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Effectiveness of the egg parasitoid *Trichogramma evanescens* preventing rice moth from infesting stored bagged commodities

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ABSTRACT

Experiments were carried out in the laboratory with the aim of accessing the effectiveness and parasitism by *Trichogramma evanescens* to prevent *Corcyra cephalonica* from infesting rice in paper and jute bags. Eight small jute or paper bags filled with 5 kg of organic rice grains were prepared and the openings sealed. Sentinel egg cards were prepared with thirty fresh eggs of *C. cephalonica* glued onto small pieces of paper cardboard. Eight sentinel egg cards were introduced into a plastic box measuring $60 \times 40 \times 21$ cm, i.e four cards on top surface of the bag and the box bottom, respectively. Approximately 500 adults of *T. evanescens* were released 10–30 cm away from the egg cards. The control boxes contained no parasitoids; there were five replicates for all treatments and controls. Two experimental conditions were tested, i) placing a single *T. evanescens*-release unit with sentinel egg cards placed every 3–4 days without any further replacement of the release unit for three weeks, ii) both new host eggs and *T. evanescens* release units were replaced every 3–4 days. Mean emergence of *C. cephalonica* was significantly ($p > 0.001$) suppressed by the release of *T. evanescens*. There was statistically no significant difference on the number of emerged moths on paper bag compared to jute bag. All sentinel egg patches were visited by *T. evanescens*. There was no correlation between the distance (10–30 cm) at which the sentinel egg cards were placed away from the *T. evanescens* release point and the number of parasitized *C. cephalonica* eggs. There was no decrease in parasitism over time. The results demonstrate that *T. evanescens* has the potential for host-location ability and parasitism of *C. cephalonica* both on paper and jute bags. This parasitoid could be a promising candidate for the biological control of moth pests in bagged stored products.

1. Introduction

Rice is the most important staple food for a large part of the world's human population, especially in the tropics (FAO, 2004a, 2004b) and provides 20% of the dietary energy supply in the world (FAO, 2004c; FAOSTAT, 2013).

The rice moth *Corcyra cephalonica* (Stainton) is a major pest of durable stored produce throughout the world causing considerable losses to cereals, grain legumes and other high value crops such as cocoa beans and dried fruits (Haines, 1992; Sedlacek et al., 1996). The control of stored-product moths in bagged commodities is difficult because the developmental stages of the moths are protected by the bagging material from control measures such as the application of contact insecticides. World-wide control of storage pests is primarily dependent upon continued application of synthetic contact insecticides and fumigants, mainly phosphine (Arthur and Peckman, 2006; Walter, 2006). Although effective, their indiscriminate use for decades has disrupted biological control by natural enemies and led to outbreaks of various insect species, development of resistance to the chemicals, undesirable effects on non-target organisms, and environmental and human health concerns (Rajendran and Narasimhan, 1994).

Small quantities of bio-organic rice are stored in paper bags especially in Europe and in jute bags in developing countries like

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Africa and are sold in bio-market and departmental stores. The paper and jute bags easily get infested with stored product insects like *C. cephalonica* and *Plodia interpunctella* (Hübner) which affect the quality for human consumption (Adarkwah et al., 2014; Schöller et al., 2006; Flinn and Schöller, 2012). The increasing concern about the adverse effects of pesticides has highlighted the need for the development of more selective insect-control alternatives that are less harmful to humans and environmentally friendly (Mbata, 1989; Subramanyam and Hagstrum, 1996; Schöller, 2010; Adarkwah et al., 2012, 2014; Trematerra, 2013; Kaur et al., 2014).

Trichogramma evanescens Westwood (Hymenoptera: Trichogrammatidae) is a polypahgous egg parasitoid of several lepidopteran species (Wajnberg and Hassan, 1994). *T. evanescens* is commercially applied in the retail trade and the food processing industry in Central Europe to control stored-product moths, mainly *P. interpunctella*, *Ephestia kuehniella* Zeller and *Ephestia elutella* (Hübner); mass-rearing and storage of this species is well established (Prozell and Schöller, 1998; Schöller, 2010). *T. evanescens* is known to be capable of developing successfully in *P. interpunctella* (Schöller and Fields, 2003) and to forage on various types of food packages (Ambrosius et al., 2006), but no information is available on the control of *C. cephalonica* in bagged stored rice by this parasitoid. The present study examined for the first time the potential of using egg parasitoid *Trichogramma* for preventing infestations of *C. cephalonica* in bagged rice typical for tropical or subtropical countries, and also examined the influence of packaging of different surface texture on parasitoid effectiveness.

2. Materials and methods

2.1. Culturing of C. cephalonica and parasitoids

The rice moth *C. cephalonica* was obtained from the permanent rearing cultures of the Federal Research Centre for Cultivated Plants – Julius Kühn-Institut, Institute for Ecological Chemistry, Plant Analysis and Stored Product Protection, Berlin, Germany. The tested strain of *T. evanescens* was originally obtained from eggs of *Helicoverpa armigera* (Hübner) (Lep.: Noctuidae) in Egypt in 1981. The strain is arrhenotokous, with a sex ratio of 1.47:1 females: males. The original population of *T. evanescens* was obtained from the Biologische Beratung Ltd. Berlin, Germany. *C. cephalonica* were reared in 1-l glass jars filled with 150 g of organic rice with a moisture content of 14% to which organic rice germs were added to make up 5% of the total. The jars were placed on a mechanical roller to mix the content properly. Two hundred and fifty *C. cephalonica* eggs were added to each jar and were kept in the culturing room. *T. evanescens* were reared on UV-sterilised eggs of *Sitotroga cerealella*. Both species were reared in a growth cabinet maintained at 65 ± 5% relative humidity (r.h.), a constant temperature of 25 °C.

2.2. Host location of T. evanescens on paper bags and jute bags

Experiments were carried out in the laboratory to assess the host location and parasitism of *T. evanescens* for biological control of *C. cephalonica* on paper and jute bags, by evaluating the efficacy of this beneficial for bagged stored rice. The jute bags used were prepared from pieces of industrial bagging material originating from Côte d'Ivoire through the importation of cocoa beans to the Port of Hamburg by cutting the original bags into different pieces. The bags were re-sewn with a needle and rope thread obtained from the Ghana Cocoa Board, Accra, Ghana. The mean mesh width of the jute fabric was 2.5 mm. The experimental paper bags used for the bioassay were also prepared from pieces of industrial bagging material obtained from the organic bakery Märkisches Landbrot GmbH, Berlin, Germany through the packaging of spelt flour Type 812 by cutting the original bags into different pieces. The organic Langkorn Spitzenreis "Thaibonnet-variety" was purchased from Hofladen Domäne Dahlem, Berlin, Germany. The rice was kept at −15 °C for two weeks to kill any living insects (Fields, 1992). After this period, the grains were removed and kept under experimental temperature and humidity conditions for 1 week before being used in the experiments. The rice grain moisture content used for experiment after the grain was kept at −15 °C was 12–14%. The moisture content was determined by using Pfeuffer Mess-

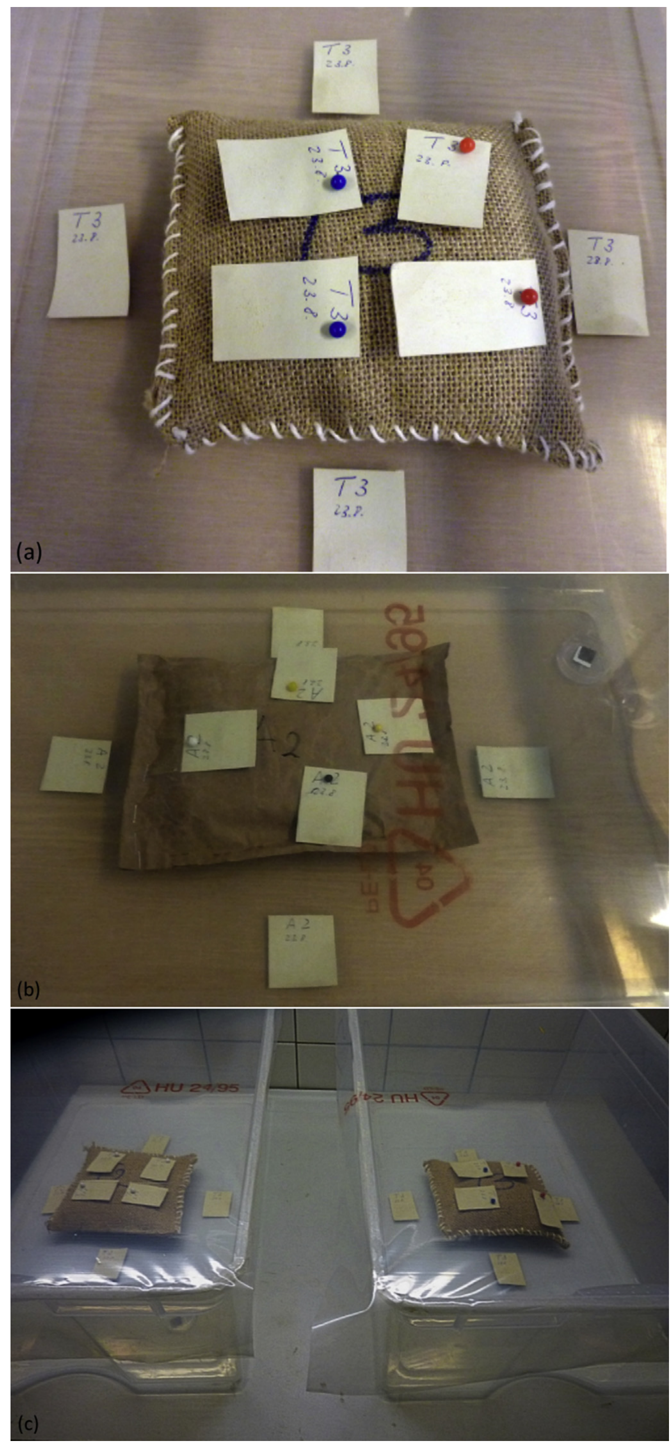

Fig. 1. Sentinel egg cards placed (a) on the surface of jute and (b) paper bags, and (c) plastic boxes containing the experimental set up.