THE POPULARITY OF AUGMENTATIVE BIOLOGICAL CONTROL IN LATIN AMERICA: HISTORY AND STATE OF AFFAIRS

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INTRODUCTION

Augmentative biological control, where natural enemies are periodically introduced, is commercially applied on large areas in various cropping systems worldwide. Initially augmentative biological control was used to manage pests that had become resistant to pesticides. Now it is applied for reasons of efficacy and cost, which are comparable with conventional chemical control (van Lenteren, 2000). Although biological control has been practiced in Latin America since the start of the 20th century, the written history of this field of science in this region is limited. Several cases of classical biological control are mentioned in DeBach (1964). Aspects of the history of biological control in Brazil can be found in Gomes (1962), for Chile in Gonzalez and Rojas (1966), and for Peru in Wille (1956). Hagen and Franz (1973) provided the first review of biological control in South and Central America. A more recent review of classical biological control in Latin America is given by Altieri and Nichols (1999). Until the 1970s, the attempts to use natural enemies in South and Central America were scattered and uneven, but thereafter biological control activities intensified in Latin America as the result of the formation of departments of entomology and biological control.

In this paper, we summarize developments in the field of augmentative biological control in Latin America that have taken place from 1972 to 2002. Up to date, reliable figures on current use of augmentative biological control were hard to obtain, but it is clear that today the use of augmentative biological control is widespread in Latin America.

CURRENT SITUATION OF BIOLOGICAL CONTROL IN LATIN AMERICA

Information about the current use of biological control in Latin America was compiled from Altieri and Nichols (1999) (classical biological control only), Zapater (1996), various papers cited below, and from personal communications with M. Gerding (Chile), R. de Vis (Colombia), A.L. Valido (Cuba), L.A.R. del Bosque (Mexico), and G. Gonzalez (Panama).

Brazil has implemented several programs of classical biological control, the most recent one being for control of *Sirex* wood wasps with entomopathogenic nematodes and three parasitoids (Iede and Penteado, 1998). Brazil is also very active in the use of augmentative biological control and has about 44 facilities for mass production of natural enemies. Brazil applies *Cotesia flavipes* (Cameron) against sugarcane borer (*Diatraea saccharalis* [Fabr.]) on about 300,000 hectares of sugarcane per year. (Macedo, 2000; Arigoni, personal communication); AgNPVirus (*Baculovirus anticarsia*) against soybean caterpillar (*Anticarsia gemmatalis* Hübner) on more than 1 million hectares of soybeans per year (Moscardi, 1999), and egg parasitoids (*Trissolcus basalis* [Wollaston]) of soybean bugs (*Nezara viridula* [Linnaeus], *Piezodorus guildinii* [Westwood] and *Euschistus heros* [Fabricius]) on 20,000 hectares of soybeans per year (Corrêa-Ferreira, personal comunication). The egg parasitoid *Trichogramma pretiosum* Riley is released on about 2,600 hectares of field tomatoes against *Tuta absoluta* (Meyrick) (N. Hiji, personal communication), and the predatory mite *Neoseiulus californicus* (McGregor) is released against the spider mite *Panonychus ulmi* (Koch) in 1,800 hectares of apples (Monteiro, personal communication).

In Chile since 1970, a large augmentative project has been implemented for the control of pine shoot moth (*Rhyacionia buoliana* [Shiff.]), with releases of the parasitoids *Orgilus obscurator* (Ness) (50,000 ha) and *Trichogramma nerudai* Pintureau and Gerding (200 ha, experimental). Programs are being developed in greenhouse tomatoes for greenhouse whitefly (*Trialeurodes vaporariorum* [Westwood]) with several *Encarsia* and *Eretmocerus* species and for the leafmining caterpillar *T. absoluta* with *T. nerudai*. Since 1990, filth flies in poultry and livestock confinement areas have been controlled by periodic releases of *Muscidifurax raptor* Girault and Sanders and *Spalangia endius* Walker. The use of entomopathogens against a variety of pests is being studied (all Chilean information based on M. Gerding, personal communication).

In Colombia, augmentative biological control is intensively applied in the Valle del Cauca, where about 200,000 ha cultivated with cotton, soybean, cassava, tomato, sorghum and sugarcane receive periodic releases of various species of *Trichogramma*. The use of *Trichogramma* spp. in cotton has decreased sharply since 1980s because of the invasion of the bollweevil (*Anthonomis grandis* Boheman). In 1991, *Trichogramma* spp. were still applied on 30,000 ha of cotton, but now these parasitoids only are used on about 5,000 ha. However, the use of biological control in sugarcane has increased recently. Three parasitoids (a species of *Trichogramma*, *Lydella minense* Townsend and *Pharatheresia claripalpis* Wulp.) are released to control the sugarcane borer (*D. saccharalis*) and other caterpillars on about 130,000 ha. Flies in poultry and other livestock confinement areas are controlled on a large scale by periodic releases of *Muscidifurax* and *Pachycrepoideus* species. Also, Lepidoptera (defoliating caterpillars) are under augmentative biological control in large forest areas.

Colombia has developed mass production technology for parasitoids, predators, and entomopathogens (Garcia, 1996), and had 30 mass production facilities for parasitoids or predators in 1990. This number had decreased to nine producers in 2000. Colombia seems to have brought *T. pretiosum* to South America at the end of the 1970s, and from there its application has spread to Costa Rica, Venezuela, Paraguay, Ecuador, and Brazil. Colombia is well known for its research on application of entomopathogenic fungi such as *Beauveria bassiana* (Bals.) Vuill., *Verticillium lecanii* (Zimmerman), *Metarhizium anisopliae* (Metsch.), and *Paecilomyces fumosoroseus* (Wise). The largest uses are (1) *B. bassiana* and *M. anisopliae*, which is applied on 550,000 ha of coffee against the coffee berry borer (*Hypothenemus hampei* [Ferrari]) and (2) *B. bassiana* against *Opsiphanes cassina* Fruhstorfer on 130,000 ha of oil palm. Entomopathogens are also used for control of *A. grandis* in cotton, thrips in ornamentals, whiteflies in beans and tomatoes, grasshoppers in pastures, and various insect pests in rice and citrus. Currently, Colombia has five producers of entomopathogenic fungi. The National Center for Coffee Research (CENICAFE) is doing extensive research on the imported parasitoids *Cephalonomia stephanoderis* Betrem and *Prorops nasuta* Waterston, which are now mass reared and released in coffee fields (Bustillo *et al*., 1995). Colombia has several integrated control programmes for greenhouse pests (De Vis *et al*., 1999).

Costa Rica uses various species of *Trichogramma* to control pests in cotton and sugarcane (Hernandez, 1996).

In Cuba *Trichogramma* species are applied to more than 685,000 ha of pastures, cassava, and vegetables for control of Lepidoptera (A.L. Valido, personal communication). Sugarcane borers are controlled with release of the native tachinid *Lixophaga diatraea* Townsend, and the spider mite *Panonychus citri* McGregor is controlled with the predatory mite *Phytoseiulus macropilis* (Banks) (areas unknown but large; Aleman *et al*., 1998). Applications of pathogenic fungi are made to large areas. In 1995, some 516,895 ha were treated (Altieri and Pinto, 1997). The sweet potato weevil (*Cylas formicarius* [Fabricius]) is controlled on more than 15,000 ha by manipulating predatory ants (*Pheidole megacephala* [F.]) and applying entomopathogenic nematodes (*Heterorhabditis* spp.) (A.L. Valido, personal communication). Cuba has 280 centers for the production of entomophages and entomopathogens (Altieri and Nichols, 1999; A.L. Valido, personal communication), which produce insect pathogenic fungi, *Bacillus thuringiensis* Berliner, *Trichogramma* spp., and sugarcane borer parasitoids. We estimate that currently 700,000 ha are treated with these biological control agents.

In Ecuador, programs of augmentative biological control are being developed for use in sugarcane and corn, using local species of *Trichogramma* (Klein Koch, 1996). Furthermore, there is some integrated control and biological control of pests in roses (about 10 ha), and natural control of leafminers in ornamentals in the field (about 50 ha).

Guatemala is using various species of *Trichogramma* against pests in cotton (14,000 ha), and a baculovirus is used against pests in vegetables and cotton (3,500 ha).

Mexico has been very active in developing augmentative control during the past 30 years. Many species of natural enemies (parasitoids, predators, and pathogens) are mass produced in more than 30 centers for rearing beneficial insects. Augmentative releases with *Trichogramma* spp., and other parasitoids, predators, and pathogens are made in crops such as corn, cotton, sugarcane, sunflower, coffee, tobacco, soybean, sorghum, vegetables, ornamentals, bean, wheat, citrus, and forests on 1,500,000 ha annually (Dominguez, 1996). For example in 1998, the natural enemies reared at just one of these organizations (Centro Nacional de Referencia de Control Biologico) through their five production centers (Centros Regionales de Estudios y Reproduccion de Insectos Beneficos) included enough *Trichogramma* spp. for releases on more than 640,000 ha, *Chrysoperla* sp. for use on more than 100,000 ha, *Habrobracon* sp. on more than 45,000 ha, and entomopathogenic fungi for application on more than 6,000 ha (H.C.A. Bernal and L.A.R. del Bosque, personal communication). In addition to natural enemy production by these centers, commercial sugar mills and other companies also produce biological control agents, such as species of *Trichogramma* for use on at least another 100,000 ha and enough entomopathogenic fungal spores for treatment of more than 50,000 ha (H.C.A. Bernal and L.A.R. del Bosque, personal communication).

Panama is using *C. flavipes* for control of sugarcane borers on about 4,500 ha of sugarcane.

Historically, Peru worked mainly on classical biological control and has imported more than 100 species of biological control agents since 1904. Augmentative programs have been developed recently for control of pests in asparagus, sugarcane, rice, and corn (with various species of *Trichogramma* and *Telenomus*), pests in citrus (using local *Aphytis* species), pests in olive (with species of *Metaphycus, Coccophagus,* and *Chrysoperla*), and pests in potato (a species of *Copidosoma*), tomato (*Paecilomyces* spp.), coffee and forests (*B. bassiana*). Peru currently has 82 mass rearing facilities for natural enemies and 27 laboratories for production of entomopathogens (Beingolea, 1996; Programa Nacional de Control Biologico del Servicio Nacional de Sanidad Agraria (SENASA), information leaflet, 2000). In these 109 facilities, 27 species of biological control agents are mass produced. In the 1970s, the national insectary for introduction and rearing of beneficial insects reared *Trichogramma* spp. for releases on about 1,300 ha (Altieri and Nichols, 1999). Peru aims to apply biological pest control on about 240,000 ha within five years (SENASA, information leaflet, 2000).

Venezuela is using *Telenomus remus* Nixon against *Spodoptera frugiperda* (J.E. Smith) in corn (Ferrer, 1998).

In Argentina, Bolivia, Honduras, Nicaragua, and Uruguay, augmentative biological control is of interest, but application is still limited (Basso and Morey, 1990; Zapater, 1996). Biological control of pests in greenhouses, which started in the 1980s in Colombia, is now also applied in greenhouses in Argentina, Chile, Mexico, Peru, and Brazil (Bueno, 1999). As a result of these diverse biological control projects, questions concerning mass production methods, guidelines for quality control of mass-produced natural enemies, and procedures for safe importation and release of natural enemies have been examined (see Bueno, 2000).

CONCLUSIONS

During the past 30 years, there has been a strong increase in the level of use of augmentative biological control in Latin America. Many resources for augmentative biological control remain to be used. With proper habitat manipulation leading to conservation of natural enemies, the inherent ability of agroecosystems to withstand pest and disease problems can be increased (Lewis *et al.*, 1997). Many native natural enemy species are available to be tested as new control agents. The International Organization for Biological Control of Noxious Animals and Plants (IOBC) can promote contacts between researchers and biological control practitioners, to stimulate development of new augmentative control programs.

However, several factors are limiting the introduction of augmentative biological control in Latin America, including (1) the influence of the pesticide industry, (2) lack of sustained financial support for most research on biological control, (3) lack of governmental efforts to implement augmentative biological control, (4) lack of organization of biological control researchers, (5) insufficient information about biological control in education programs offered by extension services, (6) inadequate transfer of knowledge from universities to farmers, and (7) little interest by consumers in pesticide-free food.

On the other hand, several Latin America countries already have very successfull biological control programs, and good mass production systems are available in some countries, especially Brazil and Mexico. Future collaboration within the Neotropical Section of IOBC should promote quicker transfer of knowledge about biological control.

REQUEST FOR INFORMATION

It has taken us a lot of time to obtain data on the use of biological control in Latin America, and we are convinced that this survey is still not complete. We encourage readers to send us up-to-date information, so we can provide a more reliable overview in the near future. (For contact information, see author list at end of volume.)

REFERENCES

Aleman, J., L. Plana, M. Vidal, G. Llanes, and M. Delgado. 1998. Criterios para el control de la calidad en la cria masiva de *Lixophaga diatraeae,* pp. 97-104. *In* Hassan, S. A. (ed.). *Egg parasitoids.* Parey, Berlin, Germany.

Altieri, G. and C. Pinto. 1997. La rivoluzione della "Naturaleza" per amore e per forza Cuba a passata all'agricoltura biologica. *Mediterraneo* 1 (3): 47-56.

Altieri, M. A. and C. I. Nichols. 1999. Classical biological control in Latin America, pp. 975-991. *In* Bellows, T. S. and T. W. Fisher (eds.). *Handbook of Biological Control*. Academic Press, San Diego, California, USA.

Basso, C., and C. Morey. 1990. Biological control of the sugarcane borer *Diatraea saccharalis* Fabricius (Lepidoptera: Pyralidae) with *Trichogramma* spp. (Hymenoptera: Trichogrammatidae) in Uruguay, pp. 165-169. *In Trichogramma and other Egg Parasitoids*. Les Colloques INRA 56, Paris, France.

Beingolea, D. O. 1996. El control biológico de plagas en el Perú: avances, perspectivas, aplicación y limitaciones, pp. 71-91. *In* Zapater, M. C. (ed.). *El Control Biológico en América Latina*. International Organization for Biological Control, Buenos Aires, Argentina.

Bueno,V. H. P. 1999. Protected cultivation and research on biological control of pests in greenhouses in Brazil. *Bulletin of the International Organization for Biological Control*, *WPRS* 22(1): 21-24.

Bueno, V. H. P. (ed.). 2000. *Controle Biológico de Pragas: Produção Massal e Controle de Qualidade*. Editora UFLA, Lavras, Minas Gerais, Brazil.

Bustillo, P. A. E., G. D. Villalba, H. J. Orozco, M. P. Benavides, A. I. C. Reyes, and C. B. Chaves. 1995. Biological control of pests in coffee in Colombia, pp. 671-680. *Proceedings of the Seizieme Colloque Scientifique International sur le Cafe*, 9-14 April, 1995. Kyoto, Japan.

DeBach, P. (ed.). 1964. *Biological Control of Insect Pests and Weeds*. Cambridge University Press, Cambridge, United Kingdom.

De Vis, R., L. E. Fuentes, and J. C. van Lenteren. 1999. Development of biological control of *Trialeurodes vaporariorum* with *Encarsia formosa* and *Amitus fuscipennis* on greenhouse tomato in Colombia. *Bulletin of the International Organization for Biological Control*, *WPRS* 22(1): 267-270.

Dominguez, E. R. 1996. Control biológico de plagas agrícolas en México, pp. 55-62. *In* Zapater, M. C. (ed.). *El Control Biológico en América Latina, International Organization for Biological Control*, Buenos Aires, Argentina.

Ferrer, F. 1998. The use of *Telenomus remus* Nixon on commercial corn fields in Venezuela, pp. 125-130. *In* Hassan, S. A. (ed.). *Egg parasitoids*. Parey, Berlin, Germany.

Garcia, F. 1996. El control biológico aplicado en Colombia, pp. 31-33. *In* Zapater, M. C. (ed.). *El Control Biológico en América Latina*. *International Organization for Biological Control*, Buenos Aires, Argentina.

Gomes, J. 1962. Histórico do combate biológico no Brasil. *Boletim do Instituto de Ecologia e Experimentação Agricolas* 21: 89-97.

Gonzalez, R. H. and S. Rojas.1966. Estudio analitico del control biologico de plagas agricolas en Chile. *Agricultura Tecnica* 26: 133-147.

Hagen, K. S. and J. M. Franz. 1973. A history of biological control, pp. 433-476. *In* Smith, R. F., T. E. Mittler, and C. N. Smith (eds.). *History of Entomology*. Annual Reviews Inc., Palo Alto, California, USA.

Hernández, J. 1996. El control biológico en Costa Rica, pp. 35-40. *In* Zapater, M. C. (ed.). *El Control Biológico en América Latina*. *International Organization for Biological Control*, Buenos Aires, Argentina.

Iede, E. T. and R. C. Penteado. 1998. Inimigos naturais introduzidos para o controle de *Sirex noctilio* (Hymenoptera: Siricidae) no Brasil. *Resumos XVII Congresso Brasileiro de Entomologia,* 9-14 Agosto, 1998. Rio de Janeiro, Brazil.

Klein Koch, C. A. 1996. Proyectos de control biológico en curso en Ecuador, pp. 41-47. *In* Zapater, M. C. (ed.). *El Control Biológico en América Latina*. *International Organization for Biological Control*, Buenos Aires, Argentina.

van Lenteren, J. C. 2000. Measures of success in biological control of arthropods by augmentation of natural enemies, pp. 77-103. *In* S. Wratten and G. Gurr (eds). *Measures of Success in Biological Control*. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Lewis, W. J., J. C van Lenteren, S. C. Phatak, and J. H. Tumlinson 1997. A total systems approach to sustainable pest management. *Proceedings Natural Academy of Science*, *USA* 94: 12243-12248.

Macedo, N. 2000. Método de criação do parasitóide *Cotesia flavipes* (Cameron), pp. 161-174. *In* V. H. P. Bueno (ed.). *Controle Biológico de Pragas: Produção massal e controle de qualidade*. Editora UFLA, Lavras, Minas Gerais, Brazil.

Moscardi, F. 1999. Assessment of the application of baculoviruses for control of Lepidoptera. *Annual Review of Entomology* 44: 257-289.

Wille, J. E. 1956. El control biológico de los insectos agrícolas en el Perú. *Proceedings International Congress of Entomology* 10: 519-523.

Zapater, M. C. (ed.). 1996. *El Control Biológico en América Latina*. *International Organization for Biological Control*, Buenos Aires, Argentina.