Some Biological Aspects of Indian Meal Moth *Plodia interpunctella* (Hübner) (Lepidoptera Pyralidae) and its Natural

Abdulbaset M. Amin Mohammed[1*]

[1]Department of Forestry, College of Agricultural Engineering Science, Salahaddin University-Erbil/Iraq
Corresponding author e-mail abdulbaset.mohammed@su.edu.krd
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Abstract

Indian meal moth, *Plodia interpunctella* (Hübner) life cycle was investigated the mean duration of the pre-mating, pre-oviposition, oviposition, and post-oviposition were 1.75, 2.50, 2.20, and 3.50 days, respectively. The average number of laid eggs was 138.80 eggs, and newly emerged larvae completed their growth inside the cages. The average incubation period, larva development period, pupation period, and adult longevity were 4.62, 28.50, 7.04, and 40.16 days, respectively. The duration of 1st, 2nd, 3rd, 4th, 5th, and 6th larval instars was 4.52, 4.80, 4.95, 3.90, 4.60, and 6.13 days, respectively, with a total larvae longevity of 28.90 days. Mentha longifolia L. had the largest mortality rate, 89.00 %, of the larvae and Ocimum basilicum extract, with a mortality rate of 81.00 %, while Thymus kotschyanus Bioss. was the lowest mortality rate, 55.00 %. The plant extracts treatment showed that the effective Mentha longifolia L., which gave 42.00 mortality for 48 hours at 50 % concentration and raised to 89.00% at a rate of 100% concentration, Ocinum basilicum gave 37.00 % and 81.00% after 48 hours at a rate of 50 % and 100 % concentration respectively, but the Thymus kotschyanus Boiss. Gave 41.00 % and 55.00% after 48 hours at 50 % and 100 % concentration, respectively.
Keywords :Indian moth Plodia interpunctella, Biology, Plant extracts, Storage foods.

Introduction

Indian meal moth, *Plodia interpunctella* (Hübner), is a significant insect that infests preserved food items [1]. Flour mills [2], food warehouses [3], and retail establishments [4] typically harbor abundant populations of adults. The ephemeral insect, with a lifespan of only 7-10 days, is active throughout the night and grows active within 24 hours following the pupation stage. Economic consequences arise from feeding larvae and webbing, which render food unsuitable for human consumption. Additionally, excessive living or dead adults in stored items can lead to food degradation, contributing to

economic consequences [5]. Investigators have extensively studied the life cycle of *P. interpunctella* (Hübner). It typically lasts between 27 and 52 days, with the duration influenced by various factors such as temperature, food odor, the existence of oil, the kind of food, the size of the female, the physiological condition of the female, food source, and temperature. In addition to these factors, food is the most crucial determinant of the insect's developmental period. *P. interpunctella* (Hübner) can be consumed from various food sources [6]. Copulation is initiated by pheromone-releasing females, stimulating males to mate [7]. Typically, mated females lay approximately 100-150 eggs throughout their lifespan, with the quantity influenced by the food quality. The larvae emerge from the eggs within 3 to 4 days, depending on the prevailing environmental circumstances. The larvae prefer consuming fragmented food, morning items, preserved cereal goods, dehydrated vegetables and fruits, manufactured foods, and prepared meals [8]. Using plant extracts as traditional and safe protectants of stored products is an old practice worldwide [9,10]. Biopesticides based on plant extracts are a complementary or alternative method for stored product protection that reduces the harmful effects of conventional synthetic pesticides [11]. This study aimed to ascertain the activity of immature stages of *P. interpunctella* (Hübner) to some plant extracts and their effect on the immature stages to find out the best plant extract to control this stored food pest and to design the scientific methods for saving our stored foods in Kurdistan-Iraq which will be introduced through future strategies programs.

Materials and Methods

Biological Studies in the lab room

The Indian meal moth, scientifically known as *P. interpunctella* (Hübner), was grown in plastic containers measuring 10×10×10 cm. The moths were raised on a diet of nuts, specifically pistachios, in an environment with a constant temperature of 30 ± 2°C and a relative humidity of 65 ± 5%. Observations revealed that moths deposit their eggs in clusters on a surface adjacent to the food source or attach them to a fragmented pistachio substance. Following the deposition of an egg, the female relocated to a different location, briefly halted her movement, oviposited, and subsequently relocated once again. The fully developed adults were gathered daily using a vacuum pump and then transferred into plastic enclosures. The eggs were taken apart daily in Petri dishes and placed into plastic containers to acquire newly hatched larvae. Biological parameters to be examined in each cage include pre-mating, pre-oviposition, post-oviposition, egg count, incubation length, larval growth duration, pupation duration, and adult lifespan. The incubation duration of eggs was estimated by observing ten recently laid eggs in four plastic containers (10×10×10 cm) as duplicates. The eggs were observed every day, and the hatching date was recorded. The larval and pupal phases were individually placed within the plastic cage and furnished with a Pistachio. Considering the life cycle's duration, lifespan, and generation, the Pistachio was replaced as needed. Four replicates

were employed, with each plastic cage housing twenty freshly born larvae. The cages were securely sealed and maintained under the experimental conditions. Regular inspections were conducted daily to document the period of the larval-pupal stage and the appearance of adult insects in the plastic enclosures. The plastic containers were enveloped with muslin cloth, secured with rubber bands, and positioned within wooden wire mesh cages measuring 30×30×60 cm. These cages were subsequently set within the experiment's laboratory. Additionally, the pest sex was distinguished based on their sizes, with males being smaller than females upon initial emergence. The male *P. interpunctella* (Hübner) has a tapering abdomen apex, while the female has a truncated abdomen apex [12]. The eggs were meticulously segregated and enumerated using a camel hair brush. Larvae subjected to natural plant extract therapy. The research study was conducted under room conditions. The treatment consisted of four replications, with each replicate containing 20 larvae instar. The larvae were in a plastic cage of 10×10×10 cm. In this study, plants were prepared and extracted from local wild plants to investigate their effect on larvae of *P. interpunctella* (Hübner).

Collection and Extraction of Plant Materials

Plants were collected from different places in Erbil city (Table 1), fresh leaves and shoots were shade-dried at room conditions, and the plant leaves were powdered in a blender; 20 grams of each plant powdered material was sequentially mixed with 100 ml water for twenty-four hours and filtered with filter paper. Then crude plants were diluted with water (0.5%), which was used directly (1.00%) was made by mixing (1.5) ml of crude plant extracts and (25) ml of tap water, and (50%) was made by mixing (50) ml tab water and (50) ml plant extracts. The crude plant extracts obtained were stored in sterilized dark-colored bottles maintained at 4 °C in a refrigerator till use. Plant extracts were obtained from plant leaves and shoots, and the toxicity effects of plant extracts were studied on the larvae of *P. interpunctella* [13].

Table (1): Scientific names, family names, common names, and collecting place of plants that were produced of the crude plant extracts.

No.	Scientific Name	Family	Common and	Local Name	Collect Place
1	*Mentha longifolia*	Lamiaceae	Peppermint	Nahnah	Erbil city
2	*Ocimum basilicum*	Lamiaceae	Common Basil	Rehan	Erbil city
3	*Thymus kotschyanus*	Lamiaceae	Common thyme	Zaatar	Erbil city

Statistical Analysis

The experiment was a factorial Randomized Complete Block Design. Data were analyzed statistically as threshold characters) by using the ready statistical program SAS (2013) (Statistical Analysis System). Mortality was recorded by mean (percentage) ± standard error and compared at (0.5) significant level using Duncan's multiple tests [14].

Mortality Bioassay

Twenty larvae of *P. interpunctella* (Hübner) were placed in each Petri dish to evaluate plant larvicidal activity. Four replicates of the treatments and untreated controls were laid out in a Randomized Complete Block Design (RCBD). The larval mortality percentage was recorded after (twenty-four and forty-eight) hours, and the (Duncan Multiple Range Test) [14] was used to compare the differences between the treatments.

$$\% \text{ Mortality} = \frac{\text{Number of died larvae}}{\text{Total number of larvae}} \times 100$$

$$\text{Corrected \% Mortality} = \frac{\%\text{Mortality Treatment} - \%\text{ Mortality Control}}{100 - \text{Mortality of Control} \times 100} \times 100$$

Results and Discussion

Biology of *Plodia interpunctella* (Hübner)

The egg hatched into a larva. The color typically appears off-white, although it has been shown to vary between pink, brown, or even somewhat greenish, contingent upon the food supply. The pest larva possesses five pairs of fully formed prolegs, en-abling them to travel significant distances to undergo pupation.

The biological study of the Indian moth Plodia interpunctella (Hübner) in laboratory environments is shown in (Table 2). The average Premating period was 1.75 days. In addition, the results showed that the average of the pre-oviposition period was 2.50 days; the average of the oviposition period was 2.20 days. Still, the average of post-oviposition period was 3.50 days.

Table (2): Pre-mating, Pre-oviposition, Oviposition, and Post-oviposition durations of *Plodia interpunctella* female in the laboratory

Cage No.	Pre-mating days	Pre-oviposition days	Oviposition days	Post-oviposition days	Total
1	2.00 ±0.14	3.00 ±0.12	2.70 ±0.19	3.00 ± 0.12	10.70 ±0.14
2	1.00 ±0.11	2.00 ± 0.17	1.48 ±0.10	5.00 ± 0.17	9.48 ±0.13
3	2.00 ±0.21	2.00 ± 0.23	1.85 ±0.12	2.00 ± 0.18	7.85 ± 0.18
4	2.00 ±0.27	3.00 ± 0.14	2.80 ±0.25	4.00 ± 0. 13	11.80 ±0.19
Average	1.75 ±0.18	2.50 ± 0.16	2.20 ± 0.16	3.50 ± 0.15	9.95 ± 0.16

[15] suggested that the meal type affects the oviposition behaviors in P. in-terpunctella (Hübner). [5] asserted that fecundity, maturation time, and other bi-ological characteristics of pests exhibit significant variability, contingent upon the exact food source employed in a given research investigation. Table (3) demonstrates that P. interpunctella (Hübner) often lays an average number of 138.80 eggs on pistachio nuts. [16] documented that females deposit 60-400 eggs on contaminated food sources. [17] discovered that female P. interpunctella (Hübner) initiated egg-laying between 12-48 hrs. after mating, with the highest rate of egg-laying observed within the initial 24 hours following mating. [18] demonstrated that the growth of stored product insects is impacted by their meals' physical, chemical, and biological components. [19] had comparable find-ings, reporting that the average fecundity of female P. interpunctella larvae reached 258, 275, and 280 when they were raised on walnuts, almonds, and wheat bran, respectively. [20] show that insects' growth, maturation, and repro-ductive processes heavily rely on nutritional value and quantity of consumed food. [21] stated that the decreased levels of protein and carbohydrates in food could hinder egg production in females and slow the growth of Ephestia kuehni-ella. The reproductive capacity of P. interpunctella varied significantly across different studies and is influenced by various parameters, including the kind of food, the size of the female, the availability of water., and the physiological con-dition of the female moth [22]. The duration that P. interpunctella needs to com-plete its life cycle is also significantly impacted by the kind of food material that it consumes [19]. A study by [15] demonstrated that the oviposition behaviors of P. interpunctella (Hübner) are affected by the type of food available.

Table (3): Oviposition of *Plodia interpunktella* female under the laboratory

Cage No.	Mean of eggs (per female)
1	138.05 ± 0.23
2	0.32 140.02 ±
3	135.04 ± 0.28
4	142.09 ± 0.40
Avg.	138.80 ± 0.30

Table (4) shows that the average incubation period, Larval development pe-riod, pupation period, and adult longevity were 4.62, 28.50, 7.04, and 40.16 days respectively. Several researchers have studied the impact of numerous diets on the biology of P. interpunctella (Hübner) [23], their research results consist-ently indicate that the duration of growth and development and the generation of adult offspring in the Indian meal moth is significantly affected by the specific diet consumed throughout the larval stage.

Table (4): Incubation period, Larval stages period, and Pupation period (days) of Plodia interpunctella (Hubner) eggs.

Cage No.	Incubation period	Larval development period	Pupation period	Adult longevity
1	4.6 ± 0.22	28.23 ± 0.21	7.20 ± 0,24	40.03 ± 0.22
2	4.4 ± 0.26	27.90 ± 0.24	6.83 ± 0.21	39.13 ± 0.23
3	4.8 ± 0.21	28.82 ± 0.22	6.75 ± 0.22	40.37 ± 0.21
4	4.7 ± 0,25	29.05 ± 0.23	7.40 ± 0.23	41.15 ± 0.23
Average	4.62 ± 0.23	28.50 ± 0.22	7.04 ± 0.22	40.16 ± 0.22

Furthermore, the pest has several larval instars; the duration of larval instars was 4.52, 4.80, 4.95, 3.90, 4.60, and 6.13 days for the 1st, 2nd, 3rd, 4th, 5th, and 6th larval instars, respectively (Table 5).

Table (5): Duration of *Plodia interpunctella* (Hübner) larval stages

Larval instars	Mean of Duration (Days)
1st	4.52 ± 0.08
2nd	4.80 ± 0.06
3rd	4.95 ± 0.07
4th	3.90 ± 0.06
5th	4.60 ± 0.02
6th	6.13 ± 0.04
Total longevity	28.90 ± 0.33

Applying crude plant extract control to reduce infestations and damage caused by the Indian meal moth, Plodia interpunctella (Hübner), showed that Mentha longifolia L. has a mortality rate of 20.00% at a concentration of 50 % after 24 hours and 89.00 % mortality at a concentration 100%, after 48 hours. So, Oci-mum basilicum L. at the rate concentration of (50) % gave 15.00 % mortality of larvae after 24 hours, while the mortality increased to 81.00%After 48 hours, at the rate of 100 % concertation, But Thymus kotschyanus Boiss. at the rate con-centration of 50 % for 24 hours gave 18.00 % and 55.00 % mortality after 48 hours at the rate concentration of 100% (Table 6). Results indicated that Mentha longifolia L is the best natural pest control and Ocimum basilicum L. has average efficiency, but Thymus kotschyanus Boiss. less effective on the immature stages of insect pests of P. interpunctella (Hübner), resulting in a decrease in the popu-lation of P. interpunctella (Hübner). This result agreed with [24] and confirmed that the crude plant extracts of Abrus precatorius, Laurus nobilis, Petroselinum sativum, and Plantago psyllium have lethal effects on the insect pest; they con-trol 100 or 95% of the tested Thaumetopoea solitaria larvae, respectively, with-out adverse effects on studied insect stages except insect of A. precatorius and our results disagree with a previous study [25], who showed that the plant extract of Achillea millefolium L. (100%) was ineffective in its activity, plant extracts from Sambucus nigra L. and Juglans regia L. were ineffective in all conducted bioassays. It agrees with [26] who showed that the susceptibility of T. wilkinsoni larvae increases in the younger larval stage.

Table (6): The mortality of *P. interpunctella* (Hubar) larval stage treated with *Mentha longifolia* L., *Ocimum basilicum L.*, and *Thymus kotschyanus* Boiss. after 24 and 48 hours

Plant extracts	**Concentration**	**(24) hrs.**	**(48) hrs.**
***Mentha longifolia* L.**	0	0.00 ± 0.00 d	0.00 ± 0.00 e
	50	20.00 ± 4.50 c	42.00 ± 5.00 cd
	75	26.00 ± 5.00 bc	62.00 ± 5.04 b
	100	36.00 ± 5.40 ab	89.00 ± 360 a
***Ocimum basilicum* L.**	0	0.00 ± 0.00 d	0.00 ± 0.00 e
	50	15.00 ± 4.00 c	37.00 ± 5.40 d
	75	16.00± 4.20 c	42.00 ± 5.60 cd

	100	39.00 ± 4.60 a	81.00 ± 4.40 a
***Thymus kotschyanus* Boiss.**	0	0.00 ± 0.00 d	0.00 ± 0.00 e
	50	18.00 ± 4.40 c	41.00 ± 5.50 cd
	75	25.00 ± 4.90 bc	42.00 ± 5.60 cd
	100	25.00 ± 4.90 bc	55.00 ± 5.60 bc

The effect of crude plant extracts on the mortality of Plodia interpunctella (Hubner) larvae increased with increasing crude plant extract concentration, and the dead num-ber of larval instars appeared that with increasing the crude plant extract concentra-tion, the mortality of treated larval instars was significantly increased, respectively. This research revealed the effect of plant extracts commonly found corresponding to different plant extracts on Plodia interpunctella (Hubner) larvae. The activity of stud-ied plant extracts was manifested in larval weight loss, reduction of pupation, and adult emergence. Mentha longifolia L and Ocimum basilicum were the most active plant species, with total inhibition of adult emergence obtained. This result agrees with [25] that the extract of Achillea millefolium L. (100%) was ineffective in insecti-cidal activity, and extracts from Sambucus nigra L. and Juglans regia L. were inef-fective in all conducted bioassays. It also agrees with [26] that the susceptibility of T. wilkinsoni larvae decreased with older stage.

References

1) FAOSTAT, F. (2020). Food and agriculture organization of the United Nations (FAO).

2) Ali, A., Adnan, M., Safdar, M. E., Asif, M., Mahmood, A., Nadeem, M., and, Raza, A. (2020). Role of potassium in enhancing growth, yield and quality of maize (Zea mays L.). International Journal of Biosciences, 16(6), 210-219.

3) Gobeze, Y. L., Ceronio, G. M., and Van Rensburg, L. D. (2012). Effect of row spacing and plant density on yield and yield component of maize (Zea mays L.) under irrigation. Journal of Agricultural Science and Technology. B, 2(2B), 263.

4) Du Jardin, P. (2015). Plant biostimulants: Definition, concept, main categories and regulation. Scientia Horticulturae, 196, 3-14.

5) Al-Sahuki, M. M. (1990). Yellow corn production and improvement. Baghdad University. Ministry of Higher Education and Scientific Research. University of Baghdad..

6) Al-Sahuki, Mudhat Majid .(2007). "Research Note: A New Perspective for Predicting the Number of Hybrid Camels from Crossbreeding Breeds with Multiple Probabilities." Iraqi Journal of Agricultural Sciences, 1, 127-125.

7) Al-Sahuki, M. M. (1990). Yellow corn production and improvement. Baghdad University. Ministry of Higher Education and Scientific Research. University of Baghdad.

8) Elsahookie, M.M.(1985). A shortcut method for estimating plant leaf area in maize. Zeitschrift für Acker-und Pflanzenbau, 154(3), pp.157-160.

9) Minotti, P. L., Halseth, D. E., and Sieczka, J. B. (1994). Field chlorophyll measurements to assess the nitrogen status of potato varieties. HortScience, 29(12), 1497-1500.

10) Al-Jubouri, S., M.,, and Awrol M. A .(2009). The Effect of Different Levels and Timing of Nitrogen Fertilizer Application on the Growth of Two Maize Varieties (Zea mays L.). Jordanian Journal of Agricultural Sciences, 5(1): 57-72.

11) Amin, A. A., Rashad, E. M., and Gharib, F. A. E. (2006). Physiological responses of maize plants (*Zea mays* L.) to foliar application of morphactin CF125 and indole-3-butyric acid. HortScience, 33(15), 149-158.

12) Abdullah, A. S. (2001). The Effect of Planting Date and Plant Density on the Characteristics and Yield of Green Forage of Maize (Zea mays L.). Master's Thesis, College of Agriculture, Tikrit University.

13) Brown, P. H., Bellaloui, N., Wimmer, M. A., Bassil, E. S., Ruiz, J., Hu, H., and Römheld, V. (2002). Boron in plant biology. Plant biology, 4(02), 205-223.

14) Sachin, D. N., and Misra, P. (2009). Effect of Azotobacter chroococcum (PGPR) on the growth of bamboo (Bambusa bamboo) and maize (Zea mays) plants. Biofrontiers, 1(1), 24-31.

15) Al-Amiri, Maitham Mohsen Ali .(2001). Variations in Growth and Yield of Maize (Zea mays L.) and Sunflower (Helianthus annuus L.) Under the Influence of Variety and Plant Density. Master's Thesis, College of Agriculture, University of Baghdad.

16) Cui, J., Mak-Mensah, E., Wang, J., Li, Q., Huang, L., Song, S., and Zhang, J. (2024). Interactive effects of drip irrigation and nitrogen fertilization on wheat and maize yield: A meta-analysis. Journal of Soil Science and Plant Nutrition, 1-13.

17) Myint, A. K., Yamakawa, T., Kajihara, Y., & Zenmyo, T. (2010). Applica-tion of different organic and mineral fertilizers on the growth, yield and nutrient accumulation of rice in a Japanese ordinary paddy field. Science World Journal, 5(2).

18) El-Hosary, A. A., Hammam, G. Y., El-Morsi, A., Hassan, E. A., El-Awadi, M. E., & Abdel-Baky, Y. R. (2013). Effect of some bio-regulators on growth and yield of some wheat varieties under newly cultivated land conditions. New York Sci. J, 6(6), 1-11.