Chilicorus cacti***) of the order Coleoptera and the family Coccinellidae; both insects devour the bodies of the cochineal insect. For this reason it is recommended that these pests be controlled manually, with periodic examinations of each of the nopal pads or plants.

A crop "cleaning" at the end of the harvest is recommended in order to avoid propagation and spread of these pests to pest-free areas.

The cochineal insects must also be protected from the numerous birds, rodents, and reptiles which are capable of consuming large numbers of them.

Production and Harvest (p. 13)

The most careful and painstaking part of the harvest begins when the females are about to lay their eggs. The "crop" can be gathered by scraping a piece of cane or a plastic cylinder over the skin of the nopal, obtaining only each mature adult. If breeding stock is desired, the insects should be allowed to freely lay their eggs in order to reproduce, thus obtaining **grana negra**. If **grana plateada** is desired, the insects should be harvested before they have begun to lay their eggs.

In the case of the San Gabriel nopal, under semicontrolled conditions a plant with four branches can produce 28 grams of fresh insects; under the same conditions a Castilla nopal can produce 17 grams per plant.

Death and Drying (p.14)

To accelerate the drying process, it is recommended that the insects be killed quickly, thus avoiding the loss of weight and carmine.

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23 "drummer worm"

There are various ways to kill the insect, for example, the immersion of the insect in recently boiled water for a period of 1.5 to 2.5 minutes. The application of water is equally effective. The insects should be arranged in a cage with a mesh bottom, and the cage placed over a container of boiling water. The dispersed vapor will cause the death of the insects.

After the insects have been killed, they should be exposed to the sun for a period of six to eight days. The insects can also be dried in shaded areas; this method is very prolonged and can be expected to take a minimum of eighteen to twenty days.