Survey Information for the National Cactus Moth (*Cactoblastis cactorum*) Detection and Monitoring Network

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GeoResources Institute, Mississippi State, MS 39762-9652
GeoResources Institute Report #5013
April 23, 2007

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Background: *Cactoblastis cactorum* Berg. was introduced into Australia from Argentina in the 1920's to control exotic invasive prickly pear cacti. The program was phenomenally successful at reducing large stands of prickly pear in a relatively short period of time. Over the next several decades, *C. cactorum* was then taken to other parts of the world to control invasive prickly pear, including Hawaii in 1950 and the Caribbean island of Nevis in 1956. Spreading from Nevis to other islands, *C. cactorum* was eventually detected in the Florida Keys in 1989. By 2004, the moth was found as far north as Bull Island, South Carolina along the Atlantic Coast and as far west as Dauphin Island, Alabama along the Gulf Coast. The westward expansion threatens to impact desert ecosystems of the southwestern US and Mexico, as well as an important agricultural crop in Mexico.

The expansion of *C. cactorum* along the Gulf Coast may indicate that it favors coastal areas and barrier islands because of the availability of host species. Limited trapping and visual surveys performed by researchers last year showed no further locations farther west than Dauphin Island along the Gulf Coast. *Cactoblastis cactorum* can spread by natural dispersal by flight, storm events, or in infested nursery stock or plant material for consumption. More survey information is needed along the Gulf States and in the Southwestern US.

Setting Up a National Detection and Monitoring Network for Cactus Moth

While USDA, APHIS, Plant Protection and Quarantine and state departments of agriculture will be performing surveys of some nursery and residential locations, there is a need to monitor natural prickly pear populations in areas at risk for *C. cactorum.* Agencies within the Department of Interior and non-profit environmental organizations with land holdings have expressed interest in helping to survey for *C. cactorum* on public and managed lands. To this end, the US Geological Survey (USGS) funded a project at Mississippi State University's GeoResources Institute (MSU-GRI) to gather data on *Opuntia* species distributions and *C. cactorum* monitoring activity.

The mechanism for gathering the information is a password protected website database that participating managed land unit managers or designees can log into and record their host occurrences and observations as they monitor prickly pear cactus sites on their land. The list of cooperating agencies or groups currently includes national parks and seashores, national wildlife refuges, national forests, military bases, state parks, The Nature Conservancy, Mississippi State University Extension Service, Mississippi Master Gardeners, and others. Many of these groups have volunteers whose observations will be entered by the land unit's program contact person. The data gathered at MSU will be reported to state departments of agriculture who will enter it into the USDA National Agriculture Pest Information System (NAPIS) database.

USDA and USGS wish to emphasize that negative observations (i.e., non-occurrence) of *C. cactorum* are just as important as positive detections, as it helps define the distribution over time. We encourage land unit managers that have prickly pear cactus to participate, however our highest priority for monitoring is with US Gulf Coast locations followed by southwestern desert land units.

How to Participate in the Cactus Moth Detection and Monitoring Network

The first steps toward participation include choosing a site, or sites, with prickly pear cactus, identifying the host, and recording the GPS (Global Positioning System) coordinates of the cactus monitoring site, also known as a "sentinel site". Then register on the MSU-GRI Cactus Moth Detection and Monitoring Network website to obtain your user name and password.

For an on-going monitoring program, make regular visual observations (monthly, bi-weekly, etc.) for larvae or eggs and record your information at the website. The information will be used to generate maps and make decisions on possible control efforts.

The site can be accessed at the following URL:

http://www.gri.msstate.edu/cactus_moth

The data forms and explanations of the data fields are available at the site.

Types of Survey Data

Host plant occurrence:
Basic data for *Opuntia* prickly pear species distributions are lacking, especially in the Southeastern US and Gulf Coast. Knowing the location of hosts is basic to finding the pest, and pest surveyors do not always know where to look. Even if you do not expect to find evidence of *C. cactorum*, participating in host occurrence data collection through this network will be a big service. The basic information needed is the georeferenced location and species, but any other abundance or habitat information will be useful.

Visual observations for C. cactorum:
These data are basically "is it present" or "is it not"? Observations of characteristic damage or the detection of larvae are not considered positive until a qualified authority identifies them. Egg sticks are not easily identified.

Trapping surveys for C. cactorum:
The Agriculture Research Service has produced an experimental sex attractant (lure) that attracts male moths. They have made its use available on a limited basis. Until the final pheromone blend is identified, the experimental lure will be available only to certain Gulf Coast land units with prickly pear cacti from the Florida panhandle to the Texas border with Mexico.

Land managers that have been contacted by a USDA-APHIS Plant Protection and Quarantine (PPQ) Pest Survey Specialist, or your state's department of agriculture surveyor, are already collecting the necessary data. Please do not duplicate their records by entering the same observations in the MSU Cactus Moth Detection and Monitoring Network database.

Host plants:

The genus *Opuntia* consists of all prickly pear cacti, those having flat-pad stem, or cladodes. Only pricklypear cacti of the genus *Opuntia* are preferred hosts to the cactus moth. The generic name *Opuntia* is often applied to a related group called "cholla" cactus (pronounced "choya"), which now are placed in a separate genus known as *Cylindropuntia*. In older taxonomic treatments, you will see *Opuntia* divided into two subgenera, *Platyopuntia*, with a pad-like stem, and

Cylindropuntia, with a cane-like stem. The list of known hosts for *C. cactorum* are prickly pear cactus species, in the genus *Platyopuntia*, with the exception of a few records from one species in the related genus, *Nopalea*. While other host records appear in the literature, none of these records of *C. cactorum* attacking any other cactus species are reliable. *Cylindropuntia* are not thought to be hosts of *C. cactorum.* Another related genus, *Grusonia*, appears in older literature as *Opuntia*, but species in that genus are also not known to be hosts of *C. cactorum.* See Appendix I for a list of all native *Opuntia* species (within the *Platyopuntia* group). Many ornamental species found in nurseries or used in landscaping are native but others may be from Mexico or South America.

Figure 1. *Platyopuntia* (left) and *Cylindropuntia* (right). The later are not considered hosts. *All photos by Joel Floyd, USDA, APHIS. PPQ, unless otherwise noted*

Figure 2. *Platyopuntia* (foreground) and *Cylindropuntia* (background).

A recent key to *Opuntia* species native to the US with illustrations and range maps, can be accessed at: http://www.efloras.org/florataxon.aspx?flora_id=1&taxon_id=123045 . Many *Opuntia* species used in landscaping or as potted nursery plants, however, may not be listed in this key if they are not native to the US.

This web-based key is from the most current revision of the genus *Opuntia* by Donald Pinkava in Flora of North America Editorial Committee, eds., 2003, *Flora of North America North of Mexico, Vol. 4., Magnoliophyta: Caryophyllidae, part 1*, New York: Oxford University Press.

Where to survey for *C. cactorum*

Potential survey sites include any place where prickly pear grows, but certain factors can narrow the potential sites to areas with the higher perceived risk of introduction.

In the Gulf States, because of the propensity for *C. cactorum* to disperse along coastal areas, surveys should be concentrated on barrier islands and other suitable habitats along the coast. The types of soils that support prickly pear cactus populations usually consist of sandy, well-drained areas, often with full sun exposures. These include sand dunes and beaches above the tide line on barrier islands and the mainland, or areas that consist of sandbanks behind beaches or near watercourses such as rivers or streams.

Prickly pear cactus can also occur throughout the region, occasionally in unexpected locations, as well as occurring as naturalized populations from former ornamental plantings. Since all prickly pear populations are potential hosts to cactus moth, these populations should be mapped.

USDA APHIS PPQ and their state cooperators will be inspecting nurseries in various states for the presence of contaminated cactus, as well as horticultural plantings on private property. It is not necessary for others to map these locations unless the property owner requests assistance.

Visual Surveys

Infestation by *C. cactorum* can be indicated by the presence of egg-sticks, which resemble cactus spines (Figures 3 and 4). However, native cactus-feeding Lepidoptera laid similar egg sticks that currently cannot be distinguished reliably from those of *C. cactorum.* Examine cactus pads that are yellowed or have clear areas and check for the presence of green, brown, or yellowish brown exudates on the pad surface for evidence of internal feeding by larvae. Frass from the larvae can usually be seen on external surfaces of the infested pad. With care not to come in contact with the large cactus spines and the barely-visible glochid spines, carefully cut open the pad to reveal internal feeding larvae (Figures 5-8).

Figure 3. Egg stick of *C. cactorum*, 2-3 cm in size containing 50-70 eggs.
Photo by Dale Habeck, Univ. of Florida

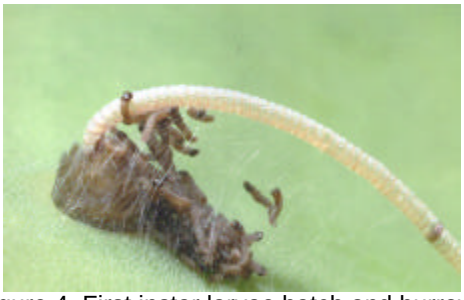


Figure 4. First instar larvae hatch and burrow into the plant where they feed gregariously.
Photo by Ignacio Baez, USDA-ARS

Figure 5. The first visible evidence of internal feeding by larvae is yellowing and frass on the plant surface.

Figure 6. Further evidence of internal feeding by larvae is yellowing and exudates of the plant. *Photo by Ken Bloem, USDA, APHIS, PPQ*

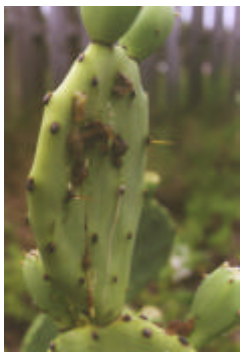


Figure 7. Symptoms of internal feeding including frass from *C. cactorum* in *Opuntia stricta.*

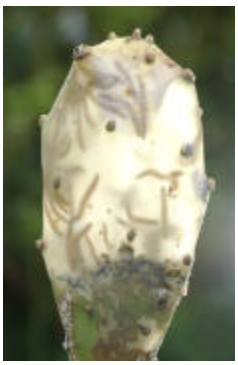


Figure 8. Hollowing out and eventual collapse of *C. cactorum* infested *O. stricta* plant.
Photo by Ken Bloem, USDA, APHIS, PPQ

Figure 9. When held up to the light, an infested prickly pear pad has a translucent quality and larvae can be seen feeding through the pad epidermis.

Figure 10. Cutting open the cactus pad in cross-section reveals *C. cactorum* larvae feeding.

Holding a pad up to the light will reveal internal feeding (Figure 9) and carefully cutting open the pad lengthwise will expose the larvae for collection and identification.

Precautions to take when handling prickly pear cacti

Obviously, cactus plants should be handled with care. *Opuntia* spp. produce two kinds of spines, the regular large sharp spines and much smaller glochids, which have a velvety appearance. The glochids (Figure 11) can enter your skin without you experiencing pain, but will become evident when you rub your fingers together. They are seen with a hand lens and can be difficult to remove. Wearing gloves only causes the gloves to be contaminated with glochids. The proper way to handle prickly pear pads is with tongs and a large knife or machete (Figure 12).

Figure 11. Spines and smaller glochids on areoles of *Opuntia ficus-indica* (l) *and O. phaeacantha (*r). *From Benson, 1982*

Figure 12. Using a knife in conjunction with tongs to handle prickly pear pads prevents injury from spines and the small glochids.

Timing of Visual Surveys

Symptoms of internal feeding on prickly pear can be seen at anytime of the year, however, larvae may be difficult to find during the colder months. Larvae tend to congregate in the lower parts of the plant and are not seen feeding in galleries when it is cold. If daytime temperatures reach a certain point, larvae will migrate to the upper cactus pads, and may even be seen on the exterior of the pad on the sunny side of the plant.

The *C. cactorum* populations in the US Gulf Coast undergo three generations per season, with adult flight and mating periods as follows:

1st flight period	late March through May
2nd flight period	July through August
3rd flight period	late September through mid November

We do not suggest monitoring visually for adults, but this generational information will assist with knowing approximate time periods in which to expect to see fresh egg-sticks and subsequent larval feeding within the cactus plants.

Identification

The adults of *C. cactorum* (Pyralidae: Phycitinae) are non-descript brownish-gray moths that can only be definitively identified by a microscopic examination of dissected male genitalia. They generally appear as typical pyralid moths with pronounced labial palps of the female, thus the name “snout moths” (Figure 19 and 20). The forewings show a characteristic banding pattern, however other related Phycitinae have similar banding.

The larvae are more distinctive with a characteristic orange to red color interrupted by dark banding or spots on the body. The more mature larvae are relatively easy to distinguish from those of native species, however some collectors have misidentified younger stages of native species as those of *C. cactorum*. The larval keys that do exist are limited to differences in color and mature larvae. Also, records of some species may only be known from limited reference material. Dr. Richard Brown at Mississippi State University is interested in receiving specimens

of any Lepidoptera found on prickly pear in the US, including different stages, accompanied by adults reared out from larval collections. Digital photos of live larvae will also be helpful in documenting color variations and providing future visual keys to surveyors.

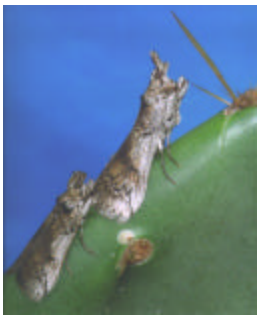


Figure19. Adult male (l) and female (r) of *C. cactorum* showing relative size.
Photo by Ignacio Baez, USDA-ARS

Figure 20. Adult female *C. cactorum* mounted showing banding on wings.
Photo by Sue Ellis, USDA, APHIS, PPQ

Figure 21. *C. cactorum* larva (right) and *Melitara prodenialis* (left).
Photo courtesy of Ignacio Baez, USDA-ARS, Tallahassee, FL. Photo by Ignacio Baez

Figure 22. *Rumatha glaucatella* larva found in Florida on prickly pear.
Photo by Dale Habeck, Univerity of Florida

For more information and a key to the cactus feeding species in the Southeastern US, see:

Solis, M. Alma, Stephen D. Hight, and Doria R. Gordon. 2004. *Tracking the Cactus Moth,* Cactoblastis cactorum *Berg., as it flies and eats its way westward in the U.S.* News of the Lepidopterists Society 46(1) 2-3.

Article at hyperlink: http://www.sbs.utexas.edu/philjs/news/pdf/CactusMoth.pdf

Of the eleven moth species found on cactus in the Eastern and Western US, only one is not native (Table 1).

Table 1. A list of Phycitine moth species that are found on prickly pear in the US.

PHYTCITINAE		***Eastern US***	***Western US***
Cactoblastis	*cactorum*	***X***	
Melitara	*prodenialis*	***X***	
	dentata		***X***
	texana		***X***
	doddalis		***X***
	apicigrammella		***X***
	junctolineella		***X***
	subumbrella		***X***
Ozamia	*fuscomaculella*		***X***
	clarefacta		***X***
	lucidalis		***X***

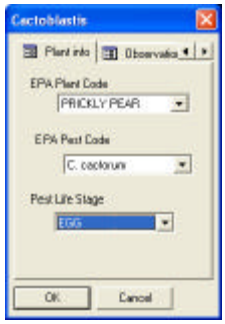
Larvae encountered on prickly pear *Opuntia* should be collected, killed in boiling water, and preserved in 70% ethyl alcohol or by following specific instructions from Dr. Brown. These should be sent to your state department of agriculture or cooperating university entomologist. The screened larvae should be verified by sending, with all collection information and any digital photos, to Dr. Richard Brown (contact information below).

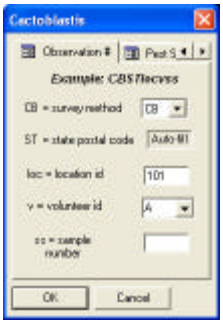
Dr. Richard Brown , Director
Mississippi Entomological Museum
Box 9775
Mississippi State, MS 39762
Phone: 662-325-2085 e-mail: moth@ra.msstate.edu

New state records will be verified by Dr. Alma Solis, of the ARS Systematic Entomology Laboratory at the US Natural History Museum, Smithsonian Institution, Washington, DC.

The use of handheld devices for recording survey observations

USDA, APHIS, PPQ in Gulfport, Mississippi has developed a software application using *C. cactorum* surveys to demonstrate the use of handheld PDA/GPS devices to collect survey information. The system uses Arc-Pad™ an ESRI® software product. Dr. Ron Weeks, USDA, has built menu-driven screens to make collecting the same data on the website more seamless, with download capability for your desktop. The host plant distribution, GPS coordinates, and cactus moth observation data collected in the field on the handheld device and then put in a cradle with a desktop computer for uploading to the database. Please contact Clifton Abbott regarding this technology.





Contacts:

For information or technical help in participating in the detection network, please contact:

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For information on the web-based database or assistance with the webpage, contact our webmaster:

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For information about the USDA Cactus moth program, contact:

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Our coordinator for federal public and private conservation lands is :

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Fax: 910-648-6763
E-Mail: rwestbrooks@usgs.gov

USDA, APHIS has a volunteer coordinator in the Gulf Coast area, and there are USDA Pest Survey Specialists that cover various regions of the US conducting surveys for various pests. If you need personal assistance, please contact Joel Floyd or go to the following URL to obtain contact information for the Pest Survey Specialists covering in your area.

http://www.ceris.purdue.edu/napis/names/pssXstate.html

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Solis, M. A., Hight, S. D., and Gordon, D. R., 2004. *Tracking the Cactus Moth,* Cactoblastis cactorum *Berg, as it flies and eats its way westward in the U.S.*, Spring, 2004, News of the Lepidopterist's Society

Internet References:

A USDA, APHIS, PPQ Pest Alert website, with additional information, will soon be available at:

http://www.aphis.usda.gov/ppq/ep/emerging_pests/cactoblastis/

For more information on *C. cactorum* biology and concerns, see the special issue of the *Florida Entomologist*, vol. 84, no. 4, "Cactoblastis cactorum *in North America: Proceedings of a Workshop for Assessment and Planning September 20-21, 2000, Tampa, FL"* found at:

http://www.fcla.edu/FlaEnt/fe844.htm

Other links:
National Invasive Species Council species profile of the Cactus moth:

http://www.invasivespecies.gov/profiles/cactmoth.shtml#fed

APPENDIX I

Table 2. *Opuntia* species that are hosts to *C. cactorum*, native and naturalized (indicated with an *), excluding non-native nursery stock.

Species / STATE	**AL**	**AZ**	**CA**	**CO**	**FL**	**LA**	**MS**	**NM**	**NV**	**TX**	**UT**
Opuntia aciculata										X	
O. atrispina										X	
O. aurea		X								X	X
O. aureispina										X	
O. basilaris		X	X								X
O. chisosensis										X	
O. chlorotica		X	X					X	X		X
*O. cochenillifera (*syn. *Nopalea cochenillifera)*					X						
O. cubensis					X						
O. chlorotica									X		
O. cymochila								X		X	
O. edwardsii										X	
O. ellisiana										X	
O. engelmannii		X	X			X	X	X	X	X	X
*O. ficus-indica**	X	X	X		X	X	X	X		X	
O. fragilis		X	X	X				X	X	X	X
O. grahamii								X			
O. humifusa	X			X	X	X	X	X		X	
O. leucotricha					X						
O. littoralis		X	X								
O. macrocentra		X						X		X	X
O. macrorhiza		X		X		X		X		X	
*O. monacantha**	X				X	X	X				
O. oricola			X								
O. phaecantha		X	X	X				X	X	X	X
O. pinkavae		X									X
O. polycantha		X	X	X				X	X	X	X
O. pusilla	X				X	X	X			X	
O. rufida										X	
O. santa-rita		X						X		X	
*O. spinosissima (*Syn. *Consolea corallicola)*					X						
O. stricta	X				X	X	X				
O. strigil										X	
*O. tomentosa**			X								
O. tortispina				X							
O. triacantha					X						