New Aspects and Practices of Biological Control Conservation

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Abstract: Natural enemies are subjected to continuous deterioration in populations especially in modern agricultural systems characterized by complete removal of plants after harvesting as well as by insecticide applications. This complete removal of plants gives rise to disappearance of natural enemies after each crop season. Conservation biological control is the protection of NEs against adverse effects of pesticides and incompatible cultural practices and improving their efficiency via providing food sources. During non-crop periods, natural enemies may need of benefit from pollen and nectar. Preservation of natural enemies can be achieved by providing habitat and resources for NEs.

The present work aimed at discussing a suggested strategy for more efficient conservation biological control comprising collection, preservation and releasing the preserved natural enemies on target crops. The collection is mainly conducted before crop harvest and during winnter from fruit orchards. Preservation greenhouses are dedicated for natural enemies rather than commercial production of crops. Natural enemies taken from preservation greenhouses are released in target crops during growing season. Different techniques used in collection, preservation and release of natural enemies are reviewed. Such a conservation biological control strategy might contribute to preserve the natural bio-diversity in the environment and provide natural alternatives to pesticides.

Zusammenfassung: Die nützlingen Insekten sind einer fortwährenden Verschlechterung der Populationen ausgesetzt, insbesondere in modernen landwirtschaftlichen Systemen, die durch vollständigen Entfernung von Pflanzen nach der Ernte sowie durch Insektizidanwendungen gekennzeichnet sind. Diese vollständigen Entfernung von Pflanzen führt dazu, dass die natürlichen Feinde (NF) nach jeder Erntesaison verschwinden. Die biologischen Bekämpfung von Erhaltungsmaßnahmen ist der Schutz von NF vor schädlichen Wirkungen von Pestiziden und inkompatiblen kulturellen Praktiken sowie die Verbesserung ihrer Effizienz durch die Bereitstellung von Nahrungsquellen. In Zeiten außerhalb der Kultur können natürliche Feinde von Pollen und Nektar profitieren. Die Erhaltung natürlicher Feinde kann durch die Bereitstellung von Lebensraum und Ressourcen für NF erreicht werden. Die vorliegenden Arbeit zielte auf die Erörterung einer vorgeschlagenen Strategie für die effizienteren biologischen Kontrolle der Konservierung ab, die das Sammeln, Bewahren und Freigeben der erhaltenen natürlichen Feinde auf Zielkulturen umfasst. Die Sammlung wird hauptsächlich vor der Ernte und während des Winters aus Obstplantagen durchgeführt. Konservierungsgewächshäuser sind eher für natürliche Feinde als für die kommerziellen Produktion von Getreide bestimmt. Eine solche Strategie zur Erhaltung der biologischen Bekämpfung könnte zum Erhalt der natürlichen Biodiversität in der Umwelt beitragen und den natürliche Alternativen zu Pestiziden bieten.

Key words: Natural enemies, collection, preservation, release, parasitoids, predators, pathogens

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Introduction

Conservation biological control is one of biological control main branches (Debach & al. 1991), which can be firstly realized by reducing the use of pesticides, use of selective pesticides, careful timing and placement of pesticide applications. We have seen what happens when insecticides destroy the natural enemies of potential pests. Insects that were of little economic importance may become destructive pests. When non toxic control method is used natural enemies are more likely to survive and reduce the populations of pests.

During non-crop periods, natural enemies may need of benefit from pollen, nectar or honeydew (produced by aphids). Many crop-plants flower for only short time, so flowering plants along the edges of the field or within the field may be needed for pollen and nectar (Wäckers & al. 2005). Preservation of natural enemies can be achieved by providing habitat and resources for natural enemies (Fiedler & al. 2008). They are usually not active during the winter. Unless they are re- released each year, they must have a suitable environment for overwintering (Leather 1993). They usually pass the winter in crop residues, other vegetation or in the soil. Ground cover of fruit orchards, winter crops, usually provides shelter for overwintering natural enemies. Adding plants or other food sources for natural enemies must be done with knowledge of the behavior and biology of the natural enemy and the pest (Bianchi & Wäckers 2008; Maoz & al. 2011).

It is widely known that the simplifications of agriculture systems towards mono-culturing are mainly responsible for decreasing environmental quality, threatening biodiversity, and increasing the possibility of insect outbreaks. Modern crops are often monocultures in highly specialized production units, where not only crop cultivation, but also harvest and packaging techniques are specialized (Huang & al. 2011; Parolin & al. 2012). The development of farming systems (field or landscape) with greater dependence on ecosystem services, such as biological control of insect pests, should increase the sustainability of agro-ecosystems (Tscharntke & al. 2007; El-Wakeil & Hussein 2009). Farming systems like greenhouses, annual crop systems and other practices that end with removing the whole crop after harvesting, may give rise to elimination of biodiversity, and decreasing the population of natural enemies in the fields or in different agricultural environments (Lavandero & al. 2006; Gurr & al. 2012), as appeared in Fig. 1. Collection and transferring of natural enemies to environmentally controlled habitats could be useful in utilizing these natural enemies until releasing them in the next crop season.

Thus, they will try to contribute to preserve the natural bio-diversity in the agricultural environment and provide natural alternatives to chemical pesticides. We concentrate here on the effects of conservative biological control on NE biodiversity and cleanliness of environment.

This work aims at discussing a suggested strategy for more efficient conservation biological control comprising of three main practices:

1. Collection of natural enemies before the end of crop season.
2. Preservation of collected natural enemies in special greenhouses during non-crop periods
3. Releasing the preserved natural enemies on target crops in the next growing season.

The sequence of these practices is illustrated in Fig 2.

Collection of Natural Enemies

The first step of the suggested strategy is collection of NE from fields shortly before the complete removal of plants and disappearance of occurring NEs. At the end of the crop season, the NEs are usually in their top population densities.

<u>Collection time</u>

Summer collection: High numbers of natural enemies may be found during the growing season on areas cultivated with some crops. These crops may not in need for these natural enemies especially in absence of insect hosts or preys. For example after heavy infestation of aphids to maize plants, high populations of aphid predators (lacewings and lady beetles) are built up. These predators could be mass collected and directly transferred to the preservation greenhouses or directly to other target crops that in need for them.
Autumn collection: Before the end of most of annual crops, there are huge numbers of natural enemies which may be lost after harvesting and removing the plants. These NEs could be collected, preserved in greenhouses during non-crop periods then released in the next season.

Fig. 1: Complete removal of maize may eliminate natural enemies (A) or after roses cutting (B)

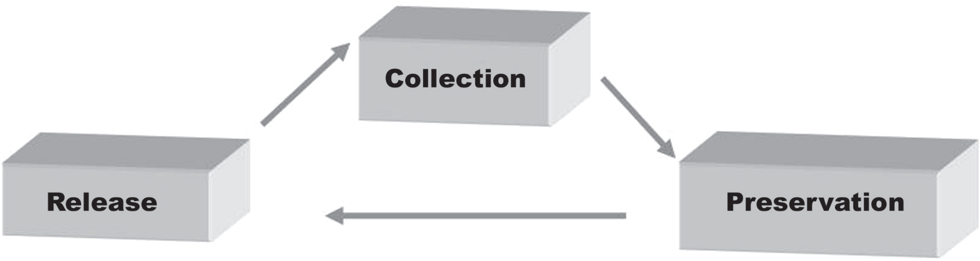

Fig. 2: Logical practices diagram of conservation biological control.

Winter collection: In cases of permanent crops like fruit orchards and alfa alfa during cold weather in winter, many numbers of natural enemies may be lost as a result of absent of their hosts and preys, especially during non-suitable weather conditions. These natural enemies could be collected and transferred to greenhouses where maintained and improved them in numbers and quality control until release during the next crop season.

<u>Collection sites</u>
Natural enemies may be abundant in many sites around the year including landscape, fruit orchards, vegetable and field crops and ornamentals and others.

<u>Collection techniques</u>
Collection techniques differ according to the nature of natural enemies, crop, time and site. The common collection techniques are vacuum collection, sweeping net, pitfall traps, manual collection and etc. Collection techniques depend on many factors like pest species, host plant, type of natural enemy, habit, time, weather and others.

Preservation of Natural Enemies
Preservation greenhouses are dedicated for natural enemies rather than commercial production of crops. Preservation practices represent the cornerstone of conservation biological control. Preservation practices could be applied individually or in combination to maintain and improve efficieny of collected natural enemies. Practices of preservation of natural enemies are many and vary according the types of natural enemies, the target pests, the plants and the ecological conditions.

<u>Plant-provided food</u>
Many plants can provide food sources for natural enemies like nectar, pollen and plant sap but the effect of these food sources depends on the type of predator / parasitoid. Specialist natural enemies only reproduce in the presence of their specific prey/host species. However, most other natural enemies are feeding on both plant resources and prey (Coll & Guershon 2002).

Food sprays

Artificial or natural food supplements can be sprayed or dusted onto the crop to support natural enemies in crops where nectar and pollen are absent or only present at low densities (Gabarra & al. 2004). For example, pollen sprays can serve as food for predatory mites and enhance their efficacy against thrips and whiteflies on cucumber (van Rijn & al. 2002; Wade & al. 2008; Nomikou & al. 2010).

Introducing non-crop plants harboring the prey species

The use of alternative prey / host plant species for the preservation of released natural enemies in many crops has been of interest for biological control of insect pests (Huang & al. 2011). A widely applied system in different crops has been the use of monocotyledonous plants with cereal aphids that serve as alternative hosts for parasitoids of aphids that attack the dicotyledon crop (Frank 2010; Huang & al. 2011).

Applying artificial food for natural enemies

The application of yeast and sugars in chrysanthemum maintained populations of astigmatic mites that are suitable prey for predatory mites (Messelink & al. 2008, 2009, 2010).

Providing oviposition sites and shelters

Suitable oviposition sites are essential for reproduction of many predators. *Orius* spp. and *Mimulus pygmaeus* lay their eggs into soft plant parts and ovipositional acceptance of the host plant depends on the morphological characteristics such as epidermal thickness or trichome density (Ode 2006; Lundgren & al. 2008; El-Wakeil & al. 2009).

Release of Natural Enemies

Release techniques are varied according the type of biocontrol agents, host plants, weather conditions. For example egg parasitoids are released as parasitized egg patches; larval parasitoids are released as adults. Predators are usually released in the pupal stage. Timing, rate and frequency of release are determined according to the nature of the target pests, natural enemies and crops. Pathogens like entompathogenic nematodes could be applied as sprays or injection (El-Wakeil & Hussein 2009; Saleh & al. 2014, 2015).

Egg parasitoids

The common techniques of releasing egg parasitoids are paper cards or strips holding the parasitized eggs. Cardboard strips containing parasitized eggs in tubes were released in tomatoes for controlling *Tuta absoluta* (Chailleux & al. 2012; El-Arnaouty & al. 2014). *Trichogramma buesi* was released against *Pieris rapae* eggs in cabbage fields (Abbas 1989). A dose of 3000 *T. evanescens* wasps / card x 3 cards / tree was applied, each card contains 3 different ages of *Trichogramma* to keep searching adults continuously; 8 – 11 releases were performed per year at 2-week intervals against *Prays oleae* in olive fields (Agamy 2010; Herz & al. 2005; Hegazi & al. 2007). Five releases of *Trichogramma* at two release levels (50 and 75 cards / ha, each contains 1000 parasitoids) were released in grape orchards for controlling *Lobesia botrana* (Ibrahim 2004; El-Wakeil & al. 2009; El-Wakeil 2011).

Larval parasitoids

Larval and pupal parasitoids are released in the pupal stage. Parasitized pupae just before emergence are carried on special carriers like talc powder and distributed in the target fields. Releasing *Bracon* spp to control corn borer larvae is one of the effective methods for controlling such insects (Zaki & al. 1998).

White fly parasitoids

Encarsia spp. or *Eretmocerus* spp are released as parasitized pupae shortly before adult emergence (Gould & al. 1992). Additional *Encarsia* species have been released against *Bemisia tabaci* reached to 65 % parasitized whiteflies (Abd-Rabou 2002; Urbaneja & al. 2009).

Aphid parasitoids

Aphid parasitoids are released as parasitized mummies of aphid host. Semi-field experiments were carried out to evaluate the performance of releaseing parasitoid species *Diaeretiella rapae* for controlling *Brevicoryne brassicae*, *Aphis craccivora* and *Aphis nerii* infesting cabbage, faba bean and oleander plants.

Predators of *Tuta absoluta* and *Bemisia tabaci*

General predators (lacewings & lady beetles) are released in the pupal stage with the suitable carriers. These general predators are used commercially for regulating many insect and mite pests. *Nesidiocoris* *tenuis* and *M. pygmaeus* were also realeased and caused a significantly reducing *Tuta absoluta* and *B. tabaci* populations (Gabarra & al. 2004; Urbaneja & al. 2009).

Entomopathogenic nematods application

Entomopathogenic nematods are injected in tunnels made by the red palm weevil larvae or sprayed around the truncks of infested trees to control the pest adults (Saleh & al. 2009).

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