Cochineal Production: A Reviving Pre columbian Industry

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Cochineal (Dactylopius coccus Costa) is a sessile, or permanently attached, parasitic insect living on cladodes, or flat leaf-like branches, of prickly pears (Opuntia ficus indica Miller). Dried females are the source of carminic acid, a red dye used in food, textile and pharmaceutical industries. After the ban of some synthetic dyes due to their negative secondary effects, the market is once again leaning toward the use of natural dyes. As a consequence, one of the most ancient pre-Columbian industries, cochineal production, has experienced a revival.

Cochineal insects were valuable products during pre-Columbian times, used in both Peru and Mexico (see Box 1). In Nahautl, the language of the Aztecs, the insect and its dye were named nocheztli (blood from prickly pear), a word that was adopted in the toponymy of some producing areas such as the Oaxacan town of Nocheztlan, “the place where there is much cochineal,” whose heraldic symbol is the Opuntia and its cochineal in a pot. During the Aztec Empire, Nocheztlan regularly tributated, 2,000 cochineal-decorated cotton blankets and 20 bags of cochineal to the Emperor resident in Tenochtitlan (fig.1). In spite of its importance, cochineal production was not based on an economy of scale, but was produced only in places where their host plants, named nopalnocheztli, “the prickly pear that produces blood fruit”, could be interspersed between subsistence crops. Cochineal were delicately collected from their host plants mainly in the Yucatan province and processed for their subsequent trade in the market of Tlalocolco. The insect was killed by immersion in hot water, dried, ground, and stored as cakes named nochettacalli. During the process, cochineal could be adulterated by mixing it with flour, clay, or false cochineal, a relative of true cochineal. The dye was fixed using vegetable mordants derived from the cuipo tree (Liatris sympetala).

When the Spaniards arrived, they interpreted new discoveries by comparison with the limited number of images with which they were already familiar. Thus, cochineal was described by the first chroniclers as “little

Box 1: Origin of cochineal

The family Dactylopiidae has only one genus, Dactylopius, with nine species, all of them native to America and specialized to inhabit Cactaceae of the genus Opuntia. D. tomentosus, D. confusus and D. opuntiae inhabit North America (New Mexico, Arizona, Texas and Mexico) while D. cycloonicus, D. australis, D. confertus, D. salmianus and D. zimmermanni inhabit South America (Andean zones of northeast Argentina, Bolivia and Paraguay). The remaining species, D. coccus has a disjointed distribution and is present in both hemispheres, in Mexico and Peru.

The origin of D. coccus is controversial. The earliest known use of the insect as a source of dye was found in textiles from the Paracas culture in Peru (700-300 BC; fig. 2), whereas evidence of cultivation and systematic exploitation of the insect comes from Toltec settlements in Mexico (AD 800-1200). There is evidence of transamerican dispersion of useful neotropical vegetables in pre-Columbian times, with crop plants being exported both from the Andes to Mesoamerica and Mexico (sweet manioc, custard apple, early large-grained corn) and in the opposite direction, from Mexico to the Andean area (avocado, chile peppers). Trading and coastal shipping between the Andean Pacific Coast and Mesoamerica has occurred since 2200 BC, and since 1450 BC to southern Mexico. Hence, it is likely that the presence of D. coccus both in Mexico and Peru is a consequence of introductions made with commercial purposes in pre-Columbian times.

Phylogenetic analysis provides the opportunity for independent evidence on different historical hypotheses about the origin and distribution of animals and plants. Recently, the phylogenetic reconstruction of the genus Dactylopius strongly suggested that cochineal originated in South America. The position of D. coccus in the phylogeny, the limited dispersion capability of the mobile stages of the insect, and the restricted natural distribution of the species suggest that the presence of D. coccus in Mesoamerica is a consequence of human action, while its disjointed distribution suggests it was most likely transported by sea, as proposed for other major products such as sweet manioc and cacao.

Fig.2: A Paracas textile from Peru, with red dye from the cochineal (photo Niemeyer and Rodriguez).

Fig.1a,b: Aztec tribute lists from the early 16th century Codex Mendoza. Arrows show symbols for bags of cochineal, numbering 5 at left, and 20 at right (the Aztec sign for 20 was a flag) (Codex Mendoza).

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worms covered by fine wool and having very red blood," and the cactus as a tree, "if a bunch of leaves one on top of the other can be described as a tree." Spaniards soon identified cochineal as a valuable product. They did not disrupt the indigenous family units responsible for the harvesting of the insects, but tribute in cochineal, instead of going to the Aztecs, was sent to the colonial Spanish state. The dried insects became the second export product of the Mexican viceroyalty after silver. During this period, cochineal were often used as the equivalent of money, since government officials, in an attempt to increase revenue, forced Indians to pay for goods with cochineal.

In the Eleventh Chapter of Book 11 of the Florentine Codex, a compendium of Aztec life prepared in the 16th century by Fray Bernardino de Sahagún in the native Nahua/ language, there is a description of the origin and preparation of cochineal.

Its name comes from nocaltli (opuntia) and catl (blood), because it is formed on the nopal and is like blood, like a blood blister. This cochineal is an insect; it is a worm. It lives, it hatches on the nopal like a little fly, a little insect. Then it grows, then it develops; then it increases in size. It fattens. Then it closes itself in fat. When the worms are dispersed, they come to rest just like blood blisters. Then they cover themselves with a web. Then they die; they fall; also they are heaped together, swept up...

This color is not yet refined. It is of quite dark surface, still like dried blood - round, small and round, a little spongy, a little dry. It is a coloring medium, a chili-red coloring medium...

Fig. 3: Cochineal colony in a prickly pear cactus (Opuntia sp.) (photo: Rodriguez and Niemeyer).

Fig. 4: Life cycle stages of the cochineal insect (Niemeyer).

Box 2: The life cycle of cochineal

The female cochineal has four developmental stages (fig. 4): egg, first instar nymph, second instar nymph and adult. Eggs are red and hatch immediately after they are laid; first instar nymphs present a migratory phase of two days and later settle on a cladode; settled nymphs molt and second instar nymphs emerge which develop and grow into females, which mate around three weeks later. Oviposition begins one month later. Male cochinantes have six developmental stages: egg, first instar nymph, second instar nymph, pre-pupa, pupa and adult. Male eggs and first instars are nearly equivalent to those stages of female insects; second instar nymphs produce a white, oval cocoon which contains a pupa and pupa develop; the adult male which emerges mates and dies a few days later. Depending on environmental factors such as light and temperature, the duration of the stages and the total life cycle is affected; it is on average two months for male and three for females.

Fig. 5: Detail of cochineal colony on a prickly pear leaf (photo: Rodriguez and Niemeyer).
almost lost in Mexico: the last Mexican export of the dye was in 1932, albeit in a non-significant volume. Today, only a much reduced family artisan production in Oaxaca remains, mainly for tapestry and other folk uses.

Recently, when the negative effects of synthetic dyes began to be more widely known, only Peru was in a condition to supply the growing demand of the market for cochineal. Peruvian production grew to cover between 85 and 90% of the global market, mainly based on the collection of insects in natural *Opuntia* scrubs located in the Andean area.

Due to the favorable environment for both the insect and its host plant, cochineal collection in Peru has a considerable social and economic importance, representing a source of income for some 100,000 families. However, a diversity of origin and management techniques makes the Peruvian production heterogeneous, and only the biggest technologically advanced enterprises can reach the current standard of quality imposed by the market, which is expressed in concentration of carminic acid per dry weight of insect.

Towards the middle of the past decade, the market tendencies and the high price of the insect generated the interest of some countries such as Ecuador and Bolivia to restore this ancient industry. Those countries projected cochineal production mainly based on the socio-economic impact of the activity for thousands of peasant families. On the other hand, Peruvian and Chilean businessmen introduced the insect into Northern Chile with commercial purposes. Within a few years, Chilean exports grew to represent 15 percent of the global market, with a uniform and high-quality product due to intensive cultivation methods and modern management techniques.

Recently, this ancient American industry reached the deserts of the Kalahari. The Kuru Cochineal Project of the African Development Foundation and the Botswana Government expect to involve San people, one of the oldest indigenous populations of the world, in the production of cochineal in small family units located in remote areas where other sources of income are scarce. More than one thousand years of history are behind this traditional activity. The mixture of the knowledge of many ancient peoples with modern techniques is allowing cochineal production to be revived stronger than ever, providing us again with its brilliant and bold colors.

**Authors' biographical notes:**

Hermann Niemeyer did undergraduate work in chemistry at the University of California at Berkeley. Since 1978 he has been professor at Universidad de Chile, leading a group investigating mainly plant-insect interactions from a multidisciplinary perspective.

Luis C. Rodríguez, a native of Peru, came to Professor Niemeyer’s laboratory in 1997 with a fellowship from LANBIO (Latin American Network for Research in Bioactive Natural Compounds). After working for about one year in aphid-parasitoid interactions, Luis started work with cochineal insects, his passion since being an undergraduate at Universidad Peruana Cayetano Heredia in Lima, Peru. Presently, he is engaged in a project aimed at increasing carminic acid accumulation in cochineal insects for economic purposes. At the same time, he is taking a Ph.D degree in Ecology at Universidad de Chile.

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**Bibliography:**


de Acosta, J. 1940. "Historia natural y moral de las Islas, en que se tratan las cosas notables del cielo, elementos, metales, plantas y animales de las islas y ceremonias, leyes y gobierno de los indios." O’Gorman, E. (ed.), *Fondo de Cultura Económica*, Mexico.


