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COMPARISON OF BEETLE DIVERSITY AND INCIDENCE OF PARASITISM IN DIABROTICINA (COLEOPTERA: CHRYSOMELIDAE) SPECIES COLLECTED ON CUCURBITS

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ABSTRACT
Diabroticina (Chrysomelidae: Galerucinae: Luperini) beetles were sampled under field conditions on two host plants of the family Cucurbitaceae, Cucurbita okeechobeensis ssp. martinezii L. Bailey (bitter, wild cucurbit) and C. moschata (Lam.) Poiret (non bitter, cultivated cucurbit). Seventeen species of Diabroticina were collected. Acalymma blomorum Munroe & Smith was the most abundant species on both host plants. The only parasitoid found was Celatoria compressa Wulp (Diptera: Tachinidae). This parasitoid attacked more beetle species on the cultivated cucurbit (65%) than on the bitter cucurbit (20%). However, the percentages of parasitism observed in all species were low (0.4% to 12.5%). These data suggest that host plant species might have an effect on parasitism.

Key Words: Acalymma, Celatoria compressa, Cucurbita okeechobeensis ssp. martinezii, Cucurbita moschata, host plant association, Diabroticina beetles

RESUMEN
Diecisiete especies de Diabroticina (Chrysomelidae: Galerucinae: Luperini) fueron colectadas en dos plantas hospederas de la familia Cucurbitaceae, Cucurbita okeechobeensis ssp. martinezii L. Bailey (amarga, silvestre) y C. moschata (Lam.) Poiret (no amarga, cultivada). Acalymma blomorum Munroe & Smith fue la especie más abundante en ambas hospederas. Se obtuvo únicamente el parasitoide Celatoria compressa Wulp (Diptera: Tachinidae) sobre las poblaciones de Diabroticina. Este parasitoide atacó mayor número de especies de escarabajos en la calabaza cultivada (65%) que en la calabaza amarga (20%). Los porcentajes de parasitismo observados se consideraron bajos (0.4% a 12.5%). Los datos sugieren que las plantas hospederas pudieron haber tenido un efecto sobre el parasitoide.

Translation provided by authors.

Diabroticina (Chrysomelidae: Galerucinae: Luperini) are native to Mexico and Central America (Webster 1895). Few data, however, are published on host plant associations (Eben & Espinosa de los Monteros 2003) and natural enemies from this area (Eben & Barbercheck 1996).

In the Diabroticites (subtribe Diabroticina), the association of a number of species with plants in the family Cucurbitaceae is a well-known example for the effect of plant secondary chemistry on plant-insect interaction (Chambliss & Jones 1966; Howe et al. 1976; Metcalf et al. 1982; Metcalf 1986). Host preferences of Diabroticites are strongly influenced by the presence of cucurbitacins (tetracyclic triterpenoids) in many wild cucurbit hosts. These non-volatile secondary compounds act as arrestants and feeding stimulants for these beetles (Chambliss & Jones 1966; Metcalf & Lampman 1989).

Furthermore, it has been proposed that Diabroticina species sequester cucurbitacins for their chemical defense. Studies of tritrophic effects demonstrated that cucurbitacins are deterrents for natural enemies such as mantids (Ferguson & Metcalf 1985), passerine birds (Nishida & Fukami 1990), the pathogenic fungus Metarhizium anisopliae (Moniliales: Moniliaceae) (Tallamy et al. 1998), and entomopathogenic nematodes (Barbercheck et al. 1995). On the other hand, no negative effects on general predators such as carabid larvae, mites, and centipedes (Brust & Barbercheck 1992) have been found. To date, no clear pattern has emerged from these studies. Field studies on larval host associations in the natural habitat are difficult due to the fact that Diabroticina larvae are root feeders.

Interestingly, although parasitoids are intimately associated with their hosts, and third trophic level effects of plant secondary compounds are described for a number of plant-insect associations (Gauld et al. 1992; Rowell-Rahier et al. 1995; Agrawal et al. 2002), no data exist for the cucurbit/Diabroticina/parasitoid system.

The objective of the present field study was to compare beetle abundance and diversity on two Cucurbita spp. that differed in presence, Cucurbita okeechobeensis ssp. martinezii L. Bailey, or absence, C. moschata (Lam.) Poiret, of secondary
compounds. Both cucurbits, the bitter *Cucurbita o. martinezii* and the cultivated *C. moschata*, are the most common cucurbits in the study area. Their morphology is similar, but the bitter species has smaller and paler flowers, and smaller leaves. Furthermore, the bitter species produces secondary compounds characteristic for Cucurbitaceae, the cucurbitacins (Metcalf et al. 1982; R. Ventura, unpubl. data). Moreover, parasitoid incidence in adult beetles was monitored and compared between individuals collected from the two host plants.

**MATERIAL AND METHODS**

**Study Area and Host Plants**

All adult insects were collected in the central zone of the state of Veracruz, Mexico. Mean annual temperature fluctuates between 18 and 25°C, with three distinct seasons: a dry-cool season (November-March), a dry-warm season (April-May) and a wet-warm season (June-October). Mean annual rainfall varies between 800 and 2500 mm, with a peak in the second warm season (Soto & García 1989). Common crops in the area are sugarcane, coffee, corn, squash, and beans. The original vegetation at lower altitudes is deciduous forest, whereas remnants of tropical cloud forest are found at higher altitudes (Gómez-Pompa 1977).

Within the study area, six locations for each *Cucurbita* spp. were identified. These locations were separated by at least nine km (i.e., 12 sample areas in total). They differed in altitude and climatic conditions (Table 1). To avoid collections of beetles which might recently have moved between hosts, sites with coexistence of both cucurbits were not accepted. Due to the fact that beetle abundance is affected by the presence of flowers (pers. observ.), insects were collected once or twice per week on flowering plants only. When plants began to dry out, they were replaced by others in flowering stage within the same area. At each collection date we recorded the diversity and abundance of beetles found on both plants.

Areas of approximately 100 m² covered by cucurbit vines were measured at each location to define the collection site.

**Beetle Collection**

Beetles were collected from August to December 2001 and from May to November 2002. Collection dates were based on previous studies (Rodriguez & Magallanes 1994; Eben & Barbercheck 1996; Cabrera & Cabrera 2004) which found a clear seasonality for Diabroticinias with peak abundance from early summer to fall. Plants were visually inspected for Diabroticina adults. The sampling unit was the number of beetles collected per person in one hour. Field collected adults were separated by species, location, and collection date. In order to allow for parasitoid emergence, the colonies of adult field collected beetles were maintained in the laboratory (25 ± 3°C), with a photoperiod of 13:11 (L:D), in transparent plastic containers (15 cm diameter × 25 cm length), with a gauze cover for ventilation. Beetles were fed fruits of *Cucurbita pepo* L. (zucchini) and artificial diet (Branson et al. 1975). Abundance of Diabroticina were analyzed by one-way ANOVA (*P* < 0.05) with SigmaStat™ statistical software version 2.0 (Jandel Scientific 1992-1997), after square root transformation.

**Parasitism Rates**

All cages with beetles were checked daily to collect and count parasitoid pupae (Eben & Barbercheck 1996). In addition, dead beetles with an entire abdomen were dissected to determine presence or absence of immature parasitoids. Percentage parasitism was calculated as the number of immature and adult parasitoids obtained for the total number of each beetle species, date, and location. Data were analyzed by a chi-square test (Zar 1999). Correlation between beetle abundance and percentage parasitism was analyzed by linear regression (Zar 1999).

**RESULTS**

In the study area, *C. moschata* is cultivated for human consumption. For this reason it was commonly found along road sides and in mixed corn-squash plots, mostly in direct sunlight. *Cucurbita o. martinezii* is grown in shadier places, with oth-

**Table 1. Climatic zones of the six collections areas in the state of Veracruz.**

| Area               | Altitude (m) | Mean annual temperature (°C) | Mean annual precipitation (mm) | Geographical location |
|--------------------|--------------|-------------------------------|--------------------------------|-----------------------|
| Coatepec           | 1200         | 19.2                          | 1926.0                         | 19°27′N/96°58′W       |
| Jalecomulco        | 340          | 24.0                          | 1125.0                         | 19°20′N/96°46′W       |
| Naolinco           | 1540         | 16.0                          | 1639.7                         | 19°39′N/96°52′W       |
| Teocelo            | 1160         | 18.1                          | 1797.0                         | 19°39′N/96°58′W       |
| Tlalnelhuayocan    | 1640         | 18.0                          | 1009.0                         | 19°39′N/96°58′W       |
| Xalapa             | 1460         | 18.0                          | 1509.1                         | 19°32′N/96°55′W       |
ers plants as climbing structures. It was most abundant in and around coffee plantations.

We found 17 species of Diabroticinas from five genera (Table 2). All species were collected from *C. moschata*, 15 species were collected from *C. o. martinezii*. The abundance of three species, *A. blomorum*, *D. balteata*, and *I. tetraspilota*, differed between both cucurbit hosts (*P* = 3.5 × 10^-9, *P* = 0.0011, and *P* = 0.048, respectively). The other 12 beetle species were not more abundant in any of the two host plants. Proportions of all species were different in the two cucurbits. In *C. moschata*, *Acalymma blomorum* was the most abundant beetle species, followed by *Diabrotica balteata*, *D. scutellata*, and *D. viridula*, and in *C. o. martinezii*, *Isotes tetraspilota*, *A. fairmairei*, and *D. scutellata*.

The most diverse genus was *Diabrotica* with six species in the *fucata* group, *D. balteata*, *D. dissimilis*, *D. nummularis*, *D. sexmaculata*, *D. tibialis*, and *D. viridula*. *Diabrotica balteata* and *D. scutellata* were the most abundant species within either group.

Cerotoma atrofasciata, *Gynandrobrotica lepida* and *G. nigrofasciata* were most common on the foliage of *C. moschata* (Table 2).

### Incidence of Parasitism

The only parasitoid found was a tachinid species, *Celatoria compressa* Wulp. Parasitoids were obtained in June and July 2002 from beetles collected on the bitter cucurbit. No parasitoids were found in beetles collected on this plant in 2001. In beetles collected on the cultivated cucurbit, parasitoids were present throughout the collecting period in both years. In general, parasitoid pupae were obtained during the first 48 h after collecting the host beetle. Adult parasitoids emerged from all parasitoid pupae (*n* = 169). The presence of other parasitoids was not observed.

The tachinid parasitoid was found in three of the 15 beetle species collected on the bitter cucurbit (20%), and in 11 of the 17 beetle species collected on the cultivated cucurbit (65%). On the bitter cucurbit, the parasitoid attacked *A. blomorum*, *A. fairmairei*, and *D. balteata* at percentages of 0.9%, 7.7%, and 5%, respectively (Table 2). In the species collected on the cultivated cucurbit, *A. blomorum*, *A. fairmairei*, *A. innubum*, *C. atrofasciata*, *D. balteata*, *D. porracea*, *D. scutellata*, *D. sexmaculata*, *D. tibialis*, *D. viridula*, and *G. nigrofasciata* were parasitized. The percentage of parasitism was highest in *A. blomorum*.

### Table 2. Diabroticina Beetle Abundance Collected on *Cucurbita okeechobensis* ssp. *martinezii* (A) and *C. moschata*; (B) (Mean Beetles Collected Per Person Per Hour), and Percentage Parasitism in the Total Number Collected of Each Beetle Species in the Years 2001 and 2002.

| Species                          | 2001          | 2002          |          |
|----------------------------------|---------------|---------------|----------|
|                                  | Mean | %  | Mean | %  |            |         |          |
|                                  | A    | B  | A    | B  | A    | B  |          |
| *Acalymma blomorum* Munroe & Smith* | 3.83 | 50.1 | 0 | 3.7 | 8.17 | 57.71 | 0.9 | 0.6 |
| *A. fairmairei* (Fabricius)      | 3.61 | 4.29 | 0 | 0.4 | 2.31 | 1.99 | 7.7 | 0.7 |
| *A. innubum* (Fabricius)         | 0.33 | 5.19 | 0 | 0.8 | 0.15 | 5.78 | 0   | 0   |
| *A. trivittatum* Mannerheim      | 0.5  | 2.33 | 0 | 0   | 0.04 | 3.22 | 0   | 0   |
| **Diabrotica group fucata**      |      |     |      |     |      |     |        |
| *D. balteata* LeConte*           | 1.11 | 0.61 | 0 | 0   | 0.44 | 35.1 | 5 | 3.7 |
| *D. dissimilis* Jacoby           | 0    | 0.04 | 0 | 0   | 0    | 0.02 | 0 | 0 |
| *D. nummularis* Harold           | 0.11 | 0.74 | 0 | 0   | 0.02 | 0.09 | 0 | 0 |
| *D. sexmaculata* Baly            | 0    | 0.22 | 0 | 0   | 0.19 | 0.31 | 0 | 5.9 |
| *D. tibialis* Baly               | 0.11 | 0.72 | 0 | 0   | 0.58 | 14.11 | 0 | 4.6 |
| **Diabrotica group virgifera**   |      |     |      |     |      |     |        |
| *D. porracea* Harold             | 0.5  | 0.24 | 0 | 0   | 0.23 | 1.81 | 0 | 2.5 |
| *D. scutellata* Baly             | 1.65 | 5.54 | 0 | 1.4 | 3.15 | 1.78 | 0 | 0.8 |
| *D. undecimpunctata duodecimnotata* Harold | 0.39 | 0.06 | 0 | 0   | 0.08 | 0.01 | 0 | 0   |
| *D. viridula* (Fabricius)        | 0.11 | 0.37 | 0 | 0   | 0.15 | 5.4  | 0 | 0.2 |
| **Cerotoma atrofasciata** Jacoby |      |     |      |     |      |     |        |
| *Gynandrobrotica lepida* (Say)   | 0    | 0.83 | 0 | 0   | 0.02 | 0.31 | 0 | 0   |
| *G. nigrofasciata* (Say)         | 0    | 1.53 | 0 | 2.5 | 0    | 0.02 | 0 | 0 |
| *Isotes tetraspilota* Baly*      | 0.44 | 0.03 | 0 | 0   | 8.56 | 0.01 | 0 | 0 |

*Significant differences between abundance per cucurbit (*P* < 0.05), and 0: No beetles nor parasitoids were found.
parasitism in these species varied between 0.4% and 12.5% (Table 2). Highest percentages of parasitism were found in \textit{C. atrofasciata}. No significant differences in parasitism between beetle species were detected. Also, no correlation between beetle abundance and percentage parasitism was found. We found, however, significantly higher numbers of parasitoids in beetles collected on the cultivated cucurbit \((X^2_{1,0.05} = 6.46)\). During the present study, parasitism was not observed in \textit{A. trivittatum}, \textit{D. dissimilis}, \textit{D. nummularis}, \textit{G. lepida}, and \textit{I. tetraspilota}.

**DISCUSSION**

The diversity of Diabroticina species on \textit{C. o. martinezii} and \textit{C. moschata} was similar. Nevertheless, \textit{Diabrotica scutellata} and \textit{Isotes tetraspilota} were more abundant on bitter \textit{C. o. martinezii}, whereas \textit{Acalymma blomorum} and \textit{D. balteata} were more abundant on the cultivated \textit{C. moschata}. \textit{Acalymma blomorum} was the most abundant species in both \textit{Cucurbita} spp. These results are similar to data obtained by Cabrera & Cabrera (2004) with respect to the abundance of \textit{Acalymma} spp. in \textit{Cucurbitaceae} in Argentina. Within the \textit{fuscata} group, \textit{D. balteata} was the most abundant species, and within the \textit{virgifera} group \textit{D. scutellata} was dominant. These results agreed with data reported by Rodriguez & Magallanes (1994) for \textit{D. balteata} in Tamaulipas and Veracruz, and by Eben & Barbercheck (1996) for \textit{D. scutellata} in Veracruz. In the present study, \textit{Diabrotica dissimilis} and \textit{G. nigrifasciata} were not collected on the bitter cucurbit. The other 12 species had a continuously low abundance on both cucurbits.

\textit{Acalymma blomorum} and \textit{D. balteata} were collected most frequently in \textit{C. moschata}, perhaps as a result of the high quantities of pollen in this cucurbit. We observed that the beetles visited these plants to feed on petals and flowers. \textit{Isotes tetraspilota} was the only species that was found feeding on the leaves of \textit{C. o. martinezii}, and it was never seen on the cultivated cucurbit \textit{C. moschata}. \textit{Acalymma blomorum}, \textit{A. fairmairei}, \textit{C. atrofasciata}, and \textit{D. balteata} were found on the cultivated cucurbit even when the plants began to dry. \textit{Gynandrobotica nigrifasciata} was collected only in 2001 on the cultivated cucurbit and furthermore, in much higher numbers, on a leguminous plant (\textit{Pachyrhizus erosus} (L.) \textit{Urban}) growing in the vicinity. Fabaceae are reported as host family for \textit{C. diabroticae} chinid in the guild of beetle species collected in both cucurbits was low, with parasitism ranging from 0.4% to 12.5%. In an earlier study similar parasitism rates of 1.0% to 11.1% were found (Eben & Barbercheck 1996). Parasitism by \textit{C. bosqi} in \textit{D. speciosa} ranged from 0.1 to 30.2% (Heineck-Leonel & Salles 1997) and \textit{C. diabroticae} parasitized \textit{D. u. howardi} with rates of 3 to 15% (Meinke & Gould 1987; Elsey 1988).

Given our observations, it would be interesting to investigate if cucurbitaceins sequestered by the beetles collected on \textit{C. o. martinezii} function as a repellent for \textit{C. compressa}. Our data suggest that a possible effect of plant secondary compounds is stronger on adult parasitoid behavior (i.e., host acceptance) than on immature physiology, since all parasitoid larvae that eclosed from beetles pupated and developed successfully into adults.

During the course of our study a larger number of isolated plants of the cultivated than the bitter cucurbit species was found. This situation was contrary to our observations in previous years. It might be the consequence of the rapidly declining number of coffee plantations in the central area of Veracruz. In this area, the main habitat of \textit{C. o. martinezii} are coffee plantations, where it is found growing in a vertical fashion upon the coffee bushes as climbing structures. By contrast, \textit{C. moschata} grows horizontally, covering bare areas exposed to plain sunlight. These differences in habitat and microclimate might have influenced the abundance and species composition of Diabroticina beetles present in both plants as well as the searching behavior of \textit{C. compressa}.

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**REFERENCES CITED**

AGRAWAL, A., A. JANSSSEN, J. BRAUN, M. A. POSTHUMUS, AND M. W. SABELIS. 2002. An ecological cost of plant
defense: attractiveness of bitter cucumber plants to natural enemies of herbivores. Ecology Letters 5: 337-385.

BARBERCHECK, M. E., J. WANG, AND I. S. HIRSH. 1995. Host plant effects on entomopathogenic nematodes. J. Invertebr. Pathol. 66: 141-145.

BRANSON, T. F., P. L. GUSS, J. L. KRYSAN, AND G. R. SUTTER. 1975. Corn rootworms: laboratory rearing and manipulation. Agric. Res. Serv. Bull. NC-28.

BRUST, G. E., AND M. E. BARBERCHECK. 1992. Effect of dietary cucurbitacins C on southern corn rootworm (Coleoptera: Chrysomelidae) egg survival. Environ. Entomol. 21: 1466-1471.

CABRERA-WALSH, G., AND N. CABRERA. 2004. Distribution and hosts of the pestiferous and other common Diabroticites from Argentina and Southern South America: a geographic and systematic view, pp. 333-350 In P. H. Jolivet, J. A. Santiago-Blay, and M. Schmitt [eds.], New Developments in the Biology of Chrysomelidae. SPB Academic Publishers, The Hague, Netherlands.

CHAMBLISS, O. L., AND C. M. JONES. 1966. Cucurbitacins: specific insect attractants in Cucurbitaceae. Science 153: 1392-1393.

CHITTENDEN, F. H. 1905. Notes on the cucumber beetles. U.S. Dept. Agric. Bur. Entomol. Bull. 82: 67-75.

EBEN, A., AND M. E. BARBERCHECK. 1996. Field observations on host plant associations and natural enemies of Diabroticite beetles (Chrysomelidae: Luperini) in Veracruz, Mexico. Act. Zool. Mexicana (n.s.) 67: 47-65.

EBEN, A., AND A. ESPINOSA DE LOS MONTEROS. 2003. Evolution of host plant breadth in Diabroticites (Coleoptera: Chrysomelidae), pp. 175-182 In D. G. Furth [ed.], Special Topics in Leaf Beetles Biology. Proc. 5th Int. Sym. on the Chrysomelidae. Pensoft Publishers, Sofia, Moscow. 300 pp.

ELSHEY, K. 1988. Cucumber beetle seasonality in coastal South Carolina. Environ. Entomol. 17: 495-502.

FERGUSON, J. E., AND R. L. METCALF. 1985. Cucurbitacins: plant-derived defense compounds for diabroticites (Coleoptera: Chrysomelidae). J. Chem. Ecol. 11(3): 311-318.

GAULD I., K. J. GASTON, AND D. H. JANZEN. 1992. Plant allelochemicals, tritrophic interactions and the anomalous diversity of tropical parasitoids: the "nasty" host hypothesis. Oikos. 65: 353-357.

GÓMEZ-POMPA, A. 1977. Ecología de la Vegetación del Estado de Veracruz. Compañía Editorial Continental, S. A. Mexico. 91 pp.

GORDON, R., J. ELLINGTON, G. F. FAUBION, AND H. GRAHAM. 1987. A survey of the insect parasitoids from alfalfa and associated weeds in New Mexico. Southwest. Entomol. 12: 335-351.

HEINECK-LEONEL, M. A., AND L. A. B. SALLES. 1997. Incidence of parasitoids and pathogens in adults of Diabrotica speciosa (Germar) (Coleoptera: Chrysomelidae) in Pelotas, R. S. Anais Soc. Entomol. Brasil 26: 81-85.

HOWE, W. L., J. R. SANBORN, AND A. M. RHODES. 1976. Western corn rootworm adult and spotted cucumber beetle associations with Cucurbita and cucurbitacins. Environ. Entomol. 5: 1043-1048.

JOLIVET, P., AND T. J. HAWKESWOOD. 1995. Host-plants of Chrysomelidae of the World. Backhuys Publishers, Leiden. 281 pp.

MEINKEN, L. J., AND F. GOULD. 1987. Thermoregulation by Diabrotica undecimpunctata howardi and potential effects on overwintering biology. Entomol. exp. Appl. 45: 115-122.

METCALF, R. L. 1986. Coevolutionary adaptations of rootworm beetles to cucurbitacins. J. Chem. Ecol. 12: 1109-1124.

METCALF, R. L., AND R. L. LAMPMAN. 1989. The chemical ecology of Diabroticites and Cucurbitaceae. Experientia 45: 240-247.

METCALF, R. L., A. M. RHODES, R. A. METCALF, J. FERGUSON, E. R. METCALF, AND P. Y. LU. 1982. Cucurbitacin content and Diabroticite (Coleoptera: Chrysomelidae) feeding upon Cucurbita spp. Environ. Entomol. 11: 931-937.

NISHIDA, R., AND H. FUKAMI. 1990. Sequestration of distasteful compounds by some pharmacophagous insects. J. Chem. Ecol. 16(1): 151-164.

RÓDRIQUEZ-DEL-BOSQUE, L. A., AND A. MAGALLANES-ESTALA. 1994. Seasonal abundance of Diabrotica balteata and other Diabroticite beetles (Coleoptera: Chrysomelidae) in northeastern Mexico. Environ. Entomol. 23: 1409-1415.

ROWELL-RAHIER, M., J. M. PASTEEELS, A. ALONSO-MEJIA, AND L. P. BROWE. 1995. Relative unpalatability of leaf beetles with either biosynthesized or seques tered classical defense. Anim. Behav. 49: 709-714.

SELL, R. A. 1915. Some notes on the western twelve-spotted and the western striped cucumber beetle. J. Econ. Entomol. 8: 515-520.

SOTO, E. M., AND E. GARCÍA. 1989. Atlas Climático del Estado de Veracruz. Instituto de Ecología, Xalapa, Ver, México. 125 pp.

TALLAMY, D. W., D. P. WHITTINGTON, F. DEFURIO, D. A. FONTAINE, P. M. GORSKI, AND P. W. GOTHRO. 1998. Sequestered cucurbitacins and pathogenicity of Metarhizium anisopliae (Monilales: Moniliaceae) on spotted cucumber beetle eggs and larvae (Coleoptera: Chrysomelidae). Environ. Entomol. 27(2): 366-372.

VENTURA PÉREZ, R. I. 2002. Aislamiento e identificación por RMN de cucurbitacinas a partir de Cucurbita maxima (Cucurbitaceae) y determinación cualitativa en Chrysomelidae. Unpubl. Bachelor thesis, Universidad Veracruzana, Xalapa.

WALTON, W. R. 1914. A new tachinid parasite of Diabrotica balteata and other Diabroticite beetles (Coleoptera: Chrysomelidae). Environ. Entomol. 23: 1409-1415.