Tenebrio molitor and its applications in Biological Control

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ABSTRACT

The growth of the world's population increases the demand for food and natural resources such as water, energy, and land use. The requisition and consequent use of natural resources in an unbridled and unsupervised way generates environmental degradation.

Intensive agriculture to feed billions of people leads to the conversion of forests and other natural ecosystems to farmland, resulting in deforestation, biodiversity loss, and soil degradation.

The need for new sources of protein, more sustainable and that collaborate with the well-being of the ecosystem, generates the process of studying the existing viabilities, even if remote or unknown, and, in this perspective, are the studies on the feasibility of insects as environmentally friendly and alternative sources of protein.

Tenebrio molitor has been the target of many studies because it has characteristics that highlight it as a promising, sustainable, economically viable and ecologically friendly option, within the context of the New Food Frontier, since Tenebrio molitor farming contributes to global food security, and requires less costs, less water and land resources, compared to conventional animal husbandry. In addition to their use as food for humans and animals, the use of by-products and in Biological Control has drawn the attention of scholars in the defense of the environment.

Biological control is a sustainable management method that uses natural enemies, such as insects, parasites, pathogens, and predators, to regulate the population of unwanted organisms, presenting an environmentally safe alternative to chemical pesticides (Roberto et al., 2002). This method helps to reduce dependence on chemical products, which, although effective, pose risks to the environment and human health, in addition to promoting the emergence of resistant and secondary pests, and negatively affecting beneficial insects (Bueno et al., 2017).

Tenebrio molitor, known as the flour beetle, has been used as a host, prey and predator in biological control programs, presenting promising and effective characteristics. This insect can host parasitoids such as Trichospilus diatraeae, Tetrastichus howardi, Palmistichus elaeisis, used to control agricultural pests such as the screwworm (Spodoptera frugiperda), fruit flies, palm moths and brown caterpillar (Thyrinteina arnobia) (Favero et al., 2014); (Tiago et al., 2019); (Zanuncio et al., 2008).

In addition to being used in the breeding of parasitoids, Tenebrio molitor has a fundamental role as prey in the breeding of predatory insects such as Podisus maculiventris, Podisus nigrispinus, Pristhesancus plagipennis (De Clercq et al., 1998).

The use of Tenebrio molitor in Biological Control has benefits for agriculture, by allowing pest control in a more sustainable way and reducing dependence on chemicals harmful to the environment, however there are also challenges such as the risk of negative impact when larvae are released into natural environments, without adequate control. More research is needed to fully understand the effects of this species on the ecosystem and ensure that its use is done in a sustainable way.

Keywords: Biological Control, Tenebrio molitor, Environmental Degradation, Intensive Agriculture.

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INTRODUCTION

DEFINITION: BIOLOGICAL CONTROL

Biological control, according to Roberto et al. (2002), is a natural phenomenon that consists of the regulation of the number of plants and animals by natural enemies, which constitute agents of biotic mortality. Thus, all species of plants and animals have natural enemies attacking their various life stages. That is, it is when an organism controls another organism.

It is a method used for the management of unwanted organisms in the environment, using biological agents, such as insects, parasites, pathogens, and predators, to control the population of the target organism. This method is considered a more sustainable and environmentally safe alternative to chemical pesticides.

With the rise of conventional agriculture, the use of chemicals has been adopted as the main method of controlling pests and diseases, although efficient they pose several risks to the environment and human health. The irrational use of insecticides causes the emergence of resistant and secondary pests and reduces the activity of beneficial insects (Bueno et al., 2017). In this way, the importance of developing productive agricultural practices, but in a sustainable way, controlling and even eliminating agricultural pests without leaving residues or causing damage to plants and the environment is increasingly debated.

APPLICATIONS IN BIOLOGICAL CONTROL

Tenebrio molitor can be used as an agent used in biological control because it can serve as a host for other parasites and is a natural predator that feeds on other insects, including fly larvae, moths and cockroaches. It has been used as an effective tool in the biological control of pests, especially with regard to the handling of insects harmful to agriculture.

Biological control programs rely on the mass breeding of parasitoids, and the lack of artificial diets makes it necessary to use preferred or alternative hosts to produce natural enemies (Pratissoli et al., 2007). These hosts should have low production costs without reducing the efficiency of the parasitoids.

The use of parasitoids in most biological control programs requires that the parasitoids meet some requirements, such as high-quality and low-cost techniques for breeding these insects (Colinet et al., 2011); (Leite et al., 2013).

BIOLOGICAL CONTROL OF THE BOLLWORM WITH TRICHOSPILUS DIATRAEAE

In biological control, *T. molitor* is used in the rearing of natural enemies, being an excellent alternative host for the rearing of parasitoids, such as *Trichospilus diatraeae* (Favero et al., 2014), *Tetrastichus howardi* (Tiago et al., 2019) and *Palmistichus elaeisis* (Zanuncio et al., 2008).

Trichospilus diatraeae is a parasitoid that can be used in the biological control of infestation by screwworm (*Spodoptera frugiperda*) (Figure 31) in corn, cotton, and other grains, fruits, and vegetables.

Figure 31

Source: https://summit-agro.com/ar/en/2020/12/18/oruga-militar-tardia/

Favero et al. (2014) [61] highlighted that the flour beetle is a viable and suitable option for breeding *Trichospilus diatraeae*. The results of this research showed that the survival of the parasite, when it was in the pupae of *Tenebrio molitor* was 92.65%. This means that Tenebrio in the pupal stage, may be a suitable option to create and provide an environment conducive to the development of the parasite *Trichospilus diatraeae.*

For information, I find it interesting to detail the procedure of using parasites created in the laboratory, in biological control, so we note where the participation of *Tenebrio molitor* in this process comes in.

How to use *Trichospilus diatraeae* in biological control:

1. Target pest identification: Before using *Trichospilus diatraeae*, it is important to correctly identify the target pest. Make sure you're dealing with the fall armyworm.
2. Trichospilus diatraeae *supply and maintenance*: Contact a reliable *Trichospilus diatraeae* supplier to obtain the adult parasitoids. They are usually made available in packs containing parasitized pupae. Follow the vendor's guidelines for proper storage and maintenance.
3. Release of parasitoids: Adult parasitoids should be released into the field when the population of stray caterpillars reaches an acceptable level of infestation. Follow the supplier's instructions to determine the proper release rate, which can vary depending on the size of the growing area and the stage of development of the pest.
2. Monitoring and evaluation: After the release of *Trichospilus diatraeae*, regularly monitor the field to assess the effectiveness of biological control. Observe the level of infestation of screwworms and check for the presence of parasitized pupae of *Trichospilus diatraeae*.

3. Complementary measures: Biological control with *Trichospilus* diatraeae can be complemented with other integrated pest management techniques, such as the use of resistant plants, crop rotation, and cultural management practices. Consult a biological control specialist or agronomist for personalized guidance based on your crop characteristics.

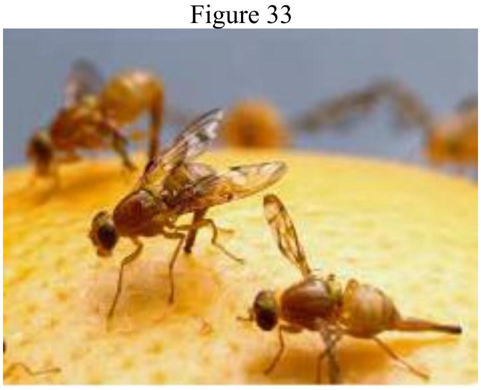
BIOLOGICAL CONTROL OF FRUIT FLIES WITH *TETRASTICHUS HOWARDI.*

Tetrastichus howardi (Figure 32) is a parasitoid insect that is widely used in biological pest control, specifically for fruit fly control (Figure 33).

Figure 32

Source: https://www.cabidigitallibrary.org/doi/10.1079/cabicompendium.53369

Figure 33



Source: https://www.ecycle.com.br/mosca-das-frutas/

Females of *Tetrastichus howardi* lay their eggs inside fruit fly larvae in the fruits, and parasitoid larvae develop inside these larvae, eventually killing them. In this way, *Tetrastichus howardi* helps to significantly reduce the population of fruit flies in agricultural crops.

Tiago et al., (2019) concluded that *Tenebrio molitor* is a suitable host for the breeding of *Tetrastichus howardi*, which is an important parasitoid of agricultural pests. The pupae of *Tetrastichus howardi* can be stored in pupae of *Tenebrio molitor* for 10.20, 30, 60 and 90 days at 10.3 C and their emerged adults used in biological control programs, preferably pupae after 10 days of storage, without deleterious effects for the population of this parasitoid.

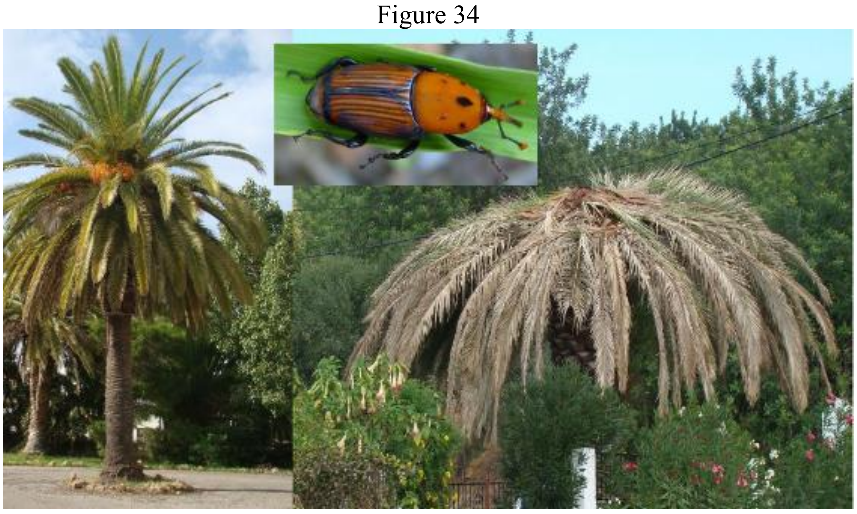
These results contribute to overcome one of the difficulties encountered in the mass production of parasitoids, which is to obtain a large number of suitable hosts when necessary. Therefore, the possibility of conserving *Tenebrio molitor* pupae for Tetrastichus howardi breeding will be useful for the use of this natural enemy in biological pest control programs.

Biological control with *Tetrastichus howardi* is an alternative to traditional pest control methods, such as the use of insecticides. It is a more sustainable and more environmentally friendly option, since it does not cause harm to non-target organisms and does not leave chemical residues in the crops.

BIOLOGICAL CONTROL OF PALM MOTHS AND BROWN CATERPILLAR WITH *PALMISTICHUS ELAEISIS*

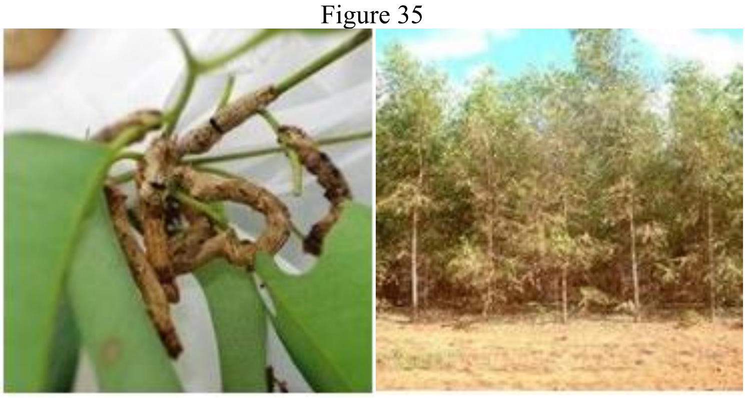
Palmistichus elaeisis (Figure 36) is a parasitoid insect used in the biological control of agricultural pests, such as palm moths (*Rhynchophorus*) (Figure 34) and brown caterpillar *Thyrinteina arnobia* (Figure 35). These pests are responsible for causing significant damage to palm and eucalyptus plantations, harming cultivation and production.

Figure 34



Source: https://www.phosphorland.pt/escaravelho-da-palmeira/

Figure 35



Source: https://www.agrolink.com.br/problemas/lagarta-dos-eucalipotos_1481.html

P. elaeisis (Figure 36) is a parasitoid that attacks the larvae of palm moths and the brown caterpillar, laying its eggs on them. The larvae of the parasitoid develop by feeding on the interior of the larvae of the caterpillars' moths, resulting in their death. Thus, the use of this parasitoid insect helps in the effective control of the palm moth population, providing a sustainable and environmental alternative.

Figure 36

Source: https://www.researchgate.net/figure/Females-of-Palmistichus-elaeisis-Hymenoptera-Eulophidae-parasitizing-pupae-of-A_fig1_261796931

Palmistichus elaeisis showed good reproductive performance (adequate parasitism, emergence, offspring by pupa, and body size, in addition to more longevity of males and females and sex assess) when reared on pupae of the alternative host T. molitor. In addition, the low cost to rear this alternative host indicates it could easily be used to rear mass the parasitoid P. elaeisis for biological control program Palmistichus elaeisis showed good reproductive performance (adequate parasitism, emergence, offspring by pupa, and body size, in addition to more longevity of males and females and sex evaluate) when reared on pupae of the alternative host T. molitor. In addition, the low cost for rear hosting this alternative indicates it could easily be used to rear mass the parasitoid P. elaeisis for biological control programs

According to Zanuncio et al., (2008), *Palmistichus elaeisis* showed adequate parasitism when reared on pupae of *Tenebrio molitor* (host). Due to the low cost and high adequacy index, the use of *Tenebrio molitor* as a host alternative for *Palmistichus elaeisis* is fully feasible to be used en masse in biological control programs.

BIOLOGICAL PEST CONTROL WITH *PODISUS MACULIVENTRIS*

In addition to being used in the breeding of parasitoids, *T. molitor* plays a fundamental role in the breeding of predatory insects. It is cultivated as prey for predators such as *Podisus maculiventris*, *Podisus nigrispinus*, *Pristhesancus plagipennis, and Supputius cincticeps*.

Studies have shown that *T. molitor* larvae have a capacity for predation, serving as prey in the breeding of predatory insects, such as: *Podisus maculiventris, Pristhesancus plagipennis,* among others.

Podisus maculiventris (Figure 37), also known as the predatory stink bug or black predator stink bug, is often used as a biological control agent in integrated pest management programs.

Figure 37

Cast Iron: https://anatisbioprotection.com/en/produit/podisus-maculiventris/?region=ca

The role of this predatory insect is to feed mainly on agricultural pests, such as caterpillars of various species of insects and aphids. By consuming these pests, *Podisus maculiventris* helps to reduce its population, thus decreasing the damage caused to crops (Figure 38).

Figure 38

Source: https://www.researchgate.net/figure/Dorsal-view-of-an-adult-spined-soldier-bug-Podisus-maculiventris-Say-feeding-on-a_fig1_237565622

This predatory stink bug is considered an effective biological control option because it is able to adapt to different agricultural crops and has a broad spectrum of prey. In addition, it is capable of reproducing itself in the laboratory, which facilitates its large-scale creation for commercial use. Precisely in this sense, there is the possibility of using Tenebrio molitor as food provided to the predatory bug.

Gyawaly (2011), conducted a study to investigate the feeding behavior of Podisus maculiventris using the yellow mealworm, *Tenebrio molitor* (Coleoptera: *Tenebrionidae*), at different life stages, which it could potentially feed on, in a mass rearing system, with the aim of determining food preferences.

It was concluded that *Podisus maculiventris* prefers to feed on large larvae against small larvae of *T. molitor*. Secondly, the study was carried out to investigate the feeding preference and feeding capacity of *Podisus maculiventris* in different types of larvae. Using smooth, hairy, coleoptera larvae, feeding preferences were determined. Third instar, fifth instar and adults of P. maculiventris significantly preferred to feed on smooth larvae. Hairy larvae were the least preferred. *P. maculiventris* showed the highest ability to feed on smooth larval species, followed by beetle and hairy larvae. The findings of this thesis have important implications for successful biological control using P. aculiventris and *T. molitor*.

In the study by De Clercq et al., (1998) whose objective was to discuss the practical value of different foods for the mass rearing of *Podisus maculiventris*, it was concluded that female predators raised with artificial diets had fecundity similar to that of females fed with larvae or pupae of *T. molitor*

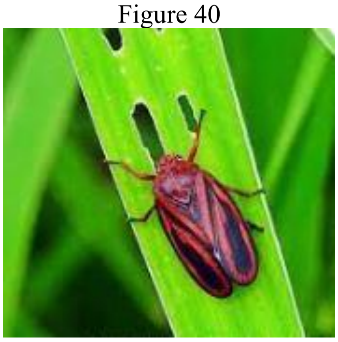
BIOLOGICAL CONTROL OF THE FLOWER LEAFHOPPER WITH *PRISTHESANCUS PLAGIPENNIS*

Pristhesancus plagipennis (Figure 39), known as the leafhopper wasp, plays an important role in biological pest control. This wasp parasitizes the nymphs of the flowerhopper (*Mahanarva fimbriolata*) (Figure 39), which is considered one of the most destructive pests for sugarcane crops.

Figure 39

Source: https://www.biodiversity4all.org/taxa/450938-Pristhesancus-plagipennis

Figure 40



Source: https://biofaces.com/post/97968/mahanarva-fimbriolata

When the spittlebug wasp lays its eggs on the nymphs, the larvae of *Pristhesancus plagipennis* develop inside the body of the host insect, feeding on it. This leads to the death of the spittlebug and reduces the population of this pest in sugarcane plantations.

Therefore, the role of *Pristhesancus plagipennis* in biological control is to regulate the population of spittlebugs, contributing to the sustainable management of agricultural pests. This makes it possible to reduce the need to use chemical pesticides, minimizing crop damage and environmental impact.

Pristhesancus plagipennis is also a larval and nymph predator of many pestiferous insects for which natural enemies are not commercially available. Grundy et al., (2000), describes a method of mass rearing in containers for *P. plagipennis* using dead larvae of *Tenebrio molitor* (L.) and *Helicoverpa armigera* (Hübner) in hot water. The larvae of the yellow flour larvae, *T. molitor,* were the most suitable prey to minimize nymphal development time and mortality, while producing insects with higher body weight.

BENEFITS AND CHALLENGES

Tenebrio molitor plays a crucial role in biological control, both as a host for parasitoids and as prey for predatory insects. Its use in the creation of these natural enemies benefits agriculture, allowing pest control in a more sustainable way and reducing dependence on chemicals that are harmful to the environment.

The use of *Tenebrio molitor* in biological control has some significant benefits. First of all, the larvae are easy to reproduce and maintain, which makes their cultivation an economically viable activity. In addition, these larvae have a minimal risk of becoming a pest themselves, as their feeding habits are primarily directed toward grains, bran, and other organic debris.

However, there are also challenges associated with the use of *Tenebrio* molitor in biological control. One of them is the risk of negative environmental impact when larvae are released into natural environments, without adequate control. In addition, more research is needed to fully understand the effects of this species on the ecosystem and ensure that its use is done sustainably.

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