ACCOMPLISHMENTS AND FUTURE OF BIOLOGICAL CONTROL AND INTEGRATED CONTROL IN BRAZIL – PART 1

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EDITOR'S NOTE

The entomologist Kenneth Sverre Hagen, professor of the University of California at Berkeley, and that moment working in the Michigan State University, was in Brazil for a three month period in 1977 as a consultant in the Program of Superior Agricultural Education (*Programa de Educação Agrícola Superior – PEAS*) of the Ministry of Brazilian of Education and Culture. During this period (from July to September), Professor Hagen trained and changed experiences with docents (university professors) and reseachers in several fields mainly in the Biological Control of Insects and Pests using ESALQ (Superior College of Agriculture) as a basing point. He visited other Brazilian Universities and Research Institutions. All of the activities are presented in the Report Biological and Integrated Control of Insects in Brazil (*Controle Biológico e Controle Integrado de Insetos no Brasil: Realizações e Futuro*), a never published document. During his stay in Brazil, he was accompanied by the professor from the entomology departament, responsible for reswuing this report. Of an invaluable historical nature, the report will be published in three partsin the Brazilian Journal of Agriculture (BJA), opening the "*Unpublished historical papers*" seltion.

INTRODUCTION

Efforts to biologically control insect pests in Brazil though modest in the past have in recent years been increasing, and the future possibilities of biological control are most promising if certain facilities and conditions are provided. As shown in the following list of accidentally introduced insect pests and potential natural enemies that could be introduced into Brazil, there is a great deal of work to be done in classical biological control. Not to mention possibilities of controlling spider mites, weeds, medically important insects and snails. Furthermore, there is much that can be done in augmenting and conserving natural occuring biological control agents.

As in other countries resistance of insect pests to insecticides, disruptions of ecosystems by many pesticides, and modern concern with environmental protection have forced agriculturists and foresters to seek alternative methods of controlling insects. Interest and support of biological control methods have increased in recent years. Biological control agents and their dynamics make up a most important if not the most important component in integrated control systems. Plant resistance to pests and chemical control are also important components. Therefore management of pests in the ecosystems of agriculture and forests is a complex ecological undertaking, and requires a multidisciplinary approach which necessitates cooperation between specialists in biological control, chemical control, plant pathologists and in plant resistance.

We shall deal here mainly with biological control. Biological control is a natural ecological phenomenon. It is the regulation of plant and animal numbers by natural enemies.

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Natural enemies are parasites, predators and pathogens. All three types have been used in the biological control of certain pests in Brazil.

There are three main approaches employed in the biological control of pests. They are: classical, augmentation and conservation, and these three methods have been applied in Brazil.

Classical biological control

Classical biological control is the importation of natural enemies against exotic pests. The key action is colonization and the global is to establish natural enemies that will reduce the pest population and be self-sustaining.

In Brazil there have been ten "exotic" insect pests against which imported natural enemies have been released and established (see species marked with an asterisk), but there are at least 150 accidentally insect pests in Brazil (see following list), and of these pests there are at least 50 species that are good candidates to apply the classicial biological control method.

COLEOPTERA

There have been 19 coleopterous pests in the world that have been partially to completely controlled by introduced natural enemies (Huffaker and Messenger 1976). In Brazil, evidently only one species of Coleoptera, the coffee borer, *Hypothenemus hampei* (Ferrari), has been subjected to classical biological control.

Shortly after the establishment of the bethylid *Prorops nasuta* Waterston in Brazil in 1929, there was an apparent reduction of the pest population levels where the parasite from Uganda was released, but later entomologists considered the bethylid to have little impact on the coffee borer populations (Gomes 1962). In 1934, the braconid *Heterospilus coffeicola* Schmied was also introduced from Uganda into Brazil against the coffee borer, but the lack of production of the parasite because of insufficient mating the parasite stock was lost; consequently the parasite did not become established (Gomes 1962). Perhaps attempts to reintroduce the braconid from Africa should be made even in the view that the borer in Uganda was apparently not adequately controlled by natural enemies.

There are at least 30 coleopterous pests that have been accidentally introduced into Brazil (see following list). Most of these beetles are stored product pests and not very amenable to classical biological control. However, where crop infestations occur in the field and at least the egg stage of the pest is exposed, natural enemies may be able to reduce the pest populations.

The beetle pests that are good candidates for consideration to have natural enemies released against them are: *Lagria villosa* F., *Cosmopolitus sordidus* Germar, *Gonipterus gibberus* (Boisd.).

List of Pest Coleoptera Suspected to be Introduced into Brazil

Anobiidae

- *Anobium punctatum* (De Geer) - Dry wood

Cosmopolitan. Thompson (1944) lists six parasites of this pest in Europe.

- *Lasioderma serricorne* (F.) - Dried foods

Cosmopolitan. Thompson (1944) lists two parasites in Europe including *Cephalonomia gallicola* Ashm., and one from Pacific Islands. Silva *et al.* (1968) list two parasitic species including *C. gallicola* in Brazil and one in Uruguay. The spider *Uloborus geniculatus* was used against this pest in Brazil (Lent and Oliveira 1964).

- *Stegobium paniceum* (L.) - Dried foods

Cosmopolitan. Silva *et al.* (1968) reports *C. gallicola* and *Habrocytus* sp. in Brazil and pteromalid *Lariophagus distenguendus* Forster in Uruguay.

Anthribidae

- *Araecerus fasciculatus* (DeGeer) - Cotton, coffee, cocoa, etc.

Cosmopolitan in tropics and subtropics, probably of oriental origin. Thompson (1944) lists three parasites from Java, one from Malaya, another from Hawaii and one in USA. Silva *et al.* (1968) list two parasites in Argentina.

Bostrichidae

- *Apate monachus* (F.) - Cocoa, coffee, fallen trees, etc.

Widespread in Africa and Madagascan region; also occurs in the Mediterranean area and has been introduced into the West Indies and Brazil (Entwistle 1972).

- *Apate terebrans* Pallas - Acacia, avocado, cocoa, citrus, etc.

It is distributed throughout Africa south of the Sahara to Natal and occurs in Arabia and has also been itroduced into parts of the West Indies and Brazil (Entwistle 1972, Reichardt 1964).

Bruchidae

- *Acanthoscelides obtectus* (Say) - Beans

Cosmopolitan where beans are grown. Oliveira (1948) reports using *Dinarmus laticeps* against the pest in Brazil with relative success.

- *Bruchus pisorum* (L.) - Peas, seeds of leguminous trees

Cosmopolitan where peas are grown. Thompson (1944) lists five parasites. A parasite was introduced into western Australia to control it (Evans 1952).

- *Bruchus rufimanus* Boheman - Beans

A European species (Essig 1926) which has become cosmopolitan. Thompson (1944) lists three parasites. In Uruguay the braconid *Triaspis primus* (Brèthes) is considered an important parasite, but *T. thoracicus* (Curt.) is also present and *Sigalphus primus* Brethes is in Argentina (Silva *et al.* 1968). Apparently these parasites are unknown to occur in Brazil.

- *Callosobruchus onalis* (F.) - Beans, peas

Cosmopolitan. Thompson (1944) list six parasites.

- *Callosobruchus chinensis* (L.) - Beans and peas

Oriental in origin. Thompson (1944) list six parasites, four from Asia and two from Hawaii. The pteromalid *Dinarmus laticeps* is recorded as a parasite in Brazil (Silva *et al.* 1968).

- *Zabrotes subfasciatus* (Boheman) - Beans, peas

Occurs from Texas to Argentina, perhaps native to Brazil. Silva et al. (1968) list *D. laticeps* as a parasite in Brazil.

Cerambycidae

Dr. Ubirajara R. Martins, of São Paulo believes that nearly all the Cerambycidae of Brazil are native or at least Neotropical. A total of

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243 species are listed by Silva *et al.* (1968) as to occur in Brazil, but only seven species of parasites, one predator and one pathogen recorded attacking cerambycids in Brazil. Entwistle (1972) discusses the parasitism of cocoa cerambycids in Africa and Trinidad. *Phoracantha punctata* F. is from Australia; now in southern Brazil, where it attacks eucalyptus.

Chrysomelidae

- *Diabrotica speciosa* (Germ.) - Many solanaceous plants, citrus

Widespread in the neotropics, but where did it originate? The tachinid *Celatoria basqi* Blanchard attacks it in Uruguay (Silva *et al.*1968).

- *Epitrix fasciata* Blatchley - Solanaceous plants

Wide spread in Americas. The above parasite also attackes this species.

- *Sternocolaspis quatuordecimcostata* (Lefevre)

A widespread apparently Neotropical species which attacks avocado, citrus, cotton, potato, etc. Where in the neotropics did it originate?

Cleridae

- *Necrobia rufipes* Degeer - Dried foods

Cosmopolitan.

Cucujidae

- *Cathartus quadricollis* Guerin - Sored grain

Cosmopolitan.

- *Laemophloeus ferrugineus* (Stephns) - Stored grain

Cosmopolitan.

- *Laemophloeus minutus* (01.) - Stored grain

Cosmopolitan. There is one parasite listed by Thompson (1944) occurring in USA.

- *Oryzaephilus surinamensis* (L.) - Stored grain

Cosmopolitan. Thompson (1944) lists two parasites.

Curculionidae

- *Cosmopolites sordidus* Germar - Banana, cocoa

Tropicopolitan, probably originated in S. E. Asia. Thompson (1944) records a tachinid on it in Dutch E. Indies. The introduction of the histerid beetle *Plaesius javanus* (Erich.) from Java into Fiji resulted in from partial to substantial control and later from Fiji to Jamaica in partial control of the weevil (Bennett 1976).

- *Gonipterus gibberus* (Boisd.) - Eucalyptus

Probably introduced from Australia. A related species accidentally introduced into South Africa, New Zealand, Mauritius and Kenya was substantially to completely controlled by introducing the mymarid *Patasson nitens* (Girlt.) (DeBach 1964). The adult *G. gibberus* feeds on young shoots of *Eucalyptus drepanophylla* in Australia, but is ranked as a minor pest (Browne 1968).

- *Sitophilus granarius* (L.) - Stored grain

Cosmopolitan. Silva *et al.* (1968) list five parasites. Thompson (1944) lists 12 parasites.

- *Sitophilus oryzae* (L.) - Stored grain

Cosmopolitan. Silva *et al.* (1968) list 4 parasites same spp. as listed for the above. Thompson (1944) lists 10 parasites mostly the same as for above species.

Dermestidae

- *Anthrenus verbasci* (L.) - Saprophagous

Cosmopolitan. Thompson (1944) lists one parasites which occurs in France.

Lagridaidae

- *Lagria villosa* F. - Vegetables, tree seedlings

Widely distributed in tropical Africa, recently invaded eastern Brazil. The adult beetles feed on young developing leaves of dicotyledonous trees and conifers. In Kenya there have been a few intances of injury of *Pinus radiata*, but the beetle has not occurred as an important forest pest. In Nigeria it occurs throughout the high forest zone, and is commonly associated with *Cassia simea*, *Gimelina arborea* and *Tectona grandis*, but damage has been negligible (Browne 1968). Recently entomologists at the Federal University of Viçosa discovered a native tachinid, *Hyalomodes brasiliensis* Tns. Parasitizing *L. villosa*.

Lyctidae

- *Lyctus brunneus* (Steph.) - Bamboo

Cosmopolitan, probably of oriental origin. The braconid parasite *Monolexis lycti* Cress. Which attacks several *Lyctus* spp. apparently has followed the beetle into Brazil (Thompson 1944). Silva *et al.* (1968) lis a eupelmid parasite and a clerid predator of *L. brunneus*.

Nitidualidae

- *Carpophilus dimidiatus* (L.) - Dried or broken fruit

Cosmopolitan.

Ostomidae

- *Tenebroides mauritanicus* (L.) - Stored grain, also predaceous

Cosmopolitan. Thompson (1944) lists two parasites.

Scolytidae

- *Cryphalus mangiferae* Steb. - Mango

Probably introduced in Brazil. It is know to occur in India and Burma (Lima 1956).

- **Hypothenemus hampei* (Ferrari) - Coffee

Originated in Africa. The betylid *Prorops nasuta* Waterston was introduced from Uganda in 1923 and became established, but apparently has not had much of an impact on *H. hampei* population levels. *Heterospilus coffeicola* also introduced into Brazil in 1934 from Uganda did not become established.

- *Xyleborus affinis* Eichhoff. - Avocado, cocoa, sugar cane

Found in Colombia, Ecuador and Brazil in the New World and in the Congo Republic, Nigeria and Java in the Old World IN Java, *Tetrastichus xyleborum* attacks sereval spp. of *Xyleborus* (Entwistle 1972).

- *Xyleborus ferrugineus* (F.) (=bispinatus Eich.) - Dead and dying trees, cocoa, mango

Very widely distributed throughout tropical Africa, south of the Sahara, Madagascar,

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tropical and subtropical America and eastern USA (Browne 1968). Entwistle (1972) reviews its impact on cocoa.

- *Scolytus rugulosus* Ratz. - Dead or dying trees

Originated in Europe, but now nearly cosmopolitan. Thompson (1944) lists 23 parasites. Silva *et al.* (1968) list two parasites in Argentina and one in Brazil.

Tenebrionidae

Five species of cosmopolitan Tenebrionidae which have apparently been introduced into Brazil. They are all associated with stored foods. They are: *Alphitobius piceus* (Oliv.), *A. bifasciatus* (Say), *Tenebrio molitor* L., *Tribolium castaneum* Herbst., and *T. confusum* Duval.

DIPTERA

There have been 11 species of Diptera partially to substantially controlled by introducing natural enemies in various countries of the world (Huffaker and Messenger 1976). In Brazil only the medfly *Ceratitle capitata* (Wied) has had a parasite introduced against it (Gomes 1962). The med fly is an excellent candidate in Brazil to introduce more parasites against it. *Biosteres tryoni* (Cam.) and *Biosteres oophilus* (Fullaway) have reduced the overall population of med fly by 50% and in coffee alone 90% parasitization is common in Hawaii. Since coffee is a major source of med fly, establishment of the above two *Biosteres* spp. (formerly in the genus *Opius*) would be a great step forward in reducing the overall population level of the med fly in Brazil. Furthermore, *B. oophilus* may also have an impact on *Anastrepha* spp. The parasites *Psilus* spp. and *Aceratoneuromyia indica* (Silv.) would attack both *Ceratitis* and *Anastrepha* spp. The above *Biosteres* spp. are available from Hawaii. The *Psilus* spp. are available from California.

The leaf miner *Liriomyza munda* has many parasites in North America that may be introduced into Brazil. The sorghum midge, *Contarina sorghicola* is also another pest that parasites could be introduced. However, in view of successfully selecting resistant varieties against the midge, this type research should have higher priority.

There are at least eight dipterous pests that have been accidentally introduced into Brazil.

List of Pest Diptera Suspected to be Introduced into Brazil

Agromyzidae

- *Liriomyza munda* (=langei Frick) - Tomato

According to Paulo Cassino and Francisco Racca (personal communication) a new leaf miner appeared as a pest of tomato in the State of Rio de Janeiro in the last four years. The specific identification is questionable. Although some parasites have been observed in the State of Rio de Janeiro and in Chile (Aguilera 1972), L. *munda* and L. *langei* have many parasites in Western North America. Over 20 species of parasites are listed under the name *Agromyza pusila* Mg. in North America (Thompson 1943).

Cecidomyiidae

- *Contarinia sorghicola* (Coq.) - Sorghum

Found in all continents. It appeared in Brazil about 1967 (Rossetto *et al.* 1967). Lara (1974) reviewed the world literature on its distribution, hosts, resistance to the fly and its natural enemies. Eight hymenopterous parasites have been mentioned in the literature from Australia,

India, Nigeria and USA. Lara (1974) reports three *Testrastichus* spp. and *Eupelmus popa* Girault have been found in Brazil. Lara found the variety of sorghum AF-28 to be highly resistant to the midge.

Drosophilidae

- *Drosophila melanogaster* Meigen - Picked fruit

Cosmopolitan.

Muscidae and Anthomyiidae

- *Fannia canniculari*s L. Filt Flies
- *Musca domestica* (L.) Filt flies
- *Stomoxys calcitrans* (L.) Filt flies

All three of these pestiferous flies are cosmopolitan. In recent years some success has been achieved to biological control these flies if the manure or breeding source is concentrated. The encyrtid *Tachinaephagus zealandicus* Ashmend attacks dipterous larvae in animal excrement, plant refuse and carrion but not tachinid larvae (Legner and Olton 1968). Five species of the genus *Muscidifurax* parasitize dipterous immatures near the surface of breeding sites (Kogan and Legner 1970). *Spalangia nigra* Latr. has also been effective in some tropical areas (Simmonds 1969). In the USA, the above parasites are periodically released in manure piles and have been successful enough for farmers to pay for this service year after year. See Bay *et al.* (1976) for biological control of medical and veterinary pests.

Stratiomyidae

- *Hermetia illucens* (L.) - Decaying organic matter.

Cosmopolitan. Silva *et al.* (1968) list a parasite and a predator in Argentina.

Tephritidae

- **Ceratitis capitata* (Wied.) - Citrus, coffee, many fruits

Present in nearly all tropical and subtropical areas of the world and extends into temperate areas of Europe. *Tetrastichus giffardianus* Silvestri was imported from Africa into Brazil in 1937 and it became established (Gomes 1962). Its impact on *C. capitata* or various *Anastrepha* spp. which it may attack in Brazil has not been evaluated. There are 35 different species of parasitic Hymenoptera that are known to parasitize the med fly (Mitchell *et al.* 1977). Of these 35, four species stand out as ideal parasites to attempt establishment in Brazil against the med fly. These are *Biosteres oophilus* (Fullaway), *Biosteres tryoni* (Com.) *Psilus* sp., and *Aceratoneuromyia indica* (Silv.).

HEMIPTERA

There are at least two hemipterous pests in Brazil which are ideal candidates to control biologically. The chinch bug not only has natural enemies abroad to be introduced but the use of *Beauveria*, which is already in culture in Brazil, may prove to be very effective. The scelionid *Trissolcus basalis* has been so successful against *Nezara viridula* elsewhere, its importation into Brazil is highly recommended.

Cydnidae

- *Scaptocoris castanea* Perty. - Corn, cotton, rice, sugar cane, etc.

This pest is common on many different crops. It may be introduced where it occurs as a pest. No natural enemies have been observed attacking

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this bug (Guagliumi 1973). Some research into the origin of this cydnid is warranted.

Lygaeidae

- *Blissus leucopterus* (Say) - Grasses, grain.

The muscardine fungus *Beauveria bassiania* (Bals.) = (*B. globulifera*) is an important natural enemy of the chinch bug in North America (De Bach 1964). Also there is a scelionid, *Eumicrosoma beneficum* Gahan, that parasitizes the chinch bug eggs in North America (McColloch and Yuasa 1915) as well as the tricogrammatid *Paracentrobia* (=*Abbella*) *subflava* (Girault). There is also a tachinid *Phorantha occidentis* Walk. reported to attack the chinch bug in North America (Thompson 1944). If erradication attempts of the chinch bug fail in Brazil, and I think they will because of its rather widespread distribution, high priority should be given to importing at least the chinch bug egg parasites since in Brazil there would be nearly a continuous source of eggs available, while in North America there are no eggs available during the winter months.

Pentatomidae

- *Nezara viridula* (L.) - Papaya, soybean, tomato, vegetables.

The scelionid *Trissolcus basalis* (Wall.) introduced into Australia and Hawaii accounted for substantial to complete biological control of *N. viridula* (Davis 1967, DeBach 1964).

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