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Biological control agents of cotton pests in Barbados

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Abstract

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Cotton, *Gossypium barbadense* L (Malvaceae) is attacked by different insects, reducing productivity and fibre quality. This study aimed to determine the natural enemies attacking the key cotton pests in Barbados. Seventeen farms were monitored weekly during cotton seasons to determine presence of predators and parasitoids. The monitoring method used was zig-zag evaluating 25 plants in each location. The different stages of the predators presented at the field level were observed and evaluated. Attacked eggs of Lepidoptera and larvae having external parasitoids were collected and isolated to study the endo- and ectoparasitoid species. In addition to the natural enemie's evaluation, a study was carried out at the field level selecting 10 farmers in order to evaluate the main pest found that leaded to the application of chemical control. Seven predator species and two parasitoid species were found. The most frequent predator species were *Chrysoperla* sp. (40 %), followed by *Cycloneda sanguinea* (L). and *Allograpta exotica* Wiedemann (15 % and 14.5 %, respectively). Parasitoid species found were: *Trichogramma chilonis* (Ishii) parasitizing *Helicoverpa* and *Heliothis* eggs, and *Euplectrus* sp. as an ectoparasitoid on *Alabama argillacea* larvae.

Additional key words: Biocontrol, cotton, natural enemies, parasitoids, predators.

Resumen

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El algodón, *Gossypium barbadense* L. (Malvaceae) es atacado por diferentes especies de insectos que reducen su productividad y calidad de la fibra. El objetivo de este trabajo fue determinar los enemigos naturales que atacan las plagas claves del algodón en Barbados. Diecisiete fincas de algodón fueron monitoreadas semanalmente durante dos zafras para determinar la presencia de depredadores y parasitoides. El método de monitoreo utilizado fue zig-zag evaluando 25 plantas en cada localidad. Se observaron y evaluaron las diferentes etapas de desarrollo de los depredadores que se presentan a nivel de campo. Huevos atacados de lepidópteros y larvas con presencia de huevos en su exterior se colectaron y se aislaron para estudiar las especies de endoparasitoides y ectoparasitoides. Además de la evaluación de la presencia de los enemigos naturales, se llevó a cabo un estudio a nivel de campo, seleccionando 10 agricultores, con el fin de evaluar las razones por las cuales se realizó la aplicación de control químico. Fueron encontrados siete especies de depredadores y dos especies de parasitoides. Las especies más frecuentes de depredadores fueron *Chrysoperla* sp. (40 %), seguido de *Cycloneda sanguinea* (L). y *Allograpta exotica* Wiedemann (15 y 14,5 %, respectivamente). Las especies de parasitoides fueron: *Trichogramma chilonis* (Ishii) parasitando huevos de *Helicoverpa* sp. y *Heliothis* sp., y *Euplectrus* sp. como ectoparasitoide de larvas de *Alabama argillacea*.

Palabras clave adicionales: Algodón, biocontrol, enemigo natural, depredadores, parasitoides.

Introduction

Cotton (*Gossypium barbadense* L.) known as "Sea Island Cotton", is attacked by various phytophagous insects which reduce productivity and quality of the final product. Primary and secondary pests attacking cotton crop have been identified in Barbados, including the pink bollworm, *Pectinophora gossypiella* (Lepidoptera: Gelechiidae), *Helicoverpa zea* (Lepidotera: Noctuidae), *Heliothis virescens* (Lepidotera: Noctuidae), *Spodoptera* spp. (Lepidotera: Noctuidae), *Alabama argillacea* (Lepidoptera: Noctuidae), *Scirtothrips dorsalis* (Thysanoptera: Thripidae), *Thrips palmi* (Thysanoptera: Thripidae) and *Bemisia tabaci* (Hemiptera: Aleyrodidae) (Bell 2004). *Pectinophora gossypiella*, *H. zea* and *H. virescens* are responsible for high yield losses in cotton in Barbados with more than 50 % caused by *P. gossypiella* in some years (Thrakika 2007). This fact, along with other factors such as low prices and high costs, has provoked the cotton industry collapse in the Caribbean (Ingram 1980).

World-wide chemical control has been the most popular method used by farmers. Excessive insecticide use not only causes damage to the environment but also affects natural enemy populations, and it induces pest resistance, often increasing production costs due to the increased frequency of applications (Matthews and Tunstall 1994). Moreover, secondary pests such as whitefly (*Bemisia tabaci*) may create resistance to chemicals after successive pesticide applications (Nauen and Denholm 2005, Kranthi et al. 2002). The primary pests cause greater damages after the natural enemies have been eliminated by pesticides (Lopez et al. 2004).

Biocontrol and bioinsecticides have been considered as an alternative for pest control in integrated pest management programmes (Espinel et al. 2008). In fact, various studies have shown successful biocontrol programmes applied to different pests in the Caribbean (Cock 1985, Alam et al. 1990, Baker 1990, Bennet 1990, Cruz and Segarra 1992). Thus, biocontrol is considered a safer pest management strategy involving the use of natural enemies to maintain pest population levels under economic threshold (Beasley et al. 1996, Parra et al. 2002).

As presented by Bergvinson (2004), due to the negative impact caused by excessive use of pesticides more sustainable methods of control are being evaluated within the context of Integrated Pest Management (IPM), such as biological control. Several biocontrol strategies have been developed for various pests. The use of microorganisms and parasites, for example, may play an important role in relation to plant protection as a key element in IPM programs (Bergvinson 2004).

Biological control in Latin America and the Caribbean is in very favourable conditions due to the weather in most countries and its rich biodiversity, which facilitates the presence of natural enemies of pests (Alves et al. 2008).

In the field farmers prefer to use the calendar of agrochemical application due the lack of familiarization with natural enemies and their use. In this regard, a study from Colombia revealed that application of any strategy to control crop pest depended in about 90.5 % of the cases on the calendar, and on the other hand that farmers commonly use cultural practices but they are not able to identify and use natural enemies (Wyckhuys et al. 2011). Successful implementation of biological control programmes should be based on a better understanding of the biological processes and the use in general of natural enemies by farmers.

Agriculture in the Caribbean region is strongly dominated by smallholding farming facing with high pest diversity, pesticides problems, low yield and marketing problems (Cruz 1996). Thus, the need to look for more sustainable ways of production has led the Caribbean governments, through CARICOM, to create working groups to implement and assess national biocontrol programmes. This strategy has been effective to include this environmental sustainable control method in integrated pest management programmes in the region. Likewise, the creation of the Pesticides Control Board for the Caribbean plays a role in the legislation and assessment of the pesticides permitted in each Caribbean island (CARDI-CTA 1995).

Even when previous studies were conducted to evaluate the presence of natural enemies in the island, there was a not direct association to Cotton Pest control. The aim of this study was to investigate the complex of natural enemies attacking cotton pests in Barbados as an alternative method of control within the Integrated Pests Management Program.

Materials and Methods

Field assessment and identification of cotton pests and their natural enemies

Seventeen farms planted with "West Indian Sea Island Cotton" were monitored weekly during two cotton seasons (September 2009 - February 2010 and September 2010 - February 2011) to determine occurrence of natural enemies associated to cotton pests in Barbados. Field observations were carried out to collect natural enemies (predators and parasitoids). Also pest species associated and development stage attacked were recorded. Flowers, fruits, and leaves showing damage symptoms were collected and taken to the laboratory of Entomology of the Ministry of Agriculture and Rural Development of Barbados for analysis. The monitoring method used was zig-zag evaluating 25 plants in each location. . The different stages of the predators present at the field level were observed and evaluated. Attacked eggs of Lepidoptera and larvae having external parasitoids were collected and isolated to study the endo- and ectoparasitoid species. The collected material was also taken to the above laboratory .

Immature stages were separated and kept under laboratory conditions until adult emergence (25 ± 1 °C and 70 % ± 10 RH). Mommies collected from the parasitoids were placed individually in gelatin capsules. From the total emerged adults, a portion of them was collected in probe tubes with cotton soaked in water and honey solution (1:1) to be released later in the field. The remaining adults were used for identification purposes. Thus, adults were placed in small tubes (2 cm x 2 cm) with 70 % alcohol.

The frequency of each predator was registered. The collected specimens were sent to the British Museum of Natural History (London, England), USDA-AHIS Texas (United States of America) and to the Universidad Centroccidental "Lisandro Alvarado" (Venezuela) for identification.

Evaluation of major reasons for field application of chemical control

In order to evaluate the main reasons for chemical applications done in the field, 10 farmers were randomly selected. They were trained to walk the field in zig-zag in order to monitor 25 plants. The species they considered as attacking cotton plants were collected and kept in plastic containers in order to give them to the technicians for further species identification at the laboratory of Entomology of the Ministry of Agriculture and Rural Development, Barbados.

Results and Discussion

Seven predators and two parasitoid species were identified (Figure 1; Table 1). The more frequent species were *Chrysoperla* sp., followed by *Cycloneda sanguinea* (L). and *Allograpta exotica* Wiedemann. Conversely, *Orius insidiosus* Say and *Haplothrips gowdeyi* (Franklin) occurred less frequently in both cotton seasons (Table 1). Although *O. insidiosus* and *Franklinothrips vespiformis* frequency was low during season 1, they occurred concomitantly in association with the invasive pest, *Scirtothrip dorsalis*. Thus these predator species could constitute a potential biocontrol agent to this pest.

Previous studies reported the third instar larvae of *Chrysoperla* species preying on cotton mealybug (*Phenacoccus solenopsis*) (Rashid et al. 2012), *Helicoverpa zea* (Boddie), *Heliothis virescens* (Fabricius), *Trichoplusia ni* (Hübner), whiteflies and aphids on cotton crops worldwide (Carvalho et al. 2003). Based on laboratory and field studies, species of *Chrysoperla* have shown great potential for the biological control of pest (Khan et al. 2012, Rashid et al. 2012, Solangi et al. 2013, Sarwar 2014)

In relation to coccinellid species, *C. sanguinea* is commonly found preying on aphids in several crops such as cotton, soybean and corn, etc. Işıkber and Copland (2001) found that the consumption rate for total development in *C. sanguinea* varied from 975.1 to 1 066 aphids/day at 25 °C and 30 °C, respectively. Accordingly, if compared to *Scymnus levaillanti*, *C. sanguinea* has shown a significantly shorter handling time and lower search rate , requiring more aphids to reach satiation (Işıkber 2005).

Some species of *Allograpta* have also been recorded in association with several species of aphids, having an important role in natural biological control of this group on citrus, subtropical fruit trees, corn, cotton, grapes and, ornamentals (Ghahari et al. 2008). Although *Allograpta exotica* has been cited as important biological control agent of *Diuraphis noxia* Mordvilko (Botto et al. 1995), there is no available information about its potential for control of cotton pest.

Given the significant importance of *S. dorsalis* as pest in the Caribbean area (Collins et al. 2006) and Venezuela (Quirós et al. 2007, Cermelli et al. 2009), our observations on association between *F. vespiformis* and *S. dorsalis* could constitute a valuable finding for future programs of pest management.

As shown in Figure 2, the most common predator registered was *Chrysoperla* sp., followed by *Cycloneda sanguinea*. During previous years *Cryptolaemus montrouzieri* was introduced in the Caribbean in order to control the Pink Hibiscus Mealybug (Kairo et al. 2000). Since then it is commonly recovered from the field.

Chrysoperla sp., *Franklinothrips vespiformis* and *Cycloneda sanguinea* were found at all locations. *Franklinothrips vespiformis* was observed to be very specific to control chilli thrips.

Figure 3 shows the percentage of natural enemies present at each of the 17 locations evaluated. It was observed that population level of natural enemies depends directly from the number of chemical applications done as this can negatively affect the different species.

The parasitoid species reported were: *Trichogramma chilonis* (Ishii) (Hymenoptera: Trichogrammatidae) parasitizing egg of *Helicoverpa/Heliothis* spp., and *Euplectrus* sp. (Hymenoptera: Eulophidae) was found as an ectoparasitoid on *Alabama argillacea* larvae. Significance of *T. chilonis* against bollworms had been previously reported, with observed damage reduction in crops infested by *H. armigera,* between 31.73 % and 36.45 % on cotton varieties (Masood et al. 2011, Rasool et al. 2002). With regard to *Euplectrus*, several species have been reported on *A. argillacea* larvae, including *E. comstockii* and *E. puttleri*, the latter parasitizing 3.3 larvae in 2.25 days (Menezes et al. 1994).

As shown in figure 4, application of chemical control is based on presence of *Heliothis* sp., regardless of the incidence of natural enemies. This shows that despite of predator and parasitoid species occurring in cotton fields in Barbados, the lack of knowledge by the farmers of how to monitor and identify pest and natural enemies, is remarkable. Some farmers applied chemical control when they observed presence of the larval stages of some natural enemies, confusing them with cotton pests. Consequently,

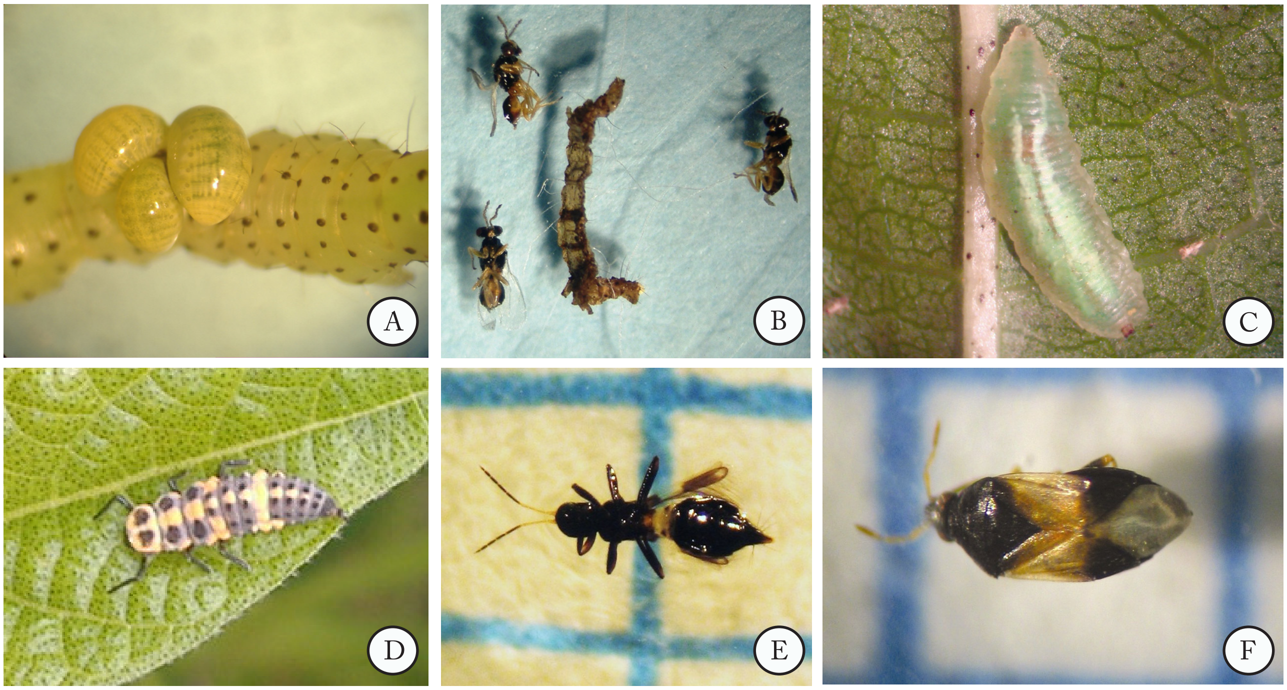

Figure 1. Some ectoparasitoids and predators associated to cotton pests in Barbados. From left to right: A. *Alabama argillacea* larva with *Euplectrus* sp. eggs; B. *Euplectrus* sp. and dead *A. argillacea* larva; C. *Allograpta exotica* larva; D. *Cycloneda sanguinea* larva; E. *Franklinothrips vespiformis* adult (2 x 2 mm grid); F. *Orius insidiosus* adult (2 x 2 mm grid). (Photo: Y. Colmenárez).

Table 1. Reported predators of different cotton pests in Barbados

Predator species	Frequency (%) S1	Frequency (%) S2	References
Allograpta exotica	15	14.5	Aphids (Arcaya et al. 2013, Gonçalves and Gonçalves 1976).
Chrysoperla sp.	51	40	Eggs and larvae of the first instars of Lepidoptera, aphids, mites and thrips (Principi and Canard 1984).
Cryptolaemus montrouzieri	7	10.1	Eggs and larvae of Lepidoptera, aphids, mealybugs and thrips (Maes et al. 2014, Amal et al. 2013, Finlay-Doney and Walter 2012, Rosas-García et al. 2009).
Cycloneda sanguinea	22	15	Eggs and larvae of the first instars of Lepidoptera, aphids, mites and trips.(Michaud 2001)
Franklinothrips vespiformis	3	9.8	Thrips (especially different stages of *Scirtothrip dorsalis*) (Hagen et al. 1999)
Haplothrips gowdeyi	1	2.8	Thrips, also reported as phytophagous (Tillekaratne et al 2011, Oparaocha et al. 2003)
Orius insidiosus	1	7.4	Eggs and larvae of the first instars of Lepidoptera, mites and trips. (Mendes et al. 2002, Osekre et al. 2008)

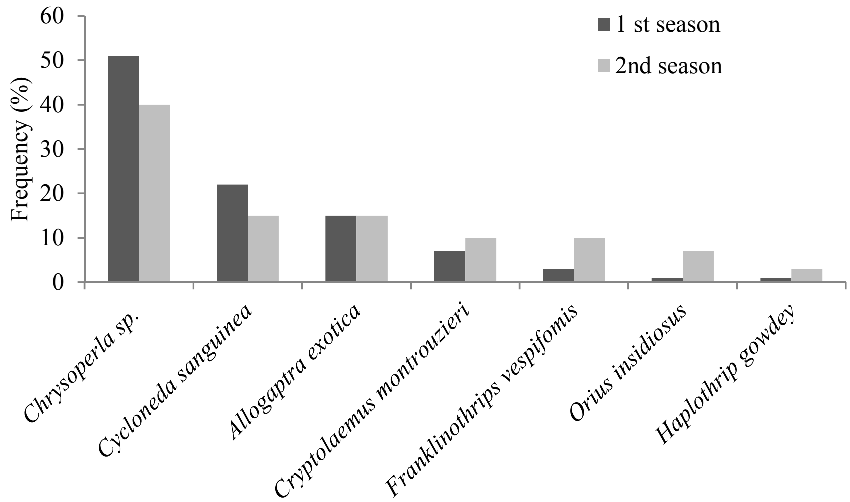

Figure 2. Percentage of frequency registered for the different predators species collected.

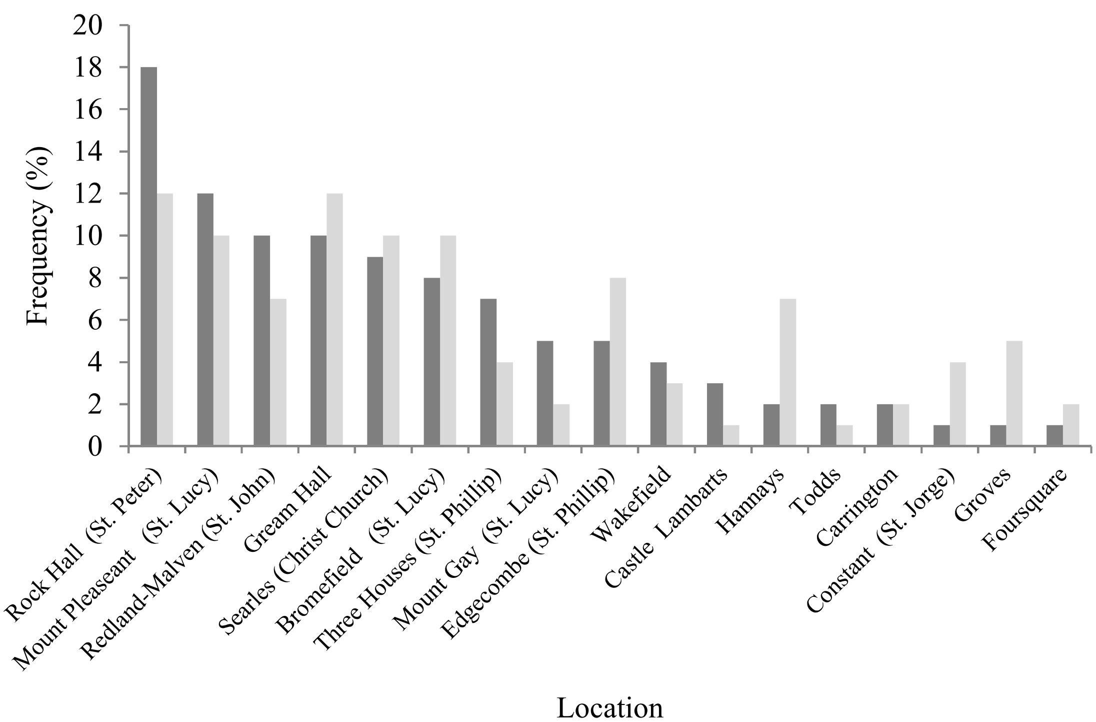

Figure 3. Percentage of Natural Enemies presented in the evaluated areas in Barbados.

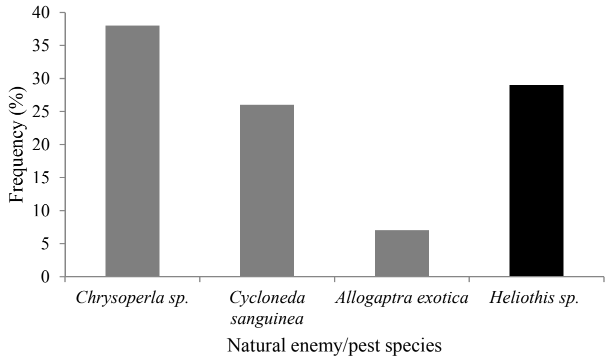

Figure 4. Percentage of natural enemies (gray bars) or pest (black bar) reported by farmers as the reason for application of chemical control.

government policies should include continuing training for farmers including identification of primary pest species and their associated natural enemies occurring in the field.

According to our results, predator and parasitoid biodiversity found in cotton fields in Barbados suggests a potentially important role of biocontrol as an alternative pest control in cotton crops. Moreover, Caribbean governments have created the Committee of Pesticides Control, with regulations to reduce the use of pesticides of high impact. This fact could exert a positive impact on implementation of biocontrol strategies available for small holder farmer in the area.

Future studies to assess control efficiency of the natural enemies identified here are needed in order to use this information for establishing Integrated Pest Management Program in cotton. Studies should include pest ecology and mass rearing techniques for biocontrol agents naturally occurring in cotton fields in order to evaluate compatibility with other control methods such as biopesticides, pheromones, among others. The implementation of a proper integrated pest management program, using biocontrol as a strategy can help to reduce the indiscriminate use of pesticides in the island and reach in this way a sustainable production of cotton.

References

Alam MM, Reid JC, Mulle G. 1990. The present status and future needs of biological control in the Caribbean community, Caribbean meetings on Biological Control, 5-7 November 1990, Guadeloupe.

Alves SB, Lopes RB, Pereira RM, Tamai MAO. 2008. Controle microbiano na América Latina. En: Alves SB, Lopes RB (Eds). Controle microbiano de pragas na América Latina- avanços e desafios. FEALQ, Piracicaba, Brazil. pp. 21-48.

Amal A, Attia AR, El Arnaouty SA, El-Metwally A. 2013. Chemical analysis of certain constituents of three prey species of the predator, *Cryptolaemus montrouzieri*. *Egyptian Journal of Agricultural Research* 91(2): 463-470.

Arcaya E, Mengual X, Pérez-Bañón C, Rojo S. 2013. Registros y distribución de sírfidos depredadores (Diptera: Syrphidae: Syrphinae) en el estado Lara, Venezuela. *Bioagro* 25(2): 143-148.

Baker P. 1990. Biological control of the coffee berry borer, Caraphin News, No 2, IICA, Trinidad and Tobago.

Beasley CA, Ellington J, Ellsworth P, Godfrey LD, Grafton-Cardwell E, Henneberry TJ, Naranjo S, Rosenheim JA, Toscano NC, Ward CR, Watson TF. 1996. Insects and mites. En: Flint ML (ed.). Integrated pest management for cotton in the western region of the United States. Second edition. University of California Division of Agriculture and Natural Resources Publication 3305. Oakland, USA. pp. 42-102.

Bell P. 2004. A Guide to Cotton Growing. Barbados Ministry of Agriculture and Rural Development. [Internet]. Available at: http://www.agriculture.gov.bb/agri/index.php?option=com_content&view=article&id=736:a-guide-to-cotton-growing&catid=175:cotton-department-knowledge&Itemid=140.

Bennett FD. 1990. An overview of classical biological control in the Caribbean and some examples of the utilization of entomophagous insects. Caribbean Meetings on Biological Control, 5-7 November 1990, Guadeloupe.

Bergvinson D. 2004. Opportunities and Challenges for IPM in Developing Countries. En: Koul O, Dhaliwal GS, Cuperus GW (Eds). Integrated Pest Management: Potential, Constraints and Challenges. CAB International. Wallingford. UK. pp. 281-312.

Botto EN, Monetti C, Ortego J, Dughetti AC. 1995. Natural enemies of cereal aphids and their potential against the Russian wheat aphid *Diuraphis noxia* (Mordvilko) (Homoptera:Aphididae) in Argentina. *Vedalia* 2: 39-40.

CARDI-CTA. 1995. Setting up an integrated pest management network for the Caribbean. Workshop Proceedings. Barbados 16-19 Octubre, 1994. 99 p.

Carvalho GA, Bezerra D, da Souza B, Carvalho CF. 2003. Efeitos de inseticidas usados na cultura do algodoeiro sobre *Chrysoperla externa* (Hagen) (Neuroptera: Chrysopidae). *Neotropical Entomology* 32(4): 699-706.

Cermeli M, Perozo J, Piñango L. 2009. *Scirtothrips dorsalis* Hood (Thysanoptera, Thripidae) nuevo insecto plaga del algodonero (*Gossypium hirsutum* L.) en Venezuela. *Entomotropica* 24(2): 85-88.

Cock MJW. 1985. Review of biological control of pest in the Commonwealth Caribbean and Bermuda up to 1982. The Commonwealth Agricultural Bureaux. 244 p.

Collins DR, Cannon R, Mac Leod A. 2006. Chilli thrips *Scirtothrips dorsalis*. Plant Pest Notice N° 40. Central Science Laboratory. DEFRA. 3 p.

Cruz C, Segarra A. 1992. Potential for biological control of crop pests in the Caribbean. *Florida Entomologist* 75(4): 400-408.

Cruz C. 1996. Control biológico de plagas en la zona del Caribe. En: Radcliffe EB, Hutchison WD, Cancelado RE (eds.). Radcliffe's IPM World Textbook. [Internet] . Available at: http://ipmworld.umn.edu/chapters/cruzspan.htm.

Espinel C, Torres L, Grijalba E, Villamizar L, Cotes AM. 2008. Preformulados para control de la mosca blanca *Bemisia tabaci* (Hemiptera: Aleyrodidae) en condiciones de laboratorio. *Revista Colombiana de Entomología* 34(1): 22-27.

Finlay-Doney M, Walter GH. 2012. Behavioral responses to specific prey and host plant species by a generalist predatory coccinellid (*Cryptolaemus montrouzieri* Mulsant). *Biological Control* 63(3): 270-278.

Ghahari H, Hayat R, Tabari M, Ostovan H. 2008. Hover flies (Diptera: Syrphidae) from rice fields and round grasslands of Northern Iran. *Munis Entomology and Zoology* 3: 275-284.

Gonçalves CR, Gonçalves AJL. 1976. Observações sobre moscas da família Syrphidae predadoras de homópteros. *Anais da Sociedade Entomológica do Brasil* 5(1): 3-10.

Hagen KS, Mills NJ, Gordh G, McMurtry J. 1999. Terrestrial arthropod predators of insect and mite pests. En: Fisher TW, Bellows TS, Caltagirone LE, Dahlsten DL, Huffaker CB, Gordh G (eds.). Handbook of Biological Control: Principles and Applications of Biological Control. Academic Press. London, UK. pp. 383-461.

Ingram WR. 1980. Studies of the pink bollworm, *Pectinophora gossypiella*, on sea island cotton in Barbados. *International Journal of Pest Management* 26(2): 118-137.

Işikber AA, Copland MJW. 2001. Food consumption and utilisation by larvae of two coccinellid predators, *Scymnus levaillanti* and *Cycloneda sanguinea*, on cotton aphid, *Aphis gossypii*. *BioControl* 46(4): 455-467.

Işikber AA. 2005. Functional response of two coccinellid predators, *Scymnus levaillanti* and *Cycloneda sanguinea*, to the cotton aphid, *Aphis gossypii*. *Turkish Journal of Agriculture and Forestry* 29: 347-355.

Kairo MTK, Pollard GV, Peterkin DD, López VF. 2000. Biological Control of the Hibiscus Mealybug, *Maconellicoccus Hirsutus* Green (Hemiptera: Pseudococcidae) in the Caribbean. *Integrated Pest Management Reviews* 5(4): 241-254.

Khan HA, Sayyed AH, Akram W, Raza S, Ali M. 2012. Predatory potential of *Chrysoperla carnea* and *Cryptolaemus montrouzieri* larvae on different stages of the mealybug, *Phenacoccus solenopsis*: a threat to cotton in South Asia. *Journal of Insect Science* 12: 1-12.

Kranthi KR, Jadhav DR, Kranthi S, Wanjari RR, Ali SS, Rusell DA. 2002. Insecticide resistance in five major insect pests of cotton in India. *Crop Protection* 21: 449-460.

Lopez V, Ramroop D, Vos J, Kairo M. 2004. Discovery learning manual for pest management in the Caribbean-cabbage and tomato. Trinidad and Tobago, CAB International. 341 p.

Maes S, Grégoire J, De Clercq P. 2014. Prey range of the predatory ladybird *Cryptolaemus montrouzieri*. *BioControl* 59(6): 729-738.

Masood A, Arif MJ, Hamed M, Talpur MA. 2011. Field performance of *Trichogramma chilonis* against cotton bollworms infestation in different cotton varieties as a sustainable IPM approach. *Pakistan Journal of Agriculture Agricultural Engineering and Veterinary Sciences* 27(2): 176-184.

Mathews GA, Tunstall JP. 1994. Insect pests of cotton. CAB International. 593 p.

Mendes SM, Bueno VHP, Argolo VM, Silveira LCP. 2002. Type of prey influences biology and consumption rate of *Orius insidiosus* (Say) (Hemiptera, Anthocoridae). *Revista Brasileira de Entomologia* 46(1): 99-103.

Menezes AO, Miguel M, Berbei BM. 1994. Biologia de *Euplectrus puttleri* Gordh, 1980 (Hymenoptera: Eulophidae) sobre lagartas do Curuquerê-do-Algodoeiro, *Alabama argillacea* Hübner, 1818 (Lepidoptera: Noctuidae). *Semina Ciências Agrarias* 15(1): 23-28.

Michaud JP. 2001. Responses of two ladybeetles to eight fungicides used in Florida citrus: Implications for biological control. *Journal of Insect Science* 1:1-6.

Nauen R, Denholm I. 2005. Resistance of Insect Pests to Neonicotinoid Insecticides: Current Status and Future Prospects. *Archives of Insect Biochemistry and Physiology* 58: 200-215.

Oparaocha ET, Okigbo RN. 2003. Thrips (Thysanoptera) of vegetable crops (okro, spinach, garden egg and pumpkin) grown in Southeastern Nigeria. *Plant Protection Science* 39: 132-138.

Osekre EA, Wright DL, Marois JJ, Mailhot DJ. 2008. Predator-prey interactions between *Orius insidiosus* (Heteroptera: Anthocoridae) and *Frankliniella tritici* (Thysanoptera: Thripidae) in cotton blooms. *The Journal of Cotton Science* 12: 195-201.

Parra JRP, Botelho PSM, Corrêa-Ferreira BS, Bento JMS. 2002. Controle biológico: terminologia. En: Parra JRP, Botelho PSM, Corrêa-Ferreira BS, Bento JMS. (Eds.). Controle biológico no Brasil: parasitóides e predadores. São Paulo: Manole. pp. 1-16.

Principi MM, Canard M. 1984. Feeding habits. En: Canard M, Séméria Y, New TR, (Eds.). Biology of Chrysopidae. Springer Netherlands, The Netherlans. pp. 76-92.

Quirós M, Petit Y, Méndez M, Portillo E, Oroño J. 2007. Situación de *Scirtothrips dorsalis* Hood (Thysanoptera: Thripidae) en viñedos del Municipio Mara, Estado Zulia, Venezuela. XX Congreso Venezolano de Entomología. Memorias. San Cristóbal 22-26 julio 2007. pp. 154.

Rashid MMU, Khattak MK, Abdullah K, Amir M, Tariq M, Nawaz S. 2012. Feeding potential of *Chrysoperla carnea* and *Cryptolaemus montrouzieri* on cotton mealybug, *Phenacoccus solenopsis*. *The Journal of Animal and Plant Sciences* 22(3): 639-64.

Rasool B, Arif J, Hamed M, Nadeem S. 2002. Field performance of *Trichogramma chilonis* against *Helicoverpa armigera* under varying sowing time and varieties of cotton. *International Journal of Agriculture and Biology* 4(1): 113-114.

Rosas-García N, Durán-Martínez E, Luna-Santillana E, Villegas-Mendoza J. 2009. Potencial de Depredación de *Cryptolaemus montrouzieri* Mulsant hacia *Planococcus citri* Risso. *Southwestern Entomologist* 34(2): 179-188.

Sarwar M. 2014. The propensity of different larval stages of lacewing *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae) to control aphid *Myzus persicae* (Sulzer) (Homoptera: Aphididae) evaluated on canola *Brassica napus* L. *Songklanakarin Journal of Science and Technology* 36(2): 143-148.

Solangi AW, Lanjar AG, Baloch N, Ul M, Rais N, Khuhro SA. 2013. Population, host preference and feeding potential of *Chrysoperla carnea* (Stephens) on different insect hosts in cotton and mustard crops. *Sindh University Research Journal* (Science Series) 45(2): 213-218.

Thrakika 2007. Barbados still struggling to make cotton farming viable. Thrakika Ekkonistiria S.A. [Internet]. August, 2015. Available at: http://thrakika.gr/en/news/detail.php?NEWS_ID=6519.

Tillekaratne K, Edirisinghe JP, Gunatilleke CVS, Karunaratne WA. 2011. Survey of thrips in Sri Lanka: A checklist of thrips species, their distribution and host plants. *Ceylon Journal of Science* (Biological Science) 40(2): 89-108.

Wyckhuys KAG, Lopez F, Rojas M, Ocampo JA. 2011. Do farm surroundings and local infestation pressure relate to pest management in three cultivated *Passiflora* species in Colombia? *International Journal of Pest Management* 57: 1-10.

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