NOSEMA (MICROSPORIDA: NOSEMATIDAE) SPECIES AS POTENTIAL BIOLOGICAL CONTROL AGENTS OF *CACTOBLASTIS CACTORUM* (LEPIDOPTERA: PYRALIDAE): SURVEYS FOR THE MICROSPORIDIA IN ARGENTINA AND SOUTH AFRICA

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ABSTRACT

Cactoblastis cactorum Berg is an invasive moth in North America where it damages and threatens many native *Opuntia* cacti. *Nosema* species of *C. cactorum* may have potential as biological control agents of the moth. Surveys for *Nosema* species were made in South Africa, where two of these Microsporidia were described from the moth and in Argentina where these pathogens may have originated. No *Nosema* were found in the *C. cactorum* larvae from South Africa and low levels of infection (0-6%) were found in the South American larvae. The low abundance of *C. cactorum* and the time of collection (austral summer) may be the reasons for the absence of or rarity of *Nosema* in these surveys. Winter collections of the larvae are suggested to obtain more abundant *Nosema* for evaluation as potential biocontrols of *C. cactorum*.

Key Words: biological control, surveys, insect pathogens, *Opuntia*

RESUMEN

Cactoblastis cactorum Berg es una polilla invasora en Norte America, donde daña y amenaza muchas especies nativas de *Opuntia*. Especies de *Nosema* que atacan a *C. cactorum* podrían tener potencial como agentes de control biológico. Se realizaron búsquedas de *Nosema* en Sudafrica donde dos de estos microsporidiosfueron descriptos y en Argentina donde estos patógenos podrían haberse originado. No se hallaron *Nosema* en larvas de *C. cactorum* de Sudafrica y se hallaron niveles muy bajos de infección (0-6%) en las larvas de Sud America. La baja abundancia de *C. cactorum* y el momento de las colecciones (verano austral) podrían ser las razones de la ausencia o rareza de *Nosema* en las búsquedas. Se sugieren colecciones de larvas durante el invierno para obtener mayor abundancia de *Nosema* para su evaluación como un agente potencial de control biológico de *C. cactorum*.

Cactoblastis cactorum Berg, is a famous biological control agent of weedy prickly pear cacti (*Opuntia*) in many parts of the world (Moran & Zimmermann 1984). This Argentine moth was introduced to Nevis in the Caribbean in 1957 for the control of native weedy *Opuntia* (Simmons & Bennett 1966). In 1989, *C. cactorum* was found in Florida where it attacks native *Opuntia* (Pemberton 1995; Johnson & Stiling 1996). The moth has the potential to spread to the western United States and Mexico where it could harm numerous native and economic *Opuntia* (Strong & Pemberton 2000; Zimmermann et al. 2000).

The potential and risk of using biological control as a possible solution to the *C. cactorum* threat was raised by Bennett and Habeck (1992) and is discussed in detail by Pemberton and Cordo (2001, this volume). Recorded parasitoids of the moth (Mann 1969; Zimmermmann et al. 1979) may have potential to control it, but they probably lack the host specificity needed to avoid use of native cactus moths and other Lepidoptera. Some insect pathogens such as *Nosema* species may be potent biological control agents of insects and also have enough host specificity to prevent non-target effects to native insects (R. Soper, pers. comm.). In many areas of the United States, *Nosema pyrausta* (Paillot) is the most important control agent of the European corn borer, *Ostrina nubialis* (Hübner) (Kogan et al. 1999). At times, *N. pyrausta* infects and kills 100% of the corn borers.

Two *Nosema* species have been recorded to attack *Cactoblastis*, both in South Africa (Fantham 1939). *Nosema cactoblastis* Fantham was described from *C. cactorum* which was originally imported for biological control from Australia. The second species, *N. cactorum* Fantham, was described from another *Cactoblastis* species, of uncertain identity, that was imported directly from Argentina. In South Africa, *N. cactoblastis* caused high mortality of *C. cactorum* larvae and pupae, and seriously hindered the ability of the moth to control weedy *Opuntia* (Petty 1948). Given this impact and the possibility that these *Nosema*

might have narrow host ranges, we decided to try to acquire them so their potential as biological control agents of the *C. cactorum* in the United States could be examined. They were sought in both South Africa and in Argentina where they may have originated.

Materials and Methods

In South Africa, searches were made of *Opuntia ficus-indica* (L.) Miller plants growing at 15 sites in the eastern Cape during March 1996 by the senior author and P. Hulley of Grahamstown University. Most of the searches were on wild plants growing in the Uitenhage area, where high levels of *N. cactoblastis* infection of *C. cactorum* had been reported (Petty 1948). Additional searches were made at Fort Hare in two plantations of *O. ficus-indica* cultivated for fruit, and two wild populations. Plants varied greatly in size (from approximately 1-4 meters tall) and density (from scattered individual plants to dense thickets of intertwined plants, to rows of spaced plants in the plantations). At each site pads with characteristic damage (exit holes, frass, hollowed out, and/or with decay) and egg sticks were looked for, then cut open for verification of living larvae. A total of 429 living larvae, from 41 pads collected at nine sites, and six frass samples were shipped to Argentina for *Nosema* detection. Argentine importation permits enable the larvae to be shipped to the Instituto Nacional de Tecnología Agropecuaria quarantine facility in Buenos Aires. After confirmation of the identification, the larvae were transferred in secured containers to Carlos Lange, contracting pathologist at University of La Plata, for *Nosema* detection. Each living larva was squashed to create a smear on a glass slide. These smears were then examined with phase-contrast microscope to search for the characteristic spores of *Nosema*.

In Argentina, surveys were made in the northern half of the country, which is the largest part of the native range of *C. cactorum*. In March 1995, we surveyed *Opuntia* species in the Argentine provinces of Entre Rios, Corrientes, Chaco, Formosa, and Santa Fe, and also along the eastern side of the Uruguay River in Uruguay. Additional surveys were made by the second author in Chaco and Formosa in Argentina and Paraguay during November-December 1995, and also in Buenos Aires, Cordoba, Santiago del Estero, Tucuman and Salta during December 1996. A total of 54 sites were surveyed in Argentina, three in Uruguay and one in Paraguay. A total of 867 plants were examined, 575 belonging to five identified *Opuntia* species and another 66 from *Opuntia* species that were not identified (Table 1). *Cactoblastis cactorum* was found in wild-growing *O. aurantiaca* Lindley, *O. paraguayensis* Schumann and *O. ficus-indica* at 14 sites. No larvae were found in either *O. monacantha* Haworth, *O. quimilo* Schumann or from unidentified *Opuntia*. A total of 528 larvae were collected for *Nosema* detection. *Opuntia* pads containing *C. cactorum* larvae were either transferred to La Plata for *Nosema* detection or reared in the laboratory to late instars to enhance detection and then transferred to La Plata for *Nosema* detection.

Results and Discussion

Nosema was not detected in the 342 South African larvae or the six frass samples examined. Low levels of *Nosema* were detected in only 4 of the 528 larvae collected in Argentina. *Nosema* spores were found in 2 of the 34 (5.88%) larvae collected from *O. paraguayensis* at Tres Isletas in Chaco Province in March 1995. The other *Nosema* infections were in larvae from *O. ficus-indica* in Cordoba Province sites collected in December 1996. At Cruz del Eje, 1 of 68 (1.28%) were infected and at Dean Funes, 1 of 26 (3.85%) were infected. The low levels of *Nosema* infection found is consistent with the apparent health of collected larvae from both South Africa and Argentina. To-

Table 1. *Cactoblastis cactorum* collection in Argentina and detected *Nosema*.

			C. cactorum larvae			
Opuntia species	No. sites with the species[1]	No. plants/ species	Total	Mean no. plant/species	Mean no. species/site	No. with *Nosema*
O. aurantiaca	15	124	135	1.08	9	0
O. ficus-indica	7	126	154	1.22	22	2
O. monacantha	2	11	0	0	0	0
O. paraguayensis	36	482	239	0.49	6.64	2
O. quimilo	7	58	0	0	0	0
O. spp.	11	66	0	0	0	0
Total	58	867	528			4

[1]Twenty sites had more than one *Opuntia* species.

tal mortality was less than 5% (25 of 600) in the Argentine larvae and less than 25% (87 of 429) in the South African larvae. This mortality probably resulted from handling and shipping conditions. Due to the low number of larvae infected, no effort was made to culture the spores to characterize the *Nosema* species involved.

The low incidence of *Nosema* in South America material may relate to the low numbers of *C. cactorum* encountered. Forty-four of the 58 Argentine sites examined (75.9%) had no detectable populations of the moth. The mean number of *C. cactorum* at these 58 sites was 9.1 larvae. At the 14 sites, where the moth was present, the mean number of larvae was 37.7 per site. Although only three of five (or more) *Opuntia* spp. plants examined had *C. cactorum* larvae, all are known to be host of the moth (Dodd 1940). *Opuntia ficus-indica* and *O. aurantiaca* had an average of one larva per plant (1.09 and 1.22 respectively) (Table 1). The most common prickly pear encountered, *O. paraguayensis*, had less than one (0.49) larva per plant. *Opuntia ficus-indica* had more larvae per site, a mean of 22 compared to about 7 for *O. paraguayensis* and 9 for *O. aurantiaca*. This may be due to a greater number of *O. ficus-indica* per site (18 compared to 13.4 and 8 for the others).

The absence of *Nosema* samples from South Africa may also relate to the relatively low levels of *C. cactorum* in the areas surveyed. The moth was more common than in South America occurring at 60% (9/15) of the sites compared to 24% (14/58) in South America. However, at five of the South Africa sites, only a single infested pad was found. The other 4 sites infested had 6, 6, 9 and 15 infested pads despite the large numbers of plants at some sites.

The absence of *Nosema* in South Africa and the low levels of the disease found in South America probably also relate to the season of collections - summer. In South Africa, *Nosema cactoblastis* infections of *C. cactorum* are known to be much less abundant in summer than in the winter (Petty 1948). For instance, at one South African site, *N. cactoblastis* was detected in 100% of the sampled larvae of the winter brood but in none of the larvae of the following summer brood. The infection rates of *Nosema* species we detected in Argentina (0.0, 1.28, 3.85, and 5.88%) are comparable to the infection rates (an average of 2%) at six coastal sites in South Africa during the summer (Petty 1948). These same sites had an average infection rate of 55.6% during the winter.

The absence of a formal biological control program for *C. cactorum* ended the research. Our efforts were opportunistic and done in conjunction with other research. We recognize that our collection times were not optimal for the detection of *Nosema*. The recent spread of the moth from Florida to Georgia and the increased concern that it will continue to spread and damage valued native *Opuntia* in North America, suggests that acquisition and examination of *Nosema* species associated with the moth should be continued. The *Nosema* spores we found are frozen and may be able to be cultured and evaluated. Renewed efforts to obtain *Nosema* species from field populations of *C. cactorum* should be more successful if winter collections are made in South Africa and Argentina.

The South African experience with *N. cactoblastis* suggests that the disease (its occurrence in the more humid winter months and its greater impact in more humid coastal regions) would be more effective in humid areas such as Florida and in the Southeast, than in the drier areas of the West. The effectiveness of the *Nosema* in low populations of *C. cactorum* is expected to be less than in high populations of the moth.

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