MISSISSIPPI STATE UNIVERSITY

Cactus Moth Update

Volume 2, Issue 1 March 2010

The latest on:

- Cactus moth reproduction
- The search for cactus moth
- Cactus moth online training
- Cactus Moth Detection and Monitoring Network
- Cactus moth genetics
- Other cactus moth research

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The Ovipositor of the Cactus Moth—A Unique Structure for Egg Deposition

By Richard L. Brown
Department of Entomology

The exotic cactus moth, *Cactoblastis cactorum,* and native cactus moths in *Melitara* are unique among the 14 genera of cactus-feeding species in the New World in producing egg sticks during oviposition. These egg sticks are oviposited on prickly pear hosts and provide some crypsis among the spines of the cladodes, although this unique adaptation may have some other function, e.g., thermoregulation. The morphological adaptations of the ovipositor for producing egg sticks and the sensory setae (sensilla) associated with the ovipositor have not been studied previously for the cactus moth, even though these structures are a critical component of the moth's reproductive success. Comparative studies of the fine structure of the sensilla are lacking for all Lepidoptera. Recent research has focused on comparing the ovipositors and their sensilla between *Cactoblastis* and *Melitara* using both light microscopy and scanning electron microscopy.

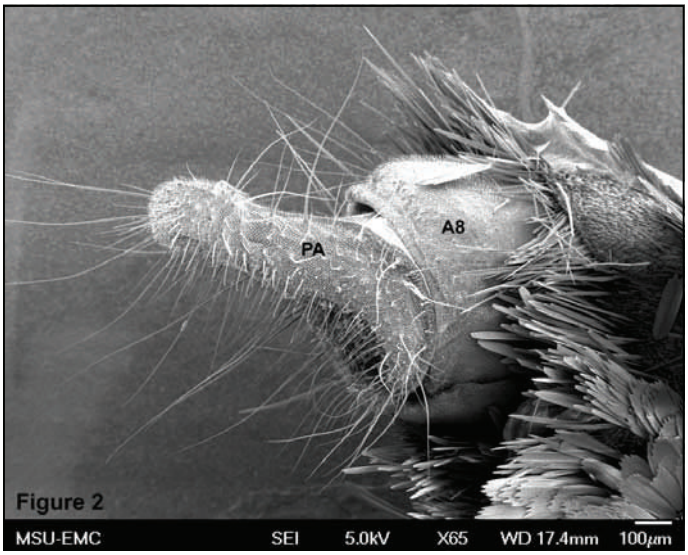
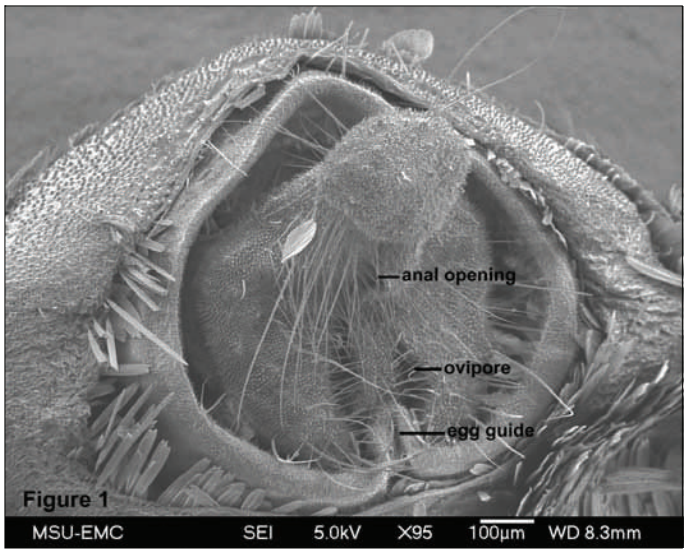


Fig. 2. Lateral view of ovipositor of *Melitara prodenialis* (PA = papillae anales; A8 – eighth abdominal segment).

Fig. 1. Ventral view of ovipositor of the cactus moth, *Cactoblastis cactorum*.



The ovipositor of the cactus moth (Figure 1) includes the eighth abdominal segment and the terminal papillae anales (or ovipositor pads) that bear sensilla. The papillae anales are narrowed posteriorly, enclosing the anal opening, and are widened and angled anteriorly. The ovipore is medially covered by a projection of the papillae anales, such that two openings appear

The Ovipositor of the Cactus Moth (continued)

to be present. The function of this projection covering the ovipore is unknown, although it may be involved in aligning the eggs that are released by the female. A similar structure has not been seen in other Lepidoptera. The ventral margin of the eighth segment is invaginated to form a groove that is interpreted to serve as an egg guide for placing the eggs on top of each other. This modification of the eighth segment has not been seen in other Lepidoptera examined previous to this study.

The papillae anales are covered with very small, unsocketed microtrichia and a large number of sensilla chaetica that vary in length. The function of the microtrichia is unknown. Sensilla chaetica are know to function as both contact chemoreceptors and mechanoreceptors. High magnifications of an individual sensillum reveal a smooth wall, a pore at the tip for allowing entry of volatiles, and in sensilla that have been broken, a hollow interior. The antennae of cactus moths also have sensilla chaetica, as well as three other types of sensilla.

However, only sensilla chaetica are present on the ovipositor and in greater numbers that are present on the antenna.

Examinations of the ovipositor of *Melitara prodenialis* (Figure 2) reveal that it is similar in shape with sensilla chaetica covering the papillae anales and an egg guide on the ventral margin of the eighth segment. No differences were found in the number, size, or distribution of the sensilla between *Cactoblastis* and *Melitara*.

Volunteers are helping with 76 sentinel sites, monitoring them for the presence of the cactus moth at certain intervals.

Cactus Moth Detection and Monitoring Network Webpage Update

By Clifton Abbott
Geosystems Research Institute

Volunteers continue to help with the Cactus Moth Detection and Monitoring Network. Volunteers continue to help in the effort to map cactus locations and monitor for the presence of the cactus moth in their area. The database exceeded the 10,000 entries mark last quarter and currently has 10,539 cactus locations. Volunteers are helping with 76 sentinel sites, monitoring them for the presence of the cactus moth at certain intervals. The cactus moth system has 90 registered users helping in this effort.

The cactus moth effort is spanning 37 states from the US and Mexico. Despite the massive effort, the cactus moth is continuing to proceed westward. Currently, the leading edge of the moth is southeast Louisiana. The purpose of all of the cactus moth focus is to prevent the moth from getting into Texas and, eventually, Mexico; where there is an ample supply of cactus.

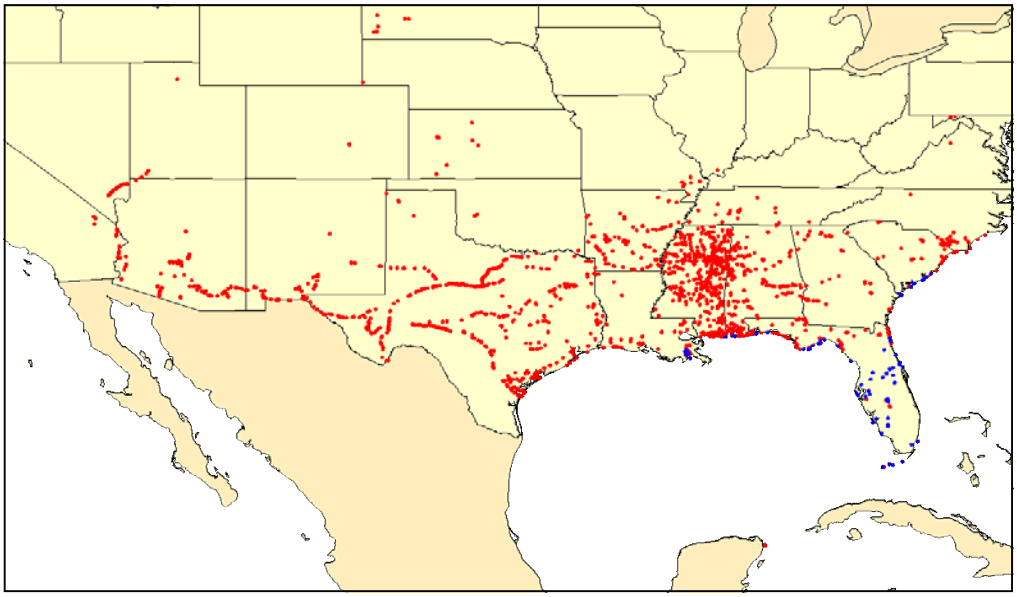


Fig. 1. Cactus Locations Mapped Across the Nation (red) with Cactus Moth Location (blue).

Pricklypear Cactus Surveys in Coastal Mississippi

Figure 1. Damage from native *Melitara* on *Opuntia humifusa* (Raf.) Raf. found on Horn Island in Mississippi (Image by Victor Maddox, MSU-GRI).

By Victor Maddox
Geosystems Research Institute

In March, a host survey was conducted in Hancock and Pearl River Counties along the coastline. New host populations were found during the survey, but no cactus moth was detected and all host populations were small in residential areas. Areas not surveyed previously were surveyed. This area was heavily damaged during Hurricane Katrina, but most roads were accessible during the survey. Both *Opuntia stricta* (Haw.) Haw. And *Opuntia engelmannii* Salm-Dyck ex Engelm. were identified during the survey. During the survey there was a sizable area in southern Pearl River County east of the Pearl River identified as not accessible by vehicle. Much of this area appears to be swamp associated with the river, but may need closer inspection for higher, dryer sites within this part of the county.

Figure 2. Close-up of native *Melitara prodenialis* Walker in *Opuntia humifusa* (Raf.) Raf. found on Horn Island in Mississippi (Image by Victor Maddox, MSU-GRI).

A survey trip to Horn Island was conducted on March 11. The area from around the dock to around the tower and east was visually inspected for cactus moth. Several damaged *Opuntia humifusa* (Raf.) Raf. and *O. pusilla* (Haw.) Haw. were found (Figure 1) both east and west of the tower, but native *Melitara prodenialis* Walker was indentified from each plant (Figure 2).

New host populations were found during the survey, but no cactus moth was detected and al host populations were small in residential areas.

Integrating Environmental Modeling and Population Genetics to Better Understand the Success of *Cactoblastis cactorum* Invasion

Preliminary analyses suggest differential performance of the native vs. invasive moths on the native Florida cacti with field studies demonstrating related patterns of differential herbivory.

By Gary Ervin
Geosystems Research Institute

Our current work encompasses three major areas of research – environmental modeling based on data from the *Cactoblastis cactorum* native range, genetic studies of *Opuntia* and cactophagous moths, and experimental studies of growth performance of *C. cactorum* and native US cactus moths on native southeastern US *Opuntia* species.

The current series of growth chamber experiments is nearing completion, and results of those studies will be presented at two conferences in 2010. One of these will be a student presentation at the MSU Biological Sciences Undergraduate Research Symposium. Anastasia Woodard, a Biology undergrad student, will present a summary of her involvement in that research. In August, Travis Marsico, a former postdoc on this research, will be presenting this work at the Ecological Society of America conference in Pittsburgh, PA. Preliminary analyses suggest differential performance of the native vs. invasive moths on the native Florida cacti (*O. humifusa* and *O. stricta*; Figs. 1,2), with field studies demonstrating related patterns of differential herbivory.

Figure 1. Mucilage exudation around feeding site on *O. humifusa* (left) and necrotic cladode on *O. humifusa* with feeding from young larvae (right).

We have developed results of those studies into a grant proposal that is currently under review at the National Science Foundation. That grant would provide funding to develop transcriptome databases for *C. cactorum*, *Melitara prodenialis*, *O. humifusa*, and *O. stricta*. Those databases of expressed gene sequences would permit us to conduct detailed studies of genes that are induced or suppressed in both the moths and the plants during the feeding interactions. Our hope is that those results would provide important information about differences in the way the invasive moth interacts with native cacti, in comparison with interactions between native moths and plants.

We are revising a manuscript that was developed on our genetic analyses of *C. cactorum* in its native range in Argentina, its invasive range in Florida, and for *M. prodenialis* across its native Floridian range. Those results also have formed the basis for a collaboration with USDA-ARS scientists from the US and Argentina, and we are preparing a grant proposal for submission later this year to continue those studies. This grant proposal will combine findings from our genetic analyses and environmental modeling results, with the objective of investigating environmental vs. reproductive influence on population genetic patterns we have identified in *Cactoblastis* in Argentina. The modeling work has brought to light some interesting hypotheses about the importance of the moth's history between the time it left Argentina and its arrival in North America. We anticipate more details being available in the June or September quarterly report.

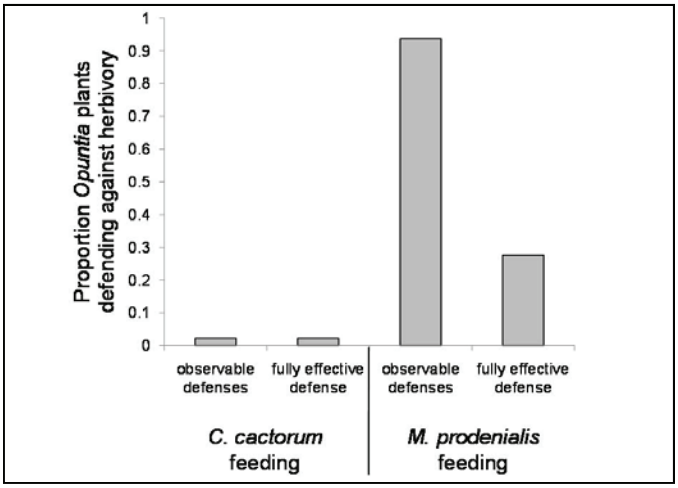


Figure 2. Experimental plants rarely defended against *C. cactorum* (left), but they frequently mounted a defense against *M. prodenialis*, often with complete success, measured by the death of all larvae ("fully effective defenses"). "Observable defenses" included exuded mucilage that often trapped young larvae and cladode necrosis that caused larval death or larvae to relocate to new areas on the plants.

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Publications January—March 2010

Conference Presentations

Marsico, T. D., **G. N. Ervin**, C. P. Brooks, B. A. Counterman, L. E. Wallace, M. E. Welch. 2010. Using next-generation sequencing approaches to investigate reciprocal recognition and response in plant-herbivore interactions. Mid-South Computational Biology and Bioinformatics Society, 7th annual conference, Arkansas State University, Jonesboro, AR, February 19-20, 2010.

Working Group Presentations

Madsen, J. D. 2010. Invasive species programs at the Geosystems Research Institute. Mississippi State University: Geosystems Research Institute Seminar Series.

Madsen, J. D. 2010. Developing GIS-based invasive species programs: From red-necks to remote sensing, terabyte servers, and parallel computing. National Biological Information Infrastructure, Biogeospatial Working Group Seminar, U.S. Geological Survey, Reston, VA.

Collaborations

Grant proposal submitted, Collaborative Research: Molecular mechanisms of reciprocal recognition and response in plant-herbivore interactions - defense and counterdefense in cactus-cactus moth systems. Submitted to the *NSF Symbiosis, Defense, and Self-recognition Program* by **G. N. Ervin**., L. E. Wallace, C. P. Brooks, B. A. Counterman, and M. E. Welch. This is a collaboration with T. D. Marsico at Arkansas State University, who previously was a postdoctoral associate on this project.

John Madsen and **David Shaw** attended the first National Invasive Species Awareness Week. John worked on the organizational committee for the meeting, and GRI provided the logo for the event held in Washington, DC from January 11-14, 2010.

Richard Brown, **Cliff Abbott**, and **John Madsen** discussed future collaboration with Thomas Naberhaus of the Big Sky Institute, working on biodiversity bioinformatics for BAMONA.

Drs. **Jim Carpenter** and **Stephen Hight**, of USDA-ARS, visited Mississippi State University on March 11-12, 2010 for collaborations related to an NSF grant proposal for continued studies in Argentina. The objective of that work, which is being coordinated by Dr. **Chris Brooks** of the MSU Biology Department, will be to investigate environmental vs. reproductive influence on genetic patterns we have identified in *Cactoblastis* in Argentina. This work also will involve the scientists at the USDA-ARS facility in Buenos Aires, Argentina.