Studii și Cercetări Științifice. Biologie
Scientific Study & Research. Biology
Print ISSN 1224-919X Online ISSN 2457-5178

2024, 33 (2), 19-22

THE ONTOGENETIC DEVELOPMENT CYCLE OF THE SPECIES *PLODIA INTERPUNCTELLA* Hbn. UNDER CONTROLLED CONDITIONS

Corina GLIBICIUC*, Tudor NASTAS

Institute of Genetics, Physiology and Plant Protection of the State University of Moldova

KEYWORDS

Eggs
Female
Imago
Larvae
Male
Nutrient medium
Plodia interpunctella

ABSTRACT

The biological indices of the species *Plodia interpunctella*, propagated under controlled laboratory conditions, were evaluated. It has been demonstrated that the biological indicators and the development period of an ontogenetic cycle of this species can be used as an alternative host for the multiplication of the entomophagous *Bracon hebetor*. A nutrient environment was developed, which allows the development of an ontogenetic cycle of the *Plodia interpunctella* species in controlled laboratory conditions during about 22-25 days.

INTRODUCTION

Solving ecological problems in contemporary agriculture can become a reality only through the complex use of harmless means of controlling the density of populations of harmful organisms. The functionality of agroecosystems, but also of natural ecosystems, is ensured to a large extent by the existing relationships between harmful and beneficial arthropod species and their interactions with abiotic factors. The existence and activity of any population, as a link in the trophic chain, is conditioned by the presence and consumption of the amount of food necessary for development and spread. Investigations into the relationships between harmful and beneficial arthropods are the foundation of plant biological protection (Bradowsky et al., 2017).
Two pest species (*Galleria mellonella* and *Ephestia kuehniella*) are currently used as laboratory hosts for mass propagation of the entomophagous *Bracon hebetor* (Voloșciuc, 2023; Брадовская et al., 2022).
The entomophagous *Bracon hebetor* can parasitize the larvae of various pests, among which *Plodia interpunctella* is the most preferred species. The species *Plodia interpunctella* Hub. is one of the most economically important as a pest of various products and stored dried fruits. This pest is also known as the Indian moth and is widespread in most countries around the world. Losses caused to stored products by the larvae of this pest can reach the rate of up to 10% annually. It is part of the family *Pyralidae* (order *Lepidoptera*) having 4 stages of development (egg, larva, pupa, imago). The requirements of mass reproduction of the entomophagous *Bracon hebetor* is to obtain as large a number of fertile females as possible in the shortest possible time. For this, it is very important to select and multiply the host species with the development of an optimal nutrient environment to maintain the host species in the necessary number on which the given entomophagus develops.
The aim of the current investigations was to identify the biological development parameters of the ontogenetic cycle of the species *Plodia interpunctella* on different nutrient media under controlled laboratory conditions and to assess the possibility of being included in the multiplication cycle of the entomophagous *Bracon hebetor*, as an alternative host the existing ones.

MATERIALS AND METHODS

In order to evaluate the biological parameters of the ontogenetic multiplication cycle of the *Plodia interpunctella* species, a series of experiments were set up under controlled laboratory conditions. The biological material was

* Corresponding author: Glibiciuc C.
E-mail address: corina.glibiciuc@sti.usm.md
https://doi.org/10.29081/scsb.2024.33.2.03

maintained in the "Niteh" type climate chamber with the regulation of temperature parameters. The relative humidity of the air was maintained within the limit of 65-70% (Table 1).

Table 1. Temperature parameters during the monitoring of the development of the *Plodia interpunctella* species, under controlled laboratory conditions

Variants	Temperature (ºC)
I	9–12
II	15–18
III	20–21
IV	25–27
V	30-35

The biological material was collected in the storage rooms of cereal products and introduced into the laboratory culture on nutrient medium of cornmeal (Figure 1).

Figure 1. The introduction of the *Plodia interpunctella* species into laboratory culture

During the experiments, the imago was kept in glass vessels with a volume of 3 liters and as food they received a sugar solution with a concentration of 7%.
Two variants of nutrient media were tested and compared for the development of the larval stage of the species *Plodia interpunctella* (Table 2).

Table 2. Components of the nutrient medium tested for the development of the larval stage of the species *Plodia interpunctella* under laboratory conditions

Variants	Dry components to obtain 1 kg of nutrient medium				
	Agar-agar (g)	Glycerin (g)	Corn flour (g)	Apple (g)	Nut kernel (g)
Nutrient medium with macerated components	10	100	190	500	200
Nutrient medium with integral components	10	100	190	500	200

The elaborated nutrient media were kept under refrigerator conditions at a temperature of 4^0C and used in the quantities required for the development of the larval stage.
The obtained data were processed according to the Microsoft software package.

RESULTS AND DISCUSSION

In order to assess the possibility of including the species *Plodia interpunctella* in the multiplication cycle of the entomophagous *Bracon hebetor*, as an alternative host to the existing one (*Galleria mellonella*), a series of experiments were set up with the aim of evaluating the biological parameters and the ontogenetic development cycle under controlled conditions.
The analysis of the imago stage showed that males are smaller than females and reach an average length of 8 mm, and females - about 10 mm. It was found that the nutritional environment for the development of the ontogenetic cycle of the moth has a significant impact on the development of both the imago stage and the larval stage. The front wings are brown, and the hind wings are gray. Imago in the passive phase have their wings folded in the form of a roof (Figure 2).
After the mating phase, the females go to the egg-laying phase. The eggs are laid directly in the substrate of the nutrient medium. The experiments set up to assess the number of eggs laid depending on the age of the females demonstrated that the egg laying extends over a period of about 5 days (until their death) (Figure 3).
As a result of the analysis of the obtained data, it was found that there is a tendency to increase the rate of eggs laid simultaneously with the increase in the age of the females. Thus, if the females on the first day lay an average of about 69 eggs, then the 5-day-old ones lay an average of about 129 eggs, which is 46.5% higher than the number of eggs laid by the females aged 24 hours. Females aged 24-48 hours lay a significantly lower number of eggs than those aged between 3 and 5 days (31.5% compared to 68.5%). At the same time, it was demonstrated that, on average, the prolificacy of a female of the *Plodia interpunctella* species, under controlled laboratory conditions, is

about 502 eggs. The rate of sterile eggs is about 34% of the total number of eggs laid. Thus, experimentally, it was identified that for the multiplication of the given species as an alternative host for the propagation of the entomophagous *Bracon hebetor*, the optimum will be the use of females older than 48 hours.

a b

Figure 2. Appearance of the imago stage of the species *Plodia interpunctella*: a. the female in the passive phase; b. male and female in mating

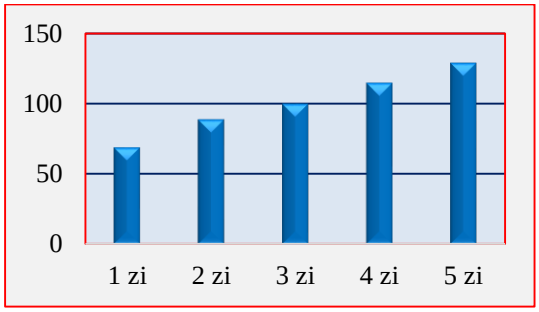

Figure 3. Prolificity of *Plodia interpunctella* females under controlled laboratory conditions, depending on age

Further investigations found that the larvae hatch from the eggs 4-5 days after they are laid. The larvae are yellowish-white, but depending on the nutrient environment they can also be pink or brown. In controlled laboratory conditions, the larvae develop during about 22-25 days (from the first to the second age - 10 days; from the third to the fourth age - 8 days; from the fourth age to the V - 7 days). The development of the larval stage ends with the emergence of the pupal stage. It has been demonstrated that the duration of the pupa stage extends over a period of about 6-7 days, after which the imago stage of a new generation is released.

The multiplication of a laboratory host is highly dependent on the temperature factor. In order to optimize the conditions for the multiplication of the *Plodia interpunctella* species, a series of experiments with the modeling of temperature factors were mounted. During the investigations, it was demonstrated that when maintaining the population of *Plodia interpunctella* within the limits of a temperature of about 9-12ºC, a gradual transition to the diapause period of the species takes place (variant I). The development of an ontogenetic cycle within the temperature limits of 15-18ºC takes place over a longer period of time, equal to about 60-65 days. The multiplication of the given species at a temperature within the limits of 20-21ºC leads to an insignificant reduction of the development period (40-55 days) (Table 3).

Table 3. The duration of the development of an ontogenetic cycle of the species *Plodia interpunctella*, under controlled laboratory conditions, depending on the temperature factor

Variants	Development temperature (ºC)	Duration of development of an ontogenetic cycle (days)
I	9-12	-
II	15–18	60-65
III	20–21	40-55
IV	25–27	22-25
V	30-35	-

It was found that at temperature factors within the limits of the rate of 30-35ºC, the development of the population of the species *Plodia interpunctella* stops completely due to the death even at the hatching stage of the larvae from the eggs. As a result of carrying out these experiences and analyzing the obtained data, it was demonstrated that the most optimal development of the ontogenetic cycle (22-25 days) of the *Plodia interpunctella* species occurs when the temperature factor is maintained within the limits of 25-27ºC. Thus, the development of an ontogenetic cycle of the species *Plodia interpunctella* under controlled laboratory conditions can be carried out within the limits of about 22-25 days. For comparison, the development of an ontogenetic cycle of the standard host *Galleria mellonella* extends over a period of about 40-45 days under the same temperature limits. Due to this moment, the species *Plodia interpunctella* can be a promising alternative as a host for the multiplication of the entomophagous *Bracon hebetor*.

The multiplication of any species as a laboratory host is directly dependent on the nutritional environment. In order to develop an efficient nutrient medium in the technology of propagation of the species *Plodia interpunctella*, in controlled laboratory conditions, 2 types of nutrient medium were modeled with a difference between the main components (dried apple fruits and walnut kernels) - macerated and intact (Figure 4).

Experiments were set up to estimate the effectiveness of these two types of nutrient medium on the development of the larval stage and the ratio of females to males obtained. The evolution was appreciated by following the process on 100 larvae of each variant. The obtained results are presented in Table 4.

The obtained results demonstrated that when applying the nutrient medium with intact components, the development of the larvae extended for about 30-35 days, which is about 5-10 days more than the development on the nutrient medium with macerated components.

Figure 4. The variants of the nutrient media tested for the multiplication of the *Plodia interpunctella* species in controlled laboratory conditions

Table 4. Estimation of the development of the larval stage of the species *Plodia interpunctella* depending on the nutritional environment

Variants of the nutrient medium	no. larvae in the experiment	no. pupae obtained	no. of imago obtained			The report females : males
			Total	female	males	
Soaked ingredients	100	94	90	39	51	0,7 :1,3
Components integral	100	53	47	12	35	0,3 : 2,9

The analysis carried out also found that in the version of the nutrient medium with macerated components, 94 pupae were obtained, while in the version with intact components - only 53, which is 43.6% smaller. It was later found that the number of imago excluded from the obtained pupae was also reduced. Thus, as a result of the development of the larvae on the nutrient medium with intact components, approximately 47.8% fewer imago were obtained compared to the larvae developed on the nutrient medium with intact components. Apart from this, a ratio between the sexes shifted significantly towards increasing the rate of males and reducing the rate of females was obtained in the population developed on the nutrient medium with integral components. Concluding all the above, it was demonstrated that for the development of the larvae of the *Plodia interpunctella* species, it is necessary to apply the elaborated nutrient medium with the macerated components.

CONCLUSION

It has been demonstrated that the biological indices and the development period of an ontogenetic cycle of the species *Plodia interpunctella* under controlled laboratory conditions can be used as an alternative host for the multiplication of the entomophagous *Bracon hebetor*;
It was found that the elaborate nutrient medium (50% - macerated dried apples + 20% - macerated walnut core + 19% - corn flour + 10% - glycerin + 1% - agar-agar), applied for the propagation of the species *Plodia interpunctella* in controlled laboratory conditions allow to obtain the development of an ontogenetic cycle during about 22-25 days.

ACKNOWLEDGEMENTS

The researches were carried out within the Subprogram 011103 Development of ecologically harmless means of reducing the impact of harmful organisms of agricultural crops against the background of climate change, financed by the Ministry of Education and Research.

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