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A rearing method of the larval parasitoid, *Apanteles carpatus* (Say) (Hymenoptera: Braconidae) on its new host *Monopis crocicapitella* (Clemens) (Lepidoptera: Tineidae)

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Host suitability of *Monopis crocicapitella* (Clemens) (Lepidoptera: Tineidae) was tested for a larval parasitoid, *Apantales carpatus* (Say) (Hymenoptera: Braconidae) under laboratory conditions. Laboratory studies indicated that larvae of *M. crocicapitella* were successfully parasitized by *A. carpatus* and fertile offsprings of *A. carpatus* were produced. Some biological characteristics and a possible rearing method of this parasitoid on the laboratory host were also studied. All experiments were conducted at 25 ± 1°C, 60 to 70% relative humidity, with a photoperiod of 16:8h (L:D). Average development time, longevity and adult emergence rate of the parasitoid was 33.8 ± 0.277 days, 15.8 ± 0.787 days and 62% on the new host, respectively. *A. carpatus* was able to parasitize young and older stages of *M. crocicapitella* larvae and completed its development successfully. A possible rearing method of *A. carpatus* on *M. crocicapitella* showed that this parasitoid was successfully reared for eleven generations. These results show that the parasitoid can be a candidate for future research as a biological control agent against an important pest, *M. crocicapitella*, and the pest may be a suitable laboratory host for rearing of *A. carpatus*.

Key words: *Apantales carpatus, Monopis crocicapitella*, parasitoid rearing method, host suitability, parasitoid biology.

INTRODUCTION

Monopis crocicapitella (Clemens) (Lepidoptera: Tineidae) is one of the most destructive pest insects of wool, feathers, carpets, fur, felt or articles manufactured from these materials. However, the larva of Monopis can live in bird's nests, on stored products of vegetable origin like flour, corn. This pest was occurred in many parts of Europe, North Africa, Australia and The USA. Temperature threshold for *M. crocicapitella* was reported at 11°C and five instars was occured during the development. Larval development, especially first instar, was affected by the humidity (Bankes, 1912; Carter, 1984; Woodroffe and Southgate, 1952; Rivett et al., 1990;

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Figure 1. *Monopis crocicapitella* (A. larva, B. pupa, C. adult, D.damage on potato tuber).

Gerard, 1995). The larva, pupa and adult stages of *M. crocicapitella* are well defined by Capuse and Georgescu (1963) and Chauvin (1977).

For the control of this insect, use of insecticides, whether applied directly onto fabric material as preventive and curative measure for controlling feeding larvae of *M. crocicapitella* or applied as atmospheric toxins to kill flying moths, has been and sometimes still is commonly used to prevent *Monopis* infestations. Integrated pest management (IPM), a successfully practiced pest management strategy with a steadily growing field of applications in agricultural systems including stored agricultural products, can be adapted to a fabric protection as well, in the commercial and private sector. One part of IPM is the combination and evaluation of physical, biological and chemical pest control measures (Back, 1940; Parker, 1990). Little, however, is known on biological counterparts like pathogens, predators and parasitoids and their potential in biological control of either *M. crocicapitella*.

Our previous laboratory observation indicated that *Apantales carpatus* (Say) (Hymenoptera: Braconidae) could parasitize larvae of *M. crocicapitella.* The parasitoid *A. carpatus* is a solitary endoparasitoid (Askew and Shaw, 1986) of larvae from Tineidae (Lepidoptera) (Viereck et al., 1916; Kemper, 1935; Fallis, 1942; Nixon, 1976). A number of authors reported that *A. carpatus* was collected from poultry manure and bird nests (Ables and Shepard, 1974; van Bronswijk, 1981; Olkowski et al., 1991). Rutz and Scoles (1989) reported that *A. carpatus* was also collected from house fly.

A. carpatus is a parasitoid of several important lepidopterous pests occurring throughout Australasian; Eastern Palaearctic; Ethiopian; Europe; Nearctic; Neotropical; Oceanic; Oriental; Western Palaearctic reagions (Yu et al., 2006). Reported hosts include *Tineola bisselliella* (Hummel), *Tinea pellionella* Linnaeus, *Tinea columbariella* Wocke, *Trichophaga tapetzella* Linnaeus, *Praeacedes atomosella* Walker, *Phereoeca uterella* Walsingham, *Niditinea spretella* Denis and Schiffermuller (Lepidoptera: Tineidae), *Acrobasis caryivorella* Ragonot, *Doloessa viridis* Zeller, *Tegulifera audeoudi* Joannis, *Pyralis farinalis* Linnaeus (Lepidoptera: Pyralidae), *Cydia funebrana* Treitschke, *Sparganothis pilleriana* Denis et Schiffermüller, *Grapholita molesta* Busck (Lepidoptera: Tortricidae), *Pectinophora gossypiella* (Saund.), *Phthorimaea operculella* (Zeller) (Lepidoptera: Gelechiidae), *Dendrolimus sibiricus* Chetverikov (Lepidoptera: Lasiocampidae), *Epanaphe carteri* Walsingham (Lepidoptera: Notodontidae), *Gypsonoma minutana* Hübner (Olethreutidae), *Illiberis sinensis* Walker (Lepidoptera: Zygaenidae), *Oecia oecophila* Staudinger (Lepidoptera: Schistonoeidae), *Orgyia leucostigma* (J.E. Smith) (Lepidoptera: Lymantriidae), *Protolychnis maculata* Walsingham (Lepidoptera: Lecithoceridae), *Kiefferia pericarpiicola* Bremi (Diptera: Cecidomyiidae) and *Musca domestica* Linnaeus (Diptera: Muscidae) (Yu et al., 2006). Consequently, *A. carpatus* is of interest as a potential biocontrol agent.

This study investigates host suitability of *M. crocicapitella* for *A. carpatus*. In addition, some biological characteristics and a rearing method of the parasitoid on *M. crocicapitella* were presented. This investigation will enable us to evaluate the potential of *A. carpatus* as a biological control agent for *M. crocicapitella*, and will also provide important information for rearing this parasitoid in the laboratory.

MATERIALS AND METHODS

Host rearing method

The moth *M. crocicapitella* used in this study was collected from infested wool carpets in Ankara (Turkey) in 2008 (Figure 1). The culturing of the moth was undertaken in an laboratory at 25 ± 1°C, 60 to 70% relative humidity (RH) and 16:8h (L:D). Three small potato tubers were placed into a sterilized plastic breeding container (20 x 14 x 7 cm). Ten pairs of the adult moths were transferred into the container. The adults lay eggs on potato tubers. We have taken this potato tuber and were replaced with new ones. The moths were fed with a 20% honey solution to stimulate oviposition. This procedure was repeated every four days.

Figure 2. *Apanteles carpatus* (A. pupa, B.-C.adult).

Development time of *M. crocicapitella* from egg to adult completed in approximately 35 to 40 days at the condition of temperature, humidity and nutrition being used. When needed, adult moths were collected with the help of an aspirator and transferred into other containers.

Host suitability

Suitability of *M. crocicapitella* for the solitary larval parasitoid *A. carpatus* was investigated at 25 ± 1°C, 60 to 70% RH, with a photoperiod of 16:8 h (L:D). *A. carpatus* was naturally obtained from larvae of *M. crocicapitella*. In the suitability experiment, 4 to 5 weeks old mature larvae of *M. crocicapitella* were used. To obtain singly parasitized host, larvae were presented individually to adult parasitoids. In the parasitisation experiment we use foraging behavior of the parasitoid. We observed the parasitoid for 5 mins and after the parasitisation, parasitized larvae were placed singly to vials with excess diet until parasitoid eclosion. As a host diet, potato tubers were used. Data were obtained from 100 parasitized host larvae. Parasitoid eclosion was checked two times during the day to ensure development time and mortality rate were accurately recorded. After the eclosion, each adult was fed with 10% honey solution. Longevity was recorded from adult emergence to its death. In order to define parasitoid reaction to young larvae, two weeks old larvae of *M. crocicapitella* were supplied to female *A. carpatus,* and parasitisation and development were observed. In the fertility experiments were used young and mature stages of *M. crocicapitella* larvae. Both stage of 10 larvae were transferred in the petri dish (9cm) and were supplied to one female parasitoid. Both stage of parasitised larvae were left to develop in the laboratory. Parasitoid eclosion were controlled every day.

Parasitoid rearing method

In the rearing method of *A. carpatus*, mature larvae of *M. crocicapitella* were used as hosts. Rearing was conducted at 25 ± 1°C, 60 to 70% RH and 16:8h (L:D). Newly emerged ten *A. carpatus* females (<24 h) were transferred into clear plastic containers (20 x 14 x 7 cm). Female parasitoids were fed with 20% honey solution for 24h before host larvae were supplied. As hosts, 4 to 5 week-old 40 to 50 mature larvae of *M. crocicapitella* were introduced into the container. The parasitoids were left the forage and oviposit for 24 h. Then parasitized larvae were transferred into another clear plastic container on potato tubers. Parasitoid eclosion was checked two times during the day. After the eclosion, when needed, adult parasitoids were collected with the help of a mouth aspirator and transferred in another container. This rearing procedure was continued for eleven generations.

RESULTS

Host suitability

Host suitability studies indicated that larvae of *M. crocicapitella* were successfully parasitized by *A. carpatus* and fertile offsprings were produced. Of the 100 parasitized mature host larvae, 62 parasitoids developed during the experiment. Development times of the parasitoid from egg to adult lasted 33.8 ± 0.277 (32 to 36) (n = 25) days, and the average longevity of the parasitoid was 15.8 ± 0.787 (8 to 21) (n = 25) days. *A. carpatus* was also able to parasitize two week-old young larvae of *M. crocicapitella* and completed its development successfully. Fertility experiments showed that *A. carpatus* produce fertile offspring both on young and mature stages of *M. crocicapitella* larvae.

Parasitoid rearing method

The rearing method of the solitary koinobiont larval parasitoid, *A. carpatus*, on the new host, *M. crocicapitella* showed that the parasitoid could be successfully reared for eleven generations (Figure 2). Development time of *A. carpatus* from egg to adult completed is approximately 33 to 42 days at the laboratory condition. In the rearing experiments, no male parasitoid was seen and unmated females produced only female progenies.

DISCUSSION

Host suitability studies show that *M. crocicapitella* is a new host for *A. carpatus*. Barbosa et al. (1982); Mackauer (1973); Vinson and Iwantsch (1980) describes those host types which can successfully be parasitized

and the degree to which they produce fertile offspring. Parasitisation and development on both young and mature stages of *M. crocicapitella* larvae may be seen as an advantage for rearing and success of the parasitoid. Rearing *A. carpatus* on the new host for eleven generations may be an important step for biological control. Having obligatory parthenogenesis (thelitoky) can make the parasitoid an ideal candidate for biological control.

The literature showed that there is no much knowledge about the biology of *A. carpatus*. Harvey et al. (2000) showed that the parasitoid *A. carpatus* is a solitary endoparasitoid that parasitizes the larval stage of several moths in the family Tineidae. They also explained that this parasitoid lays its eggs into the host's hemocoel, egresses from the host at the end of its larval development to spin a cocoon, and emerges as an adult, and development time for *A. carpatus* from egg to adult emergence changed with host size at oviposition. Plarre et al. (1999) reported that the average development time from egg to adult on 4 week and 5 week-old larvae of *Tineola bisselliella* were 34 ± 10 and 34 ± 12 days, the average adult longevity of parasitoid was 26.7 ± 1.8 and the emergence rate of adult parasitoid on 4 and 5 week-old larvae of *T. bisselliella* were 87 and 68%, respectively.

This first study between *A. carpatus* and *M. crocicapitella* indicates that *M. crocicapitella* may be a factitious host for *A. carpatus*, and the parasitoid can be a candidate for future research as a biological control agent against this pest and some other important lepidopteran and dipteran pests as mentioned in introduction section. It means that *A. carpatus* has a potential in IPM program to reduce applications of synthetic insecticides for fabric protection in household and museum collections.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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