

*Revisão de Literatura*

**BIOLOGICAL CONTROL OF FRUIT FLIES**

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**Abstract** - The biological control of fruit flies interacts with a set of integrated management strategies, meeting the demands of consumer markets. Biological control can serve as a tool available to the producer to control this pest, resulting in fruit with lower levels of pesticide residues and impact on the environment. Therefore, the biological control of fruit flies can be a process that can partially replace other methods of control in integrated management programs for these insects, especially the use of agrochemicals, presenting economic and environmental advantages for tropical fruit. Therefore, this study aimed to bring together information on the biological control of fruit fly, by entomopathogenic fungi, insect predators and parasitoids.

**Key words:** entomopathogenic, predators and parasitoids.

**CONTROLE BIOLÓGICO DE MOSCAS DAS FRUTAS**

**Resumo** - O controle biológico de moscas-das-frutas interage com um conjunto de estratégias de manejo integrado, atendendo as exigências dos mercados consumidores. O controle biológico pode servir como uma ferramenta a disposição do produtor no controle dessa praga, resultando em frutos com níveis de resíduos de agrotóxicos mais baixos e em menor impacto ao meio ambiente. Portanto, o controle biológico de moscas das frutas pode representar um processo que pode substituir parcialmente outros métodos de controle em programas de manejo integrado destes insetos, em especial o uso de agroquímicos, apresentando vantagens econômicas e ambientais para a fruticultura tropical. Portanto, este trabalho teve como objetivos aglutinar informações sobre o controle biológico de mosca das frutas, através de fungos entomopatogênicos, insetos predadores e parasitoides.

**Palavras-chave:** entomopatógenos, predadores, parasitoides.

**CONTROL BIOLÓGICO DE MOSCAS DE LAS FRUTAS**

**Resumen** - El control biológico de moscas de las frutas interage con un conjunto de estrategias de manejo integrado, atendiendo como exigencias de los mercados consumidores. El control biológico puede servir como una herramienta Un disposición productor ningún control de esa praga, resultando en frutos con niveles de residuos de agrotóxicos más bajos y en más pequeño impacto por la mitad ambiente. Por lo tanto, el control biológico de moscas de las frutas puede representar un proceso que puede sustituir parcialmente otros métodos de control en programas de manejo integrado de estos insectos, en especial el uso de agroquímicos, presentando ventajas económicas y ambientales para un fruticultura tropical. Por lo tanto, este trabajo tuvo como objetivos aglutinar informaciones sobre el control biológico de mosca de las frutas, a través de fungos entomopatogênicos, insectos predadores y parasitoides.

**Palabras-llave:** entomopatógenos, predadores, parasitoides.

## INTRODUCTION

The indiscriminate use of pesticides to control fruit flies causes a serious ecological imbalance and triggers the emergence of populations of other pests by eliminating natural enemies, and lead to human infection and the environment (MENDES et al., 2007). The development of techniques to control these pests is of paramount importance, due to considerable economic losses caused to fruit (CORSATO, 2004).

A viable alternative is the biological control of insects. This control can be done in several ways, involving different species, including other insect pest controllers agricultural. Biological control has been assuming increasing importance in programs of Integrated Pest Management - IPM fruit fly. It is one of the cornerstones of any IPM program and to act as one of the few alternatives for the future due to a global demand for food without pesticide residues. It is one of the most valued alternatives as it offers the potential to reduce or even eliminate the use of pesticides, thus reducing the problems that these compounds cause to the environment because of their abuse and indiscriminate.

Aiming to improve the quality of the fruit, the biological control of fruit flies interacts with a set of integrated management strategies, meeting the demands of consumer markets. Being used as an isolated strategy, biological control does not solve the problem of controlling the fruit flies, but can serve as a tool available to the producer to control this pest, resulting in fruit with lower levels of pesticide residues and less impact on the environment (CARVALHO & NASCIMENTO, 2002). Therefore, this study aimed to bring together information on the biological control of fruit fly, by entomopathogenic fungi, insect predators and parasitoids.

## BIOLOGICAL CONTROL

Biological control has been defined as the ability to maintain the population of other organisms in a lower average compared to what would occur in their absence this maintenance is done by the predators, parasitoids and pathogens. The pest population density tends to decrease with the increase in population density of natural enemies.

The biological control of fruit flies is given by parasitoids, predators and pathogens (SALLES, 1991). Very little is known about the action of predators of fruit flies in Brazil. Major hymenopteran parasitoids of flies belong to the families Braconidae, Pteromalidae and Figitidae (SALLES, 1995; MALAVASI & ZUCCHI, 2000). In Europe, for control of *Anastrepha Schiner*, 1868 (Diptera: Trypetidae) is performed by parasitoids through classical biological control, to achieve these augmentative releases of natural enemies are multiplied in mass (ALUJA 1994).

## ENTOMOPATHOGENIC FUNGI

Entomopathogenic fungi are also considered the main agents that control insect pests in agroecological systems, especially with regard to biological control. They stand out because they act differently from bacteria, protozoa and viruses, therefore, the mode of action of fungi occurs mainly by contact, clinging to the cuticle of insects, it is not necessary to have the intake, as insects can infect not only the intestine but also by the spiracles, and particularly the surface of the skin (SILVA, 2000), allowing the infection of insects regardless of their feeding activity (FERRON, 1978; HAJEK & LEGER, 1994). Organisms are easily spread and its commercial production is relatively easy (MAGALHÃES et al., 2000). Fungi can be used alone or integrated with other methods, such as natural insecticides of plant origin, pheromones, plant varieties resistant to insects (LOURENÇÃO et al., 1993). The infected insects lose their mobility and coloration, with his body stiff and brittle, and can sometimes be covered by mycelium and spores in appearance and coloration typical entomopathogenic associated (SILVA, 2000).

Several literatures have demonstrated the susceptibility of a large number of insect pests to entomopathogenic microorganisms, and from these fungi have given more attention potential (SILVA, 2001) for the control bodies of the order Coleoptera (McLAUGHILIN, 1962; BELL & HEBBEBERRY, 1980), Lepidoptera (WRIGHT & KNAUF, 1994; HINZ & WRIGHT, 1997), Hemiptera (PAPIEROK, 1987; KNAUF & WRIGHT, 1994), Orthoptera (MAGALHÃES & GAMA, 1995) and Diptera (STEINKRAUS et al., 1990; KAAYA & MUNYINYI, 1995; CASTILHO et al., 2000; ONOFRE et al., 2002).

The entomopathogenic fungi are responsible for about 80% of diseases that can cause diseases in populations of insects (ROBBS & BITTENCOURT, 1998). They are known more than 70 species of fungi that attack insects, therefore, it is estimated that that number is still much higher, because a large amount of existing species of insects and fungi (AZEVEDO, 1998). *Metarhizium*, *Beauveria*, *Verticillium*, *Nomuraea*, *Hirsutella*, *Entomophthora* and *Asckersonia* are the genera most commonly used in microbial control of insect pests. However, among the species most studied, so far, for the control of fruit flies are *Paecilomyces fumosoroseus* (Wise), *Beauveria bassiana* (Bals.) Vuill. and *Metarhizium anisopliae* Sorok.

The use of entomopathogenic fungi for biological control of pests, has been studied for over 100 years, with applications in local and regional scales. One factor that has attracted great interest in the study of fungi hyphomycetes is that they possess almost all the desirable characteristics for a pathogen to be effective as a commercial product (ALVES, 1998). Microbial agents of pest control are very important and often necessary to

control some pests that have a high reproductive capacity and short life cycle such as aphids. Bodies are considered safe for both the environment and to humans and other natural enemies (MILNER, 1997).

The pathogens present strategies for dissemination in the environment of major importance in triggering the infective process and can directly affect the programs release manipulated by man, or in the course of the winds, which interact to the occurrence of natural outbreaks. The means of transmission must be identified and the dispersal ability of pathogens quantified to facilitate understanding and predicting the development of diseases. In addition to the host itself, rain, wind, gravity, insects and birds are the most frequently involved in transmission of pathogens. Different ways of predators and parasitoids transmit or disseminate *B. bassiana* in populations of pests is through the body surface contaminated feces - while feeding on infested hosts - with the pathogenic activity generally maintained after passing through the digestive tract of predators (YOUNG & HAMM, 1985; MOSCARDI et al., 1996), or by contamination of the mouthparts.

The entomopathogenic fungi are microorganisms that have great dispersal ability due to their distribution in most of the world. They can be found associated with insects that live in different habitat types such as fresh water, air seats, and interior surfaces of soils (HAJEK & LEGER, 1994; SAMISH & REHACEK, 1999). Reys (2003) highlights that the most common agents of entomopathogenic Diptera are: *Entomophthora muscae* (Cohn) Fresen, *Cotoneaster apiculatus* and *Erynia sp.* The fungi *E. muscae* caused 100% mortality of *Musca domestica* L. (BENOIT et al., 1990), in addition, research conducted in the United Kingdom have shown the efficiency of the pathogen *S. castrans* in control of Anthomyiidae *Delia radicum* (L.) (EILENBERG et al., 1992).

Fungi hyphomycetes are recorded as the main pathogens of arthropods, which often leads to large decrease in population levels of pests (GOETTEL & HAJEK, 2001), there is advantage to directly penetrate the cuticle and need not be ingested by target insects and thus causing diseases. Among the representatives of this family, stand out with greater relevance of research with the fungi *Metarhizium* and *Beauveria*. These agents are considered effective control agents of terrestrial insects because of their wide geographical distribution, a large number of hosts and their exceptional ability to germinate in an environment of relatively low humidity, a factor of great importance to increase the possibility of using these agents in control fruit flies in dry regions. The use of commercial formulations of fungi against insects is seen growing. Studies in relation to possible alternative ways of making these formulations microorganisms are promising as commercial agents for biological control of pests (REYS, 2003).

Entomopathogenic fungi can be used in programs to control *C. capitata* by soil application against their larvae and pupae, offering great advantages because it

allows the multiplication of pathogens in agroecosystems. Mochi et al. (2005) found that the application of conidial suspension of *M. anisopliae* on the surface of the soil decreased the survival in the pupal and adult *C. capitata*. According to Onofre et al. (2002) this is a promising alternative for controlling fruit flies, because they are known to be pathogenic to flies as fly African tsetse *Glossina morsitans morsitans* Westwood (KAAYA & MUNYINYI, 1995), *C. capitata* (CASTILLO et al., 2000) and *M. domestica* (STEINKRAUS et al., 1990).

The microbial control of fruit flies can be a process that can partially replace other methods of control in integrated management programs for these insects, especially the use of agrochemicals, presenting economic and environmental advantages for tropical fruit. Rodrigues-Destéfano et al. (2005), reported mortality of up to 86% for concentrations of conidia of  $2.52 \times 10^{10}$  for simulating field conditions in soil autoclave and  $2.52 \times 10^{10}$  for tillage autoclaves. In other hands, Ekesi et al. (2003) found wide variation in the responses obtained for the isolates. According Lanza et al. (2004) soil type and degree of compaction influence the survival of *M. anisopliae* in the soil, being favored in the soil with sandy-clay texture and when the soil is very compacted.

Oliveira (2008), studying the effects of concentrations corresponding to  $5.00 \times 10^9$ ,  $7.50 \times 10^9$ ,  $10.00 \times 10^9$ ,  $12.50 \times 10^9$  viable conidia/L of water, *B. bassiana* and *M. anisopliae* on larvae of the 1st and 3rd instar, and pupae aged 8 to 10 days of *C. capitata*, found that the mortality of *C. capitata* varies depending on their stage of development, and the stage was less susceptible to pupation. This author reported that the total mortality of larvae of the 1st and 3rd instar of *C. capitata*, in all concentrations of conidia of *M. anisopliae*, and a dose dependent effect in all treatments mentioned.

Results obtained by Reys (2003) on the effect of the fungi *M. anisopliae* on the mortality of fly larvae Mexican (*Anastrepha ludens* (Loew)), revealed high levels of pathogenicity of the fungi *M. anisopliae* to larvae of this insect pest. Quesada-Moraga et al. (2006) observed lethal and sub-lethal suspensions of *B. bassiana* and *M. anisopliae* in *C. capitata*, causing mortality in adult *C. capitata*, ranging from 30 to 100%. These researchers also found that *B. bassiana* reduced fecundity and fertility of *C. capitata* up to 71.2% and 60.0%, respectively. Dimbi et al. (2003), reported an overall mortality of adult *C. capitata*, *C. rosa* variety fasciventris Karsch and *C. cosyra* (Walker) (Diptera: Tephritidae) submitted applications with low concentrations of conidia of *B. bassiana* and *M. anisopliae*.

Most research has emphasized the adoption of strains of entomopathogenic fungi only in control of pupae and adults of fruit flies (DIMB et al., 2003). In other hands, Oliveira (2008), emphasizes the possibility of using *B. bassiana* and *M. anisopliae* as a further measure of control larvae of 1st and 3rd instar of *C. capitata*, because the control of larvae present in infested fruits lying on the ground is a very useful in the multiplication

of entomopathogenic microorganisms and in preventing the spread of these insects in the field.

## PARASITOIDS

Major hymenopteran parasitoids of flies belong to the families Braconidae, Pteromalidae and Figitidae (SALLES 1995, MALAVASI & ZUCCHI, 2000). In Europe, for control of *Anastrepha*, is performed by parasitoids through classical biological control, to achieve these augmentative releases of natural enemies are multiplied creations mass (ALUJA, 1994).

Virtually no study on some Braconid fruit fly in Brazil for about fifty years. The research on these insects in Brazil were extremely incremented from a dissertation on the taxonomy associated with braconid flies fruit displayed Escola Superior de Agricultura Luiz de Queiroz in 1991 (ZUCCHI, 2002). Several authors in Brazil have studied the importance of braconidae as agents of mortality of fruit flies (LEONEL Jr. et al., 1996; SALLES, 1996) as measured by levels of parasitism. However, in many regions where the fruit is a major concern, for example, Janaúba/Jaíba (MG), Petrolina/Juazeiro (PE/BA) and Rio Grande do Norte/Açú (RN), information related braconid are considered incipient (ALVARENGA et al., 2000; HAJI & MIRANDA, 2000; ARAUJO et al., 2000).

In many countries, has been used for biological control, primarily through the use of braconid parasitoid Hymenoptera (Opiinae) of the family Braconidae, as a method of controlling flies fruit (CLAUSEN, 1956; WHARTON, 1989; OVRUSKI et al., 2000), especially because of its specificity as to the use of tephritid as hosts (WONG et al., 1984; STECKER et al., 1986; WONG & RAMADAN, 1987; JIRON & MEXZON, 1989; ALUJA et al., 1991; LEONEL Jr. et al., 1996). However, for the success of a program of biological control with parasitoids in the region, it is necessary to understand the diversity of native species of parasitoids and their population dynamics. In studies conducted in Brazil, were found 13 species of Braconid, and *Doryctobracon areolatus* (Szépligeti) (Hymenoptera: Braconidae), the most common (CANAL & ZUCCHI, 2000).

Another species of parasitoids successfully used in biological control programs is the braconid *Diachasmimorpha longicaudata* (Ashmead) (Hymenoptera: Braconidae), and the species most used around the world because of its ease of creation in the laboratory, through rapid adaptation to environments where released and the condition in the specialist tephritid parasitism (CARVALHO & NASCIMENTO, 2002). The need to meet the demands of consumer markets, for the quarantine measures imposed, led Brazil in 1994 to introduce the exotic parasitoid, *D. longicaudata*, as part of a set of integrated management strategies aimed at improving the quality of fruit. Parasite, preferably, larvae of 2nd and 3rd instar *D. longicaudata* is among the five

species of the braconid subfamily Opiinae important in regulating populations of fruit flies (PURCELL et al., 1994).

The Ministry of Agriculture of Brazil, through its Superintendent of Agriculture in the Amazonas has made in recent years the release of an exotic parasitoid species, *D. longicaudata* in an attempt to control the *Bactrocera dorsalis* (Hendel) (Diptera: Tephritidae) (Silva et al., 2004). In the region of Goiania, Goiás State, Marchiori et al. (2000) found three species of parasitoids in the following proportions: *Doryctobracon areolatus* with 89.60% *Aganapis pelleranoi* with 6.20% and *Pachycrepoideus vimdamniae* with 4.20% of individuals. The result shows that *D. areolatus* can be considered the most important parasitoid fruit flies in this region. A study conducted at the Experimental Station of the South Central Regional, Piracicaba-SP was revealed that *D. areolatus* was the only species of parasitoids recorded. Because we have ovipositor longer and parasitize larvae in fruits of larger size, this species of parasitoid is associated with parasitism of larvae in a large number of fruit species (LEONEL Jr. et al., 1995). In the State of Amapá, Guimaraes et al. (2004) reported *Leptopilina bouvardi* as a species of parasitoid of *Tephritidae*. Seven other species were related by Silva & Silva (2005): *Doryctobracon areolatus* (Szépligeti), *Doryctobracon sp.*, *Opius sp.*, *Opius bellus* (Gahan), *Utetes anastrephae* (Viereck), *Asobara anastrephae* (Muesebeck) and *Aganaspis pelleranoi* (Brèthes).

The preservation of areas of refuge within the property and use of exotic parasitoid *D. longicaudata* (Hymenoptera: Braconidae), are tactics to increase the population of native parasitoids, being very useful in the ecological management of this pest on family farms agroecological profile. It is expected to reduce the infestation of fruit flies, with the presence of exotic species established in both plants exploited commercially as the native plants that host the pest in the off-season.

## PREDATORS

Very little is known about the action of predators of fruit flies in Brazil. A study by Galli & Rampazzo (1996), with the objective of identifying groups of insect predators of larvae and pupae of fruit flies *Anastrepha*, found a high occurrence of predators, the total number of 8572 arthropods collected. The Hymenoptera were present in greater quantity in dermapters and beetles, with a total of 7541, 531 and 500 individuals, respectively, for each order. The Hymenoptera of the genus *Pheidole* and *Solenopsis* were found in greater numbers, 5802 and 1652 individuals respectively. With 531 individuals collected in the order Dermaptera, the genre had *Labidura* with 1 presence. In order Coleoptera, the species *Belonuchus ruffipenis* and genus *Scarites* and *Callas* are insects that stood out, with 153; 142 and 120 individuals, respectively.

According to the authors, arthropods collected in greater intensity and more important for the biological control of larvae and pupae of fruit flies on the ground, were Carabidae (*Calasoma granulatum* Perty; *Calleida* sp. Fabricais; *Scarites* sp. Dejean), Staphylinidae (*Belonuchus hemorroidal* Fabricius and *B. ruffipenis* Fabric), Labiduridae (*Labidura* sp), Formicidae (*Pheidole* sp. and *Solenopsis* sp) and Mutilidae.

## CONCLUSIONS

Biological control of fruit flies can serve as a tool available to the producer to control this pest, resulting in fruit with lower levels of pesticide residues and impact on the environment. Therefore, the biological control of fruit flies can be a process that may partially replace other methods of control in integrated management programs for these insects, especially the use of agrochemicals, presenting economic and environmental advantages for tropical fruit.

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