



Use of the larvae of the red flour beetle *Tribolium castaneum* (Coleoptera: Tenebrionidae) in rearing of the spider *Plexippus paykulli* (Araneae: Salticidae)

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Abstract

This study was conducted with the aim of propagating the predatory spider *Plexippus paykulli* in the laboratory after capturing it from one of the old granaries. It was raised on a pest *Tribolium castaneum* inside the food substance (flour), which the predator did not approach throughout the breeding periods due to the difficulty of jumping on it. The predator did not feed on the adult stages of the prey, but rather captured the larvae that crawled out of the flour. Shows that the salticid spider *Plexippus paykulli* goes through seven larval stages before reaching of the adult stage, the duration of immature stages recorded these values (12.6, 13.9, 14.3, 10.1, 15.9, 21.5 and 15.2) for the instars from the first to seventh stage, respectively. The daily number of prey was not large for each individual predator during the immature stages, but it was enough to keep the predator active to complete its life cycle. While it reached a large number 6.2 days when the predator was adult.

Keywords: *Plexippus paykulli*, *Tribolium castaneum*, salticid spider

Introduction

The red flour beetle *Tribolium castaneum* is considered a widespread global pest and it is more developed on grain products such as wheat flour. Although it infects the wheat grain itself, its development is rapid on flour (Arthur *et al.*, 2019a, b) [3, 4]. In addition to it has a large penetration into stored foodstuffs it has a relatively short life cycle (Aditi Pai and Gregor Bucher 2019) [1]. There are many reports confirming that this pest develops rapidly in relatively high temperature storage conditions; the incomplete stages only took 23 days to reach the adult stage at a temperature of 37°C; that was proved by (Arthur *et al.*, 2020) [5]. On the other hand; May pest's behavior is one of its weaknesses in the presence of the predator as like the salticid spider *Ballus piger* as (Kana Konishi *et al.*, 2020) [6] reported that the red flour beetle feign death under attacking of the females of the spider salticid spider, *Hasarius adansoni* when them tested that behavior for to strain of the red flour beetle. It is worth saying that spiders are among the most voracious predators in the environment, especially the jumping spiders which were chosen in this work due to the reports that prove their ability to feed on *Tribolium castaneum* after periods of starvation as well as their ability to capture prey, which may help to use this behavior in biological control methods. The capabilities of this predator can be deduced from the common name, as it has high capabilities to jump distances that may reach fifty times the length of its body, as it extends its legs and pushes its body into the air quickly (Hadley and Debbie, 2020) [7]. Mentioned that jumping spiders (salticidae) can tolerate a wide range of habitats from the very dry to the very wet and from intertidal zones to mountains, but their hearts are in the tropical forests.

Although; there have been no adequate studies on the behavior of these predators inside stored food. However, there have been no prior studies on the behavior of spiders inside stored food.

Of course, a member of the family was chosen due to its nature of movement, and based on some other

characteristics, this research was conducted. The aim of it was: Is it possible that some families of spiders are a potential enemy of stored food pests?

Especially that this species *Plexippus paykulli* that was studied was observing in the granary in large numbers, so this experiment aimed to study predation in an artificial feeding environment similar to what a spider might be exposed to in the granary.

Thus; in this work, the adult and immature stages of the red flour beetle were exposed to the predator, thus the behavior of the pest in three kind of stored product (Bran and flour) and the predator was monitored, as well as the development of the prey that was calculated in this artificial ecosystem. This work also allowed for easy rearing of these predators by feeding them on larvae of the red flour beetle *Tribolium castaneum*.

Martial and methods

1- Rearing Conditions of test insect

Fresh wheat grains were washed and kept in a freezer at -20°C under closed conditions for seven days or until we use it in the experiments to avoid any insects infestation. The insects reared in 1L wide-mouthed glass Mason jars containing 100 g of untreated flour mixed with yeast 10:1 (w/w) for *T. castaneum* and covered with muslin cloth and tied with rubber bands to avoid the escape of culture insects and the entry of other insects. About five hundred adults (1-2 weeks old) were introduced into the jars for 3days to oviposit in the medium under controlled conditions, then insects were separated from the food and the jars kept in the rearing room at 30± 1°C and 65 ± 5% R.H, and 12:12 h photoperiod to get the fresh adults of the test insects.

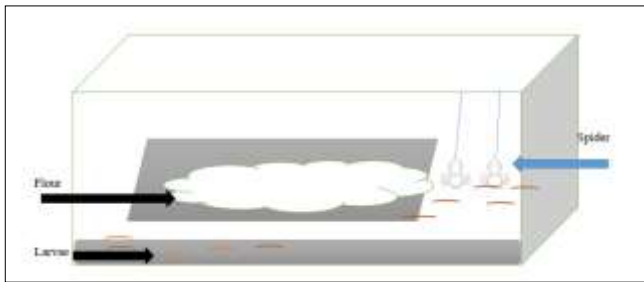
2-Getting of the predator salticid spider

Female adults of *Plexippus paykulli*. Jumper spider, collected from an old silo ,they were walking on the walls of one of the old warehouses in Giza Governorate Each female spider was maintained in aplastic Petri dish (8 cm diameter,

2 cm height) with wet cotton, and provided with adult of the housefly *Musca domestica*. Before the tests. This protocol was based on previous identical procedures carried out by (Takahisa Miyatake, 2004).

3- Artificial feeding environment- Spiders feed on larvae of the red flour beetle *Tribolium castaneum*

As shape (1) for easily rearing spiders; 6 square plastic containers were brought, 10 cm high and 20 cm wide. The plastic cans have a groove on the lower side edges. Each package contains a fixed weight of flour, which in turn contains 30 (egg, larvae and adult individuals). After the egg sacs of the spiders hatched, the larvae were transferred to circular plastic containers 5 cm x 5 cm, containing the same food material.



Fig

Result and discussion

Observations

1-Spider movement

This species did not come close to flour in one way or another, and no presence was recorded on it. Perhaps this behavior is due to the fact that these jumping individuals need a solid ground that enhances the ability of their legs to create a reaction force that helps them jump. This hypothesis is closely aligned with (David E. Hill. 2018), But the slow movements of the larvae allowed the predator to move carefully without getting into the flour, which would paralyze its jumping movement, so the spider would wait until the larvae emerged to a place where it would be easy to catch them; these results confirm that jumping spiders make several behavioral choices related to the behavior of the prey, such as the ability to escape, the ability to hunt, and the movement of the prey as well; mentioned that (Allon B. and Oren H., 1997) reported that salticid spiders can deal with changes in the trade-off relationships between its aspects and the prey behavior.

2-The behavior aspects of the red flour beetle *Tribolium castaneum* with the spiders.

Noted that the most of the adult individuals of the pest moved next to the spider predator without any fear, but they feigned death for long periods when the predator attacked; the predator climbs and spins on the top roof of the plastic container while the adult individuals of the prey climb to the top edges. These conditions are a good opportunity to catch whole stages repeatedly, some of which get stuck in the spider's thread. The immature stages provided a good opportunity for spiders feeding, as they were moving out of the flour and descending intensively to groove which is located on the underside of plastic containers. The spiders did not approach the flour. They were only descending to feed on the larvae that emerged far from the flour Even

when the containers were shaken violently, the spiders stuck to their places and did not fall into the food flour; it just falls off with severe knocking.

3-The developmental stages and rate of the feeding capacity the salticid spider *Plexippus paykulli* when fed on the larvae of the red flour beetle *Tribolium castaneum*.

Data which inserted in table (1) Shows that the salticid spider *Plexippus paykulli* goes through seven larval stages before reaching of the adult stage, the standard deviation clearly indicates the Individuals do not reach the next instar equally. That there were a three days as a standard deviation when the individuals had been crossing during the first instar. Same a significant differentiation had been repeating through the (second, fifth and the sixth) larvae stages, which recorded about (5.1, 6.5 and 5.1) days respectively. May this discrepancy may be due to the individuals feeding on larvae of different ages and sizes; this may confirm that the factor of this type of nutrition may give rapid generations of predators. The duration of immature stages recorded these values (12.6, 13.9, 14.3, 10.1, 15.9, 21.5 and 15.2) for the instars from the first to the seventh, respectively. The daily number of prey was not large for each individual predator during the immature stages, but it was enough to keep the predator active to complete its life cycle. While it reached a large number 6.2 days when the predator was adult.

Table 1: The developmental stages and rate of the feeding capacity the salticid spider *Plexippus paykulli* when fed on the larvae of the red flour beetle *Tribolium castaneum*

Stages	Mean of Duration of stages	Upper and lower	Feeding capacity
Incultation period	8.9±0.99	7-10	
First instar	12.6±3.83	7-20	1.7±0.78
Second instar	13.9±5.1	7-22	1.8±0.87
Third instar	14.3±3.7	6-16	2.2±0.6
Forth instar	10.1±2.5	6-14	2.6±0.5
Fifth instar	15.9±6.5	8-32	2.7±1.5
Sixth instar	21.5±5.1	16-29	4.5±1.1
Seventh instar	15.2±1.4	13-16	4.8±2.3
Total immature stages	99.9±3.6		1.1±0.5
Adult males	25.3±3.5	19-31	6.2±1.3

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