

USES OF *OPUNTIA* SPECIES AND THE POTENTIAL IMPACT OF *CACTOBLASTIS CACTORUM* (LEPIDOPTERA: PYRALIDAE) IN MEXICO

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ABSTRACT

In Mexico, cactus pears (*Opuntia* spp.) are regarded as very important plants, especially in semi-arid and arid regions where few crops can be cultivated. Historically, Mexicans have used cactus pears for food, as fodder for cattle, for medicinal purposes, in cosmetics, to produce dyes, and as natural fences. Cactus pears are also an important component of native ecosystems. Central Mexico is considered to be one of the main centers of cactus diversity. Approximately 200 species of *Opuntia* are recognized worldwide, 114 of which occur in Mexico. Because most *Opuntia* species are thought to be susceptible to attack by the cactus moth, *Cactoblastis cactorum* (Berg), spread of this moth into Mexico would likely have significant economic and social impacts. A number of the most widely used and/or distributed species, including *O. compressa* Macbride, *O. ficus-indica* (L.) Miller, *O. megacantha* Salm-Dyck, *O. stricta* (Haw.) Haworth and *O. tomentosa* Salm-Dyck, are known hosts of the cactus moth.

Key Words: prickly pear, cactus moth, invasive species

RESUMEN

Los cactus del género *Opuntia* son muy importantes en Méjico especialmente en las áreas semi áridas y áridas donde pocos otros cultivos económicos pueden florecer. Históricamente estas plantas han sido utilizadas como alimento, forraje para ganado, en la manufactura de productos medicinales, cosméticos, tintes y como barreras limitrofes naturales. Asimismo, la fruta del cactus (tuna) constituye un importante componente de los ecosistemas naturales en Méjico. La parte central de Méjico se considera como un centro de diversidad para plantas de este género. Aproximadamente 200 especies de *Opuntia* se conocen mundialmente y de estas 114 especies ocurren en esta región de Méjico. Debido a que la mayoría de las especies de este género son susceptibles al ataque por *Cactoblastis cactorum* (Berg) la posible invasión de esta especie de lepidoptero al territorio mejicano tendría consecuencias muy adversas tanto económicas como sociales. Varias de las especies más ampliamente distribuidas o utilizadas en la manufactura de alimentos o productos son atacadas por esta especie. Entre ellas se incluyen *O. compressa* Macbride, *O. ficus-indica* (L.) Miller, *O. megacantha* Salm-Dyck, *O. stricta* (Haw.) Haworth y *O. tomentosa* Salm-Dyck.

In Mexico, cacti in the genera *Nopalea* and *Opuntia* are known as "nopal". They belong to the subfamily Opuntioideae and comprise more than 200 species worldwide, 114 of which occur in Mexico (Bravo 1978; Barthlott & Hunt 1993; Guzmán 1997). The nopal are probably among the most versatile cacti in the family, considering their wide geographic distribution and the great diversity of habitats they occupy. They also constitute one of the most valuable natural resources for peasants and farmers in Mexico, being a source of fruit ("tunas") and vegetables ("nopalitos") for human consumption, as well as fodder for cattle and other animals during the dry seasons.

The production of prickly pear in Mexico can be divided into three systems: 1) wild prickly pear; 2) prickly pear on family farms; and 3) commercial plantations of prickly pear for fruit and nopalitos (Flores et al. 1995; Flores 1997). The total area with significant prickly pear production, both wild and cultivated, exceeds 3,000,000 ha

(Flores 1997). There are approximately 217,856 ha of commercial production, of which 150,000 ha are used for livestock feed, 56,856 ha for fruit, 10,400 ha for nopalitos (Flores et al. 1995) and about 100 ha for cochineal production (Portillo 1999). From an economic and social point of view, the use of prickly pear is considered a subsistence alternative, providing marginal communities with employment and other benefits (Flores 1997; Flores & Aranda 1997).

USES OF PRICKLY PEAR

Historically, Mexicans have used prickly pear (*Opuntia* spp.) in a number of ways:

1. Fruit. The cactus pear or fleshy fruits called "tunas" are in great demand on the local market, and are exported to the U.S., Canada, Japan, and some European countries.
2. Vegetable. The tender cladodes of certain species are cut up and eaten as a vegetable

called "nopalitos". Because there is an abundant supply of nopalitos throughout the year, they are also used as an ingredient in many traditional dishes.

3. Fodder. Prickly pear is used to feed cows on cattle farms in the north, especially during the dry seasons. The cladodes are first scorched to remove the spines and then chopped up before mixing them into fodder.
4. Medicinal Products. The consumption of nopalitos and the acid fruits (xonostle) of certain species have been shown to reduce blood glucose and cholesterol levels. The plant parts are consumed cooked, in capsules, and in pill form.
5. Agro-industry. Nopalitos are canned and used in a variety of processed foods for the commercial market. The fruit is used to produce marmalade, juice, nectars, pigments, pectin and fructose.
6. Cosmetics. Extracts from *Opuntia* cacti are used to make soaps, body creams, shampoos and cosmetic gels that are said to reduce body fat.
7. Pigments. About 12 *Opuntia* species are used to rear the cochineal insect (*Dactylopius coccus* Costa) for dye production.
8. Fencing. Some of the more spiny *Opuntia* species are used to delimit terrains, family farms and cattle camps. This is an ancient and common activity in Mexico.

In addition to the uses listed above, prickly pears are now being looked at as a potential source of anti-polluting agents to clean dirty water, as a source of oil, and as a mechanism to prevent soil erosion.

Cactus Fruit

There are approximately 24 species of *Opuntia* from which cactus fruit are collected. Table 1 lists some of the more popular species. Most wild fruit is collected from *Opuntia* species in the Strep-

thacanthae series, while most commercial varieties, known as "mansas", are from the *Ficus-indicae* series. The harvested fruit is eaten fresh and used to produce candy ("queso de tuna"), marmalade ("melcocha") and an alcoholic beverage called "colonche". Demand for the fruit has been increasing steadily since the 1950's, as has been the number of hectares planted to commercial production of the fruit (Flores & Gallegos 1993). The agricultural management of both wild and commercial varieties is to select for fruits that are large, with few seeds and that have a sweet, juicy pulp (SAIMEX 1981).

Prickly Pear as Vegetable

Two genera within the Opuntioideae are used for the commercial production of nopalitos: *Nopalea* and *Opuntia*. In particular, there are four species of *Opuntia* that are most commonly used: *Opuntia ficus-indica* (L.) Miller variety Copena VI, developed by F. Barrientos in 1960, is the most sought-after due to its excellent flavor and low acidity; *O. joconostle* Haage & Schmidt has fruits that are used mainly as a vegetable or spice (Sánchez et al. 1990) (Table 2); *O. robusta* Wendland is commercially grown in a small area of the Potosi state tablelands, where the cladodes are sold on the local market and processed for exportation. Currently, *O. atropes* Rose is very popular in the state of Jalisco because local consumers like its flavor and texture. The exact area planted is unknown but is estimated at around 500 ha (Sierra 1999).

Table 3 shows the main species and varieties of prickly pear used for nopalitos production in Mexico. Prickly pears are cultivated in 18 states of Mexico, although 71.4% of the cultivated area falls within one state (Distrito Federal) (Table 4) (Flores et al. 1995; Flores 1997). The total production area is around 10,500 ha with an annual yield of 575,575 tons.

Prickly Pear as Fodder

Some of the characteristics that make prickly pear cacti a valuable addition to fodder for cattle, goats, horses and a variety of wild animals are its high palatability and digestibility, its great abundance, and its high productivity and quick recovery after harvesting (López et al. 1996; Fuentes 1997). There are two cattle systems that use prickly pear in Mexico: free roaming cattle and farm cattle. Free roaming cattle are raised on wild cacti and other wild plants on about 150,000 ha in the states of Tamaulipas, Nuevo Leon, Coahuila, Chihuahua, Sonora, San Luis Potosi, Zacatecas and Durango. In the second system, the cladodes of certain cultivated cactus varieties (Table 5) are harvested and added to commercial concentrates together with oats, maize, wheat and salts (Fuentes 1997).

TABLE 1. MAIN *OPUNTIA* SPECIES UTILIZED FOR THEIR FRUIT.¹

Species	Common name
<i>O. alfajayuca</i> Haage & Schmidt	Nopal alfacayuca
<i>O. amyclaea</i> Tenore	
<i>O. ficus-indica</i> (L.) Miller	Nopal de castilla
<i>O. hyptiacantha</i> Weber	
<i>O. leucotricha</i> De Candolle	Nopal duraznillo
<i>O. megacantha</i> Salm-Dyck	Nopal tapón
<i>O. streptacantha</i> Lemaire	Nopal cardón
<i>O. tapona</i> Engelmann	Nopal tapón
<i>O. robusta</i> Wendland	Nopal camueso

¹Flores & Gallegos 1993.

TABLE 2. CACTUS SPECIES USED TO OBTAIN XOCONOSTLE FRUITS.¹

<i>Opuntia leucotricha</i> De Candolle
<i>O. joconostle</i> Haage & Schmidt
<i>O. matudae</i> Scheinvar
<i>O. oligacantha</i> Salm-Dyck
<i>O. heliabravoana</i> Scheinvar
<i>O. spinulifera</i> Salm-Dyck
<i>O. zamudioi</i> Scheinvar
<i>O. imbricata</i> (Haworth) De Candolle

¹Scheinvar 1999; Cano et al. 1999.

Production of Cochineal Dyes

The cochineal insect *Dactylopius coccus* Costa is native to Mexico and has been used since pre-Hispanic times to produce crimson dyes. The insects are reared on certain species of *Opuntia* (Table 6), mature females are collected and dried, and the pigments extracted from the dried bodies. Commercial production and use of cochineal dye is limited, however, its use continues to be an important local tradition (Portillo & Arreola 1994; Portillo 1995; Vigueras & Portillo 1997). The exact acreage of *Opuntia* cacti under cultivation for rearing the cochineal insect is not known but it is estimated to be around 100 ha (Portillo 1999).

TABLE 3. MAIN SPECIES AND VARIETIES OF PRICKLY PEAR (*OPUNTIA* AND *NOPALEA*) USED FOR NOPALITOS.¹

Species	Variety
<i>O. atropes</i> Rose	Blanco
<i>O. ficus-indica</i> (L.) Miller	Milpa Alta
<i>O. ficus-indica</i>	Atlixco
<i>O. ficus-indica</i>	Copena V1
<i>O. ficus-indica</i>	Copena F1
<i>O. ficus-indica</i>	Moradilla
<i>O. ficus-indica</i>	Blanco
<i>O. ficus-indica</i>	Negro
<i>O. ficus-indica</i>	Blanco w/ spines
<i>O. ficus-indica</i>	Polotitlan
<i>O. ficus-indica</i>	Alba
<i>O. ficus-indica</i>	Lutea
<i>O. ficus-indica</i>	Asperma
<i>O. ficus-indica</i>	Piriforme
<i>O. ficus-indica</i>	Serotina
<i>O. ficus-indica</i>	Italiana
<i>O. ficus-indica</i>	Villanueva
<i>O. ficus-indica</i>	Jalpa
<i>O. inermis</i> De Candolle	Tlaconopal
<i>O. robusta</i> Wendland	Tapon
<i>O. streptacantha</i> Lemaire	Cardon
<i>N. cochenillifera</i> (L.) Salm-Dyck	Tamazunchale

¹Bravo 1978; Flores 1995; De la Rosa & Santamaria 1998; Blanco et al. 1999.

POTENTIAL IMPACT OF *C. CACTORUM*

The arrival in Mexico of the exotic pest, *Cactoblastis cactorum* (Berg), could pose a potentially very serious threat to both wild and cultivated prickly pears. Many of the more widely distributed and commonly used *Opuntia* species, which have previously been shown to be heavily attacked by this insect, are native to Mexico (Table 7). Small and young plants are particularly vulnerable to *C. cactorum*. This could have serious implications for the long-term sustainability of some ecosystems because reproductive events and/or conditions favorable for reproduction often occur only every few years. This could leave the soil in many arid and semi-arid regions unprotected to erosion, since prickly pear is one of the few plants that grow in these areas. The rich diversity of *Opuntia* cacti in Mexico also supports a rich diversity of native fauna. For example, 102 insect species have been found to interact with the genus *Opuntia*, representing nine orders, 29 families and 71 genera (Rodriguez et al. 1999).

The introduction of *C. cactorum* could also have significant social impacts. In 1996, the cultivation of prickly pear involved some 20,300 fruit producers and 8,095 producers of nopalitos. Additional people are involved in processing industries and cochineal production. Prickly pear cultivation has provided marginal and subsistence communities with employment, food, income and enabled them to remain on their land (De la Rosa & Santamaría 1998).

The potential routes that this insect might take to invade Mexico, as well as its ability to disperse over long distances (DeBach 1964), need to be better evaluated. Currently the moth occurs in Florida and is slowly moving west around the gulf coast. One of its primary hosts is *O. stricta* (Haw.) Haworth, which occurs along the coast from Florida to Texas. Once in Texas it could easily pass into Mexico. Another potential entrance point is through the Yucatan. Some concern has been raised that it might already be there, although initial surveys have been negative. The illegal transport of cacti from other countries through airports, harbors and international borders is an additional serious concern.

POSSIBLE CONTROL OPTIONS

The use of chemicals to control *C. cactorum* is not recommended, at least not in Mexico. Aerial applications of pesticides would not be economical and probably would not be effective, given the internal feeding behavior of this insect. Systemic insecticides or chemicals that accumulate in the plant tissues could have human or other non-target toxicity effects. In addition, much of the area from which cactus pads and fruit are harvested is

TABLE 4. PRODUCTION OF NOPALITOS IN MEXICO BY STATE (1996).¹

State	Area (ha)	Production (tons)	Yield (tons/ha)
Distrito Federal	7,500	450,000	60.0
Morelos	450	31,500	70.0
Puebla	400	16,000	40.0
San Luis Potosí	350	10,500	30.0
Michoacán	320	10,500	35.0
Tamaulipas	300	9,000	30.0
Guanajuato	280	9,800	35.0
México	200	6,000	30.0
Baja California	150	9,000	60.0
Jalisco	120	7,200	60.0
Oaxaca	100	6,000	60.0
Aguascalientes	80	2,400	30.0
Zacatecas	75	2,250	30.0
Hidalgo	60	2,400	40.0
Tlaxcala	45		25.0
Querétaro	35		20.0
Durango	15		20.0
Sonora	10		80.0
Other	10		10.0
Total	10,500		

¹Flores 1997.

wild habitat and the use of pesticides could have wide ecological effects on diverse fauna.

Biological control, based on the use of natural enemies such as *Apanteles alexanderi* Brethes (Hym.: Braconidae), *Phyticiplex doddi* (Cushman) and *P. eremnus* (Porter) (Hym.: Ichneumonidae), is also potentially controversial. The introduction of new natural enemies could have negative impacts on the complex but fragile native cactus ecosystems.

Potential control options would be the use of traps or attractant-and-kill systems. However, such systems have yet to be developed. Another alternative might be the use of biopesticides such as neem. Again, however, these have not been tested.

TABLE 5. CULTIVARS OF *OPUNTIA FICUS-INDICA* (L.) MILL. USED AS LIVESTOCK FEED.¹

Copena CE-1
Copena CE-2
Copena F-1 maduro (without spines)
Copena F-1 tierno (with spines)
Nopal Rojo Pelon
Nopal Amarillo Milpa Alta
Nopal 30 Huatusco
Nopal Amarillo Milpa Alta Tierno
Nopal 31 Azul
Nopal 7 Texas

¹Fuentes 1997; Vazquez & De la Garza 1999.

Among the essential preventative actions would be to alert all producers and technicians involved in prickly pear cultivation of the threat this insect poses and what they should do if they encounter it. The information campaign should involve cactus societies, environmental groups, grower groups and research institutions, and

TABLE 6. PRICKLY PEAR SPECIES (*OPUNTIA* AND *NOPALEA*) REPORTED AS HOSTS OF THE COCHINEAL INSECT *DACTYLOPIUS COCCUS* COSTA AND USED FOR DYE PRODUCTION.¹

Species	Common name
<i>O. atropes</i> Rose	Nopal blanco
<i>O. amyclaea</i> Tenore	
<i>O. crassa</i> Haworth	
<i>O. ficus-indica</i> (L.) Miller	Nopal manso de Castilla
<i>O. incarnadilla</i> Griffiths	
<i>O. fulginosa</i> Griffiths	
<i>O. jaliscana</i> Bravo	Azucar
<i>O. megacantha</i> Salm-Dyck	Pescuezon, jarrito
<i>O. pilifera</i> Weber	
<i>O. sacra</i> Griffiths	
<i>O. streptacantha</i> Lemaire	
<i>O. tomentosa</i> Salm-Dyck	San Gabriel
<i>O. undulata</i> Griffiths	
<i>N. cochenillifera</i> (L.) Salm-Dyck	

¹Portillo 1995; Viguera & Portillo 1997.

TABLE 7. MEXICAN *OPUNTIA* SPECIES THAT ARE KNOWN TO BE SUSCEPTIBLE TO ATTACK BY *CACTOBLASTIS CACTORUM* (BERG).¹

Species	Uses
<i>O. compressa</i> McBride	
<i>O. ficus-indica</i> (L.) Miller	Nopalitos, forage, fruit, cochineal
<i>O. megacantha</i> Salm-Dyck	Nopalitos, forage, fruit, cochineal
<i>O. streptacantha</i> Lemaire	Nopalitos, forage, fruit, cochineal
<i>O. stricta</i> (Haw.) Haworth	
<i>O. tomentosa</i> Salm-Dyck	Cochineal

¹Mann 1969; Zimmermann & Pérez-Sandi 1999; Zimmermann et al. 2000.

should include the development and distribution of posters and pamphlets. Pressure also should be exerted on the government to enhance the phytosanitary practices aimed at preventing the entrance of exotic organisms into Mexico from other parts of the world. A number of Mexican institutions, including the University of Guadalajara, CONABIO, Government of Queretaro, ITESM, SEMARNAP and NAKARI, already have begun to collaborate on awareness campaigns for *C. cactorum* in their own regions.

CONCLUSIONS

Mexico has a tremendous diversity of prickly pear species. The cactus moth, *Cactoblastis cactorum*, would likely attack many, if not most, of these species, given its wide geographic and host ranges. Considering the prominent role prickly pears play in native ecosystems and local economies, the impact of this moth in Mexico could be extremely significant.

With increased global trade, it is difficult to predict when or from where the moth will arrive, but its presence and spread in Florida is disturbing. Certain parts of Mexico have habitats that are very similar to those in Argentina where *C. cactorum* completes two generations per year. Its biology could be similar in Mexico. Currently, there are no effective control measures for the moth other than the hand removal of egg sticks. Public and governmental awareness of the threat *C. cactorum* poses to Mexico and the development of responses prior to its establishment are critical.

REFERENCES CITED

- BARTHOLOTT, W., AND D. R. HUNT. 1993. Cactaceae IN Kubitzki, K. Rohwer, J. G. and Bittrich [eds.] V. The families and genera of vascular Plants. Vol. II, Flowering Plantas Dicotyledons, Berlin, Springel-Verlag.
- BLANCO, M. F., R. D. VALDEZ C., R. R. RUIZ G., AND A. LEGASPI G. 1999. Producción de nopalitos bajo mi-
- crotunel en Zacatecas, pp. 73-74. In J. R. Aguirre-Rivera and J. A. Reyes A. [eds.]. Proc. VIII Congreso Nacional y VI Congreso Internacional Sobre Conocimiento y Aprovechamiento del Nopal. Universidad Autónoma de San Luis Potosí, Mexico.
- BRavo, H. H. 1978. Las cactáceas de México. Vol. I. U.N.A.M. México, D. F. 743 p.
- CANO, C. I. M., O. CAÑA M. H., O. VÁZQUEZ Z., J. OLIVARES O., R. CALDERÓN A., R. PAYÁN C., L. SCHEINVAR, AND A. CHIMAL H. 1999. Comercialización del fruto del xoconostle en el Valle de México, pp. 53-54. In J. R. Aguirre-Rivera and J. A. Reyes A. [eds.]. Proc. VIII Congreso Nacional y VI Congreso Internacional Sobre Conocimiento y Aprovechamiento del Nopal. Universidad Autónoma de San Luis Potosí, Mexico.
- DEBACH, P. (ed.) 1964. Biological control of insect pests and weeds. Rienhold, New York. 844 pp.
- DE LA ROSA, H. J. P., AND D. SANTAMARÍA A. 1998. El nopal, usos, manejo agronómicos y costos de producción en México. Ed. CONAZA-UACH-CIESTAAM. Chapingo, Mexico. pp. 132.
- FLORES, V. C. A. 1995. "Nopalitos" production, processing and marketing, pp. 92-99. In Agro-ecology cultivation and uses of cactus pear. FAO plant production and protection paper 132.
- FLORES, V. C. A. 1997. La producción de nopalito en México, pp. 28-38. In R. E. Vázquez-Alvarado, C. Gallegos-Vázquez, N. Treviño-Hernández, and Y. Díaz-Torres [eds.]. Proc. VII Congreso Nacional y V Congreso Internacional Sobre Conocimiento y Aprovechamiento del Nopal. Facultad de Agronomía, Universidad Autónoma de Nuevo León, Monterrey, Mexico.
- FLORES, V. C. A., AND G. ARANDA O. 1997. *Opuntia* based ruminant feeding systems in Mexico. J. PACD. Vol. 2. U.S.A. pp. 3-8.
- FLORES, V. C., M. DE LUNA J., AND P. RAMÍREZ P. 1995. Mercado Mundial del Nopalito. ASERCA-UACH-CIESTAAM. Chapingo, Mexico. 115 pp.
- FLORES, V. C. A., AND C. GALLEGOS V. 1993. Situación y perspectivas de la producción de tuna en la región centro norte de México. Universidad Autónoma de Chapingo-CIESTAAM. Chapingo, Mexico. 42 pp.
- FUENTES, 1997. El nopal: alternativa forrajera en las zonas áridas del norte de México, pp. 82-87. In R. E. Vázquez-Alvarado, C. Gallegos-Vázquez, N. Treviño-Hernández, and Y. Díaz-Torres [eds.]. Proc. VII Congreso Nacional y V Congreso Internacional Sobre Conocimiento y Aprovechamiento del Nopal. Facultad de Agronomía, Universidad Autónoma de Nuevo León, Monterrey, Mexico.
- GUZMÁN, C. L. U. 1997. Grupos taxonómicos, pp. 37-41 IN Suculentas Mexicanas/Cactáceas. CVS Publicaciones, S. A., de C. V. Mexico.
- LÓPEZ, J. J. G., A. RODRÍGUEZ G., L. PÉREZ R., AND J. M. FUENTES R. 1996. A survey of forage uses of cactus in Northern Mexico. J. PACD. Vol. 1. USA. pp. 10-15.
- MANN, J. 1969. Cactus-feeding insects and mites. Bull. U.S. Nat. Mus. 256: 1-158.
- PORTILLO, M. L. 1995. Los nopales hospederos de las cochinitas del carmín (*Dactylopius* spp.) y algunas consideraciones sobre su aprovechamiento, pp. 62-65. In E. Pimienta-Barrios, C. Neri-Luna, A. Muñoz-Urias and F. M. Huerta-Martínez [eds.]. Proc. VI Congreso Nacional y IV Congreso Internacional Sobre Conocimiento y Aprovechamiento del Nopal. Universidad de Guadalajara, Mexico.

- PORTILLO, M. L. 1999. Situación de la grana cochinilla en México, p. 113. In J. R. Aguirre-Rivera and J. A. Reyes A. [eds.]. Proc. VIII Congreso Nacional y VI Congreso Internacional Sobre Conocimiento y Aprovechamiento del Nopal. Universidad Autónoma de San Luis Potosí, México.
- PORTILLO, M. L., AND H. ARREOLA N. 1994. Los nopales hospederos de la cochinilla fina o cultivada (*Dactylopius coccus* Costa). Cact. Suc. Mex. 39(4): 90-95.
- RODRIGUEZ, A. F., A. FIERRO A., AND M. M. GONZALEZ L. 1999. Contribución al estudio de la entomofauna asociada a los cultivos de nopalito (*Opuntia ficus-indica*), en la región de Milpa Alta, D. F., p. 96. In J. R. Aguirre-Rivera and J. A. Reyes A. [eds.]. Proc. VIII Congreso Nacional y VI Congreso Internacional Sobre Conocimiento y Aprovechamiento del Nopal. Universidad Autónoma de San Luis Potosí, México.
- SAIMEX. 1981. Perspectivas de la utilización del nopal y la tuna. Monografía. Gobierno del Estado de México. Metepec, México. 78 pp.
- SANCHEZ V. G., ORTEGA, D. M. L., GRANADOS, S. D. AND J. P. CRUZ H. 1990. Fenología y crecimiento de *Opuntia joconostle* Weber, p. 31. In Proc. IV Congreso y II Congreso Internacional Sobre Conocimiento y Aprovechamiento del Nopal. Zacatecas, Zac., México.
- SCHEINVAR, L. 1999. Biosistemática de los Xocostyles mexicanos y su potencial económico, pp. 255-274. In J. R. Aguirre-Rivera and J. A. Reyes A. [eds.]. Proc. VIII Congreso Nacional y VI Congreso Internacional Sobre Conocimiento y Aprovechamiento del Nopal. Universidad Autónoma de San Luis Potosí, México.
- SIERRA, M. 1999. Experiencias en el cultivo del nopal blanco (*Opuntia atropes* Rose) en San Isidro Zapopan, Jalisco. Nakari 11(2): 22.
- VÁZQUEZ, A. R. E., AND R. DE LA GARZA V. 1999. Caracterización de cinco cultivares de nopal forrajero, pp. 107-108. In J. R. Aguirre-Rivera and J. A. Reyes A. [eds.]. Proc. VIII Congreso Nacional y VI Congreso Internacional Sobre Conocimiento y Aprovechamiento del Nopal. Universidad Autónoma de San Luis Potosí, México.
- VIGUERAS, G. A. L., AND L. PORTILLO M. 1997. Cría de cochinilla, pp. 2-4. In R. E. Vázquez-Alvarado, C. Gallegos-Vázquez, N. Treviño-Hernández and Y. Díaz-Torres [eds.]. Proc. VII Congreso Nacional y V Congreso Internacional Sobre Conocimiento y Aprovechamiento del Nopal. Facultad de Agronomía, Universidad Autónoma de Nuevo León, Monterrey, Mexico.
- ZIMMERMANN, H. G., AND M. PÉREZ SANDI C. 1999. A new insect pest on *Opuntia* in wait for Mexico, pp. 333-341. In J. R. Aguirre-Rivera and J. A. Reyes A. [eds.]. Proc. VIII Congreso Nacional y VI Congreso Internacional Sobre Conocimiento y Aprovechamiento del Nopal. Universidad Autónoma de San Luis Potosí, México.
- ZIMMERMANN, H. G., V. C. MORAN, AND J. H. HOFFMANN. 2000. The renowned cactus moth, *Cactoblastis cactorum*: its natural history and threat to native *Opuntia* floras in Mexico and the United States of America. Diversity and Distributions 6: 259-269.