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Feeding Effects of three Verities of Date fruits on the Biology of *Cadra cautella* (Walker) (Lepidoptera: Pyralidae)

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Abstract: The study investigates the impact of feeding the fig moth, *Cadra cautella* (Walker), on three varieties of Libyan dates (Saeidi Awjila, Saeidi Gallo, and Bekrary from the West Coast) under laboratory and incubator conditions. The main findings reveled that the life cycle duration of *C. cautella* was significantly affected by the rearing environment. The life cycle lasted 60.1 ± 6.1 days outside the incubator and 79.2 ± 6.6 days inside the incubator when larvae were fed mixed date varieties. Inside the incubator, the larval stage duration was not significantly influenced by the date varieties. Outside the incubator, a significant difference in the larval stage duration was observed between the Bekrary variety and the Saeidi Awjila and Saeidi Gallo varieties. The longest life cycle was recorded on cut Bekrary dates outside the incubator, averaging 85.8 ± 9.9 days. The shortest life cycle was observed on perforated Saeidi Awjila dates inside the incubator, averaging 53.8 ± 2.6 days. The physical form of the dates (cut or perforated) influenced the development period, highlighting its role in the insect's life cycle. The variety of dates significantly affected the completion time of the life cycle, suggesting that fruit characteristics, such as texture or nutrient composition, play a critical role in fig moth development. This study underscores the importance of both environmental conditions and the type of date variety in determining the life cycle longevity. Such findings can help optimize pest management strategies by identifying date varieties and storage conditions that may hinder the rapid development of *C. cautella*.

Keywords: Date palm pests, *Cadra cautella*, life cycle, fig moth, Libyan date fruits, insect rearing, insect feeding.

تأثير تغذية ثلاثة أصناف من التمور علي بيولوجية *Cadra cautella* (Walker) (Lepidoptera: Pyralidae))

المستخلص: تبحث الدراسة في تأثير تغذية فراشة التين *Cadra cautella* (Walker)، على ثلاثة أنواع من التمور الليبية (صعيدي أوجلة و صعيدي جالو و بكراري من الساحل الغربي) في ظل ظروف المعمل والحضان. وبينت النتائج تأثر مدة دورة حياة *C. cautella* بشكل كبير ببيئة التربية. استمرت دورة الحياة 60.1 ± 6.1 يومًا خارج الحاضنة و 79.2 ± 6.6 يومًا داخل الحاضنة عندما تم تغذية اليرقات بأصناف التمور المختلط. داخل الحاضنة، لم تتأثر مدة مرحلة اليرقات بشكل كبير بأصناف التمور. خارج الحاضنة، لوحظ اختلاف كبير في مدة طور اليرقات بين صنف بيكراري وأصناف الصعيدي أوجله وصعيدي جالو. تم تسجيل أطول دورة حياة في التمور بيكراري المقطوعة خارج الحاضنة، بمتوسط 85.8 ± 9.9 يومًا، لوحظت أقصر دورة حياة في تمور الصعيدي أوجلة المثقوبة داخل الحاضنة، بمتوسط 53.8 ± 2.6 يوم، أثر الشكل الفيزيائي للتمور (المقطوعة أو المثقبة) على فترة التطور، مما سلط الضوء على دورها في دورة حياة الحشرة، وأثر تنوع التمور بشكل كبير على طول دورة الحياة، مما يشير إلى أن خصائص التمور مثل الملمس أو المحتوى الغذائي، تلعب دورًا مهمًا في تطوير فراشة التين، وتؤكد هذه الدراسة على أهمية كل من الظروف البيئية ونوع تنوع التمور في تحديد طول دورة الحياة ويمكن أن تساعد هذه النتائج في تحسين استراتيجيات إدارة الآفات من خلال تحديد أصناف التمور وظروف التخزين.

الكلمات المفتاحية: آفات التمور، *Cadra cautella* دورة الحياة، فراشة التين، تربية الحشرات، تغذية الحشرات.

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INTRODUCTION

Cadra cautella is recognized globally as a major indoor pest of stored dates, almonds, and other dried fruits. Infestation significantly affects the quality and marketability of dates and other fruits (Oyewo and Amo 2018, 2020, Sukirno *et al.,* 2021,Singh *et al.,* 2021). In Libya, high infestations have been recorded in regions like Tamanhint, Sabha, Wadan, and Houn, with Apel date varieties in Wadan being the most affected (Bataw and Ben Saad,1990, 1995).

The life cycle and development of *C. cautella* vary depending on diet and environmental factors, Cox (1974, 1987) showed development times ranging from 35.35 days on almonds to 84.0 days on raisins. Temperature significantly affects development, with shorter life cycles at higher temperatures and affect a total lifespan, fecundity, egg hatchability, and overall survival of all life stages of *C. cautella* (Aldawood *et al.,* 2013).Studies in Egypt identified differences in development across date varieties (Ajwa, Khaki, Sultani, Freehi), with food type influencing larval stages and longevity (Abdel-Salam & El-Saeady 1983).

While *C. cautella* is a known pest of Libyan dates, studies have largely focused on geographical distribution and infestation levels. The biological development of this pest under controlled laboratory conditions using different date varieties has not been thoroughly examined.Understanding the biology of *C. cautella* on local date varieties will highlight the specific vulnerabilities of different date types, offer actionable knowledge to minimize postharvest losses through targeted interventions and contribute to sustainable pest management practices for the Libyan date industry.

Previous studies have primarily explored the pest's distribution, while its biology on different Libyan date varieties (Saeidi Awjila, Saeidi Gallo, and Bekrary) under laboratory conditions

remains insufficiently studied. The study aims to fill this gap by examining the biological development of *C. cautella* when fed three Libyan date varieties under varying conditions.

Materials and Methods

Date Samples: Samples of date fruit varieties were collected from three distinct regions in Libya: Saeidi Ujla, Bakrari from north Coast, and Saeidi Jalu. Each sample, weighing 1 kg, was collected directly from the fields, placed in sealed plastic bags, and brought to the laboratory. Infected fruits were carefully examined and excluded. Healthy fruits were sterilized by refrigeration at temperatures ranging from -1°C to 4.5°C for 30 days (Damual *et al.,* 1974).
Insect Culture:Adults of *Cadra cautella* were reared on a date-based diet in an incubator maintained at 25±2°C and 65±5% relative humidity (RH). Transparent containers with opaque lids and small openings for ventilation were used. Larvae were separated and isolated in pairs (male: female ratio of 1:1) to obtain eggs. Newly hatched larvae were distributed at a density of 4 larvae per container for experimental purposes. Four experiments were conducted:
Experiment 1:Investigated the effect of rearing methods on the duration of different life stages.**Experiment 2**:Studied the impact of date fruit shapes (complete, cut, and perforated) on the length of various life stages.
Experiment 3: Examined the influence of date fruit varieties and rearing methods on the longevity of insect stages.
Experiment 4: Explored the combined effects of date fruit varieties, shapes, and rearing methods on the development stages of *Cadra cautella*.
All experiments were repeated five times. Containers were kept in an incubator equipped with temperature and humidity control switches, regulated with sodium acetate (Shazali *et al.,* 1985, 1990). Parallel experiments were conducted outside the incubator where the temperature and humidity unstable and fluctuated. Replicates were monitored daily until the experiments concluded, recording: Duration of larval, pupal, and adult stages. And Feeding behavior during development.
Duration (in days) of each stage:
Larval stage: From egg hatching to pupal entry.
Pupal stage: From the end of the larval stage to adult emergence.
Adult stage: Lifespan of newly emerged adults.

Statistical Analysis: Data were analyzed using a Completely Randomized Design (CRD) in Minitab Ver. 10. Significance was determined at a 5% probability level, and the Least Significant Difference (LSD) test was used to separate means.

Results and Discussion

The place of insect rearing (inside or outside the incubator) significantly influenced (P=0.05) the longevity of various life stages of *Cadra cautella* when reared on mixed date varieties. The larval stage showed the longest longevity (In days) when reared outside the incubator (67.31±6.8), as shown in Table 1. The external environment outsid the incubator likely provided less optimal conditions for larval stage compared to the controlled conditions of the incubator (49.06±6.2$^{)}$. While no significant differences were observed in the pupal stage duration between the two rearing environments, indicating that this stage might be less sensitive to external environmental variations

The adult stage reared inside the incubator had a shorter longevity (3.6±0.6), reflecting faster development under stable and suitable conditions (4.3±1.2) (P=0.05). The life cycle inside incubator shows short longevity (60.1±6.1) compare with insect reared outside the incubator (79.2±6.6) The controlled temperature and humidity inside the incubator likely optimized the physiological processes of the insect.

This finding aligns with previous studies by Abdel-Salam, & El-Saeady, (1983). who observed significant differences in development rates based on rearing methods, and noted that rearing *C. cautella* on stored dates under laboratory conditions resulted in a longer life cycle compared to rearing at elevated temperatures.

The analysis revealed no significant differences (P= 0.01) in the longevity (day) of the larval, pupal, adult stages, or the complete life cycle when larvae were fed on mixed dates fruits in different forms (complete, perforated, or cut).

Table (1). The effect of place of rearing with mixed verities on the longevity (in days) of the different life stages development of *C. cautella* (Mean ±SE)

Type	Larval stage	Pupal stage	Adult stages	Life cycle
Inside incubator	49.06±6.2[a]	7.4±0.8[a]	3.6±0.6[b]	60.1±6.1[b]
Outside incubator	67.31±6.8[b]	7.5±0.6[a]	4.3±1.2[a]	79.2±6.6[a]
Mean±SE	58.1±6.5	7.5±0.7	3.9±0.9	69.6±6.3

Similar letters (in a same column) means no significant differences at a probability of 0.05 or less.

This experiment investigated how the shape of date fruits (complete, perforated, or cut) influences the longevity of the life stages of *Cadra cautella*. The results are presented in Table 2.

The lack of differences may be attributed to the mixed nature of the date fruit samples used in the study, combining various shapes and varieties. This mixture likely minimized any detectable effect of fruit shape on the developmental biology of the fig moth.(El-Maged *et al.*, 2022). The findings suggest that when *C. cautella* infests a mix of dates with varied shapes and types, the insect's life cycle remains consistent across the different forms. This observation aligns with the general adaptability of *C. cautella*, a cosmopolitan pest capable of thriving on a variety of stored food products under diverse conditions. Darwish et al (2013) shown that the date fruit variety on which *C. cautella* were raised affected both the developmental period of the immature stages and adult fecundity, and that the Sakkoti variety (dry-date) is more suited for *C. cautella* feeding than the Saidy variety (semi-dry).

However, it is essential to note that the results may not fully reflect the effect of individual fruit shapes on the moth's development. A more controlled study focusing on single-shape date samples (rather than a mixture) could provide deeper insights into whether fruit shape alone influences the longevity of life stages.

Table. (2): Effects of feeding of Fig moth (*C. cautella*) with different shapes and mixed of varieties of date on insect life stages (Mean days ±SE)

Date fruit shape	Larval stage	Pupal stage	Adult stage	Life cycle
Complete	57.1±11.1[a]	7.5±0.6[a]	4.0±1.1[a]	64.0±11.3[a]
Perforated	57.9±11.5[a]	7.5±0.8[a]	4.1±0.8[a]	61.81±2.0[a]
Cutted	60.5±10.9[a]	7.3±0.5[a]	3.7±0.9[a]	71.6±11.1[a]
Mean	58.5±111.1	7.5±0.7	3.9±0.9	65.6±11.5

Similar letters (in a same column) mean no significant differences at a probability of 0.05 or less.

The study evaluated the development rates of *C. cautella* when reared on three different shapes of date fruit (complete, perforated and cutted) for each Libyan date variety (Saeidi Ujla, Bakrari, and Saeidi Jalu) under two rearing conditions (inside and outside an incubator). Significant differences (P=0.05) occurred on larval stage when *C. cautella* was reared outside incubator on different fruit shapes, bekrary dates outside the incubator record longest period (73.0±6.6), while insects reared inside incubator on Bekrary recorded a shortest period (48.3±6.4), likely due to the influence of temperature during breeding. This finding aligns with earlier studies (Cox, 1974), which demonstrated that larva development rates are affected by rearing methods and date varieties. The study revealed a significant effect of breeding methods and date varieties on the duration of the full life cycle:

Maximum Duration: The longest life cycle (84.3 ± 6.3 days) was recorded when insects were reared on Bakrari dates outside the incubator. (Table 3). Minimum Duration: The shortest life cycle (58.2 ± 4.7 days) occurred when insects were reared on Saedi Gallo dates inside the incubator. These findings demonstrate that environmental factors (e.g., temperature, humidity) and biotic factors (e.g., food type, moisture content, and chemical composition) significantly influence the full life cycle. Previous studies (Abdel-Salam & El-Saeady 1983; Cox, 1975) corroborate these results, showing that temperature and food quality impact developmental stages and longevity.

The differences in life cycle durations emphasize the role of temperature. The incubator environment, with controlled and favorable conditions, facilitates faster development compared to non-incubator settings and the nutritional value and chemical composition of date varieties directly affect growth and reproduction. Dates with higher nutrient content likely meet the insect's dietary needs more effectively, promoting faster life cycle completion, the significant differences across varieties highlight potential genetic and chemical traits in date fruits that influence *C. cautella* development.

Table (3). The effect of feeding of mixed shapes of each t variety of date rearing inside and outside incubator on the longevity of the development of different life cycle stages of *C. cautella* (Mean (days) ± SE)

Factors		Larval stages	Pupal stages	Adult stages	Life cycle
Inside incubator	Saeidi Ujla	51.1±7.3[c]	7.7±0.6[a]	3.6±0.6[d]	62.4±6.5[d]
	Bekrary	48.3±6.4[c]	7.6±0.7[a]	3.6±0.3[b]	59.6±6.4d[e]
	Saeidi Jalu	47.7±4.4[c]	6.9±0.8[b]	3.6±0.7[a]	58.2±4.7[e]
Outside incubator	Saeidi Ujla	65.8±5.3[b]	7.7±0.3[a]	5.3±1.4[a]	78.9±5.4[b]
	Bekrary.	73.0±6.6[a]	5.5±0.5[a]	7.3±0.5[b]	84.3±6.3[a]
	Saeidi Jalu	62.9±5.3[b]	7.3±0.8[a]	4.0±0.8[b]	74.4±4.1[c]
Mean (±SE)		58.1±5.8	7.5±0.7	3.9±0.7	69.6±5.5

Similar letters (same column) means no significant differences at a probability of 0.05 or less.

These findings underscore the importance of considering both breeding methods and date variety characteristics in pest management strategies. The significant variations in life cycle duration across conditions and varieties highlight the adaptability of *C. cautella* to different environmental and nutritional contexts. Future studies could delve deeper into the specific chemical and physical traits of date varieties that influence pest development. The result reveled the effect of date varieties, shapes, and rearing methods on the longevity of developmental stages of *Cadra cautella* (Table 4).

The results showed that date varieties, shapes, and rearing methods significantly influenced the larval stage longevity: The longest larval stage (74.6 ± 10.1 days) was observed when larvae were reared on Bakrari cut dates outside the incubator.The shortest larval stage (43.4 ± 2.2 days) occurred when larvae were reared on healthy Saedi Gallo dates inside the incubator. These findings indicate that the larval stage is highly sensitive to both food type and environmental conditions. The nutritional content, physical shape, and moisture levels of the dates, coupled with temperature and humidity, play critical roles. These results align with earlier studies (Abdel-Salam, & El-Saeady 1983), which found that larval development was prolonged on less favorable food types and under lower temperature conditions. It is well known that an insect's ability to survive and reproduce can be directly impacted by the type and amount of food it consumes (Razmjou *et al.,* 2006). Variations in developmental growth may be caused by physical or chemical characteristics of the dates

The study revealed significant differences(P=0.05) in the pupal stage based on date variety, shape, and rearing methods:The longest pupal stage (8.1 ± 0.5 days) occurred when larvae were reared on perforated Awjila dates inside the incubator. The shortest pupal stage (6.6 ± 0.2 days) was recorded on healthy Saedi Gallo dates inside the incubator. The findings suggest that perforated dates may delay pupation due to the larval feeding environment, while intact dates may provide a more stable nutritional source. These observations are consistent with Cox (1974), who reported that temperature significantly impacts the pupal stage, with cooler environments extending developmental time.

The longevity of adult *C. cautella* varied depending on adult's status: The longest pupal stage (6.0±1.5 days) occurred when adult was reared on perforated Awjila dates inside the incubator. The shortest pupal stage (2.9±0.2 days) was recorded on healthy Saedi Gallo dates inside the incubator. These results highlight the influence of mating status on adult longevity, with unmated individuals generally living longer, likely due to the absence of energy expenditure on reproductive activities. The total life cycle of *C. cautella* was significantly affected by the combination of date variety, shape, and rearing method: The longest life cycle was recorded when the insect was reared outside the incubator in all form of Bekrary date fruit shape (cutted = 85.8 ± 9.9, perforated = 84.6±4.0 and complete = 82.4±3.9 days).The shortest life cycle (53.8 ± 2.6 days) was recorded on Saeidi Ujla Perforated dates inside the incubator.

Table: (4). The effect of varieties shapes of date fruits and rearing place on the longevity of life cycle stages of *Ephestia cautella* (Mean (days)±SE).

Factors			Larval stage	Pupal stage	Adult stage	life cycle
Inside incubator	Saeidi Ujla	Complete	43.4±2.2^{f}	7.8±0.4^{ab}	3.6±0.9^{caf}	55.3±2.4^{gh}
		Perforated	50.6±4.3^{e}	8.1±0.5^{a}	3.9±1.0^{caf}	62.7±3.7^{de}
		Cutted	59.2±2.8^{cd}	7.1±0.8^{bcd}	2.9±0.2^{g}	69.3±2.8^{c}
	Bekrary	Complete	56.18±5.2^{d}	7.8±0.8^{ab}	3.3±0.2^{efg}	67.3±5.3^{dc}
		Perforated	43.6±1.5^{f}	7.9±0.6^{ab}	3.9±0.4^{cdef}	55.5±2.40^{gh}
		Cutted	45.21.2^{fe}	7.1±0.6^{ab}	3.9±0.4^{edef}	56.1±1.4^{fgh}
	Saeidi Jalu	Complete	49.8±3.7^{e}	6.6±0.2^{d}	3.2±0.5^{cdefg}	59.8±3.9^{efg}
		Perforated	43.9±2.3^{ef}	6.9±1.0^{cd}	3.0±0.4^{fg}	53.8±2.6^{h}
		Cutted	49.3±4.6^{e}	7.4±0.9^{abcd}	4.4±0.5^{bed}	61.2±4.3^{ef}
Outside incubator	Saeidi Ujla	Complete	71.0±5.6^{a}	7.6±0.2^{abc}	5.2±1.3^{bc}	84.0±5.5^{b}
		Perforated	63.8±3.6^{bc}	7.7±0.4^{abc}	4.6±1.4^{bc}	76.2±4.7^{b}
		Cutted	62.6±1.4^{bc}	7.8±0.3^{ab}	6.0±1.5^{ae}	76.5±2.1^{b}
	Bekrary	Complete	70.7±4.0^{a}	7.5±0.6^{abc}	4.1±0.2^{defg}	82.4±3.9^{a}
		Perforated	73.8±4.8^{a}	7.2±0.4^{abcd}	3.5±0.5^{defg}	84.6±4.0^{a}
		Cutted	74.6±10.1^{a}	7.7±0.5^{ab}	3.4±0.5d^{efg}	85.8±9.9^{a}
	Saeidi Jalu	Complete	59.91.2^{bcd}	7.3±0.9^{acd}	4.5±0.9^{efg}	71.8±1.4^{b}
		Perforated	63.6±5.5^{be}	7.6±0.4^{abc}	3.6±0.9^{bcd}	74.9±5.9^{b}
		Cutted	65.3±2.0^{bc}	7.1±1.0^{bcd}	3.9±0.4^{f}	76.3±2.9^{b}
Mean (±SE)			58.13±11.2	7.5±0.7	3.9±0.6	69.6±3.8

Similar letters (same column) means no significant differences at a probability of 0.05 or less

The incubation environment provided a more favorable setting, likely due to controlled temperature and humidity, which accelerated development. The perforated dates seemed to offer better conditions than cut dates, possibly due to reduced moisture loss and protection against desiccation. These results corroborate findings by Allotey et al. (1990), who reported shorter life cycles of *C. cautella* when reared on nutrient-rich substrates like walnuts, also with (Oyewo and Amo 2020) who investigated the important of food types as a main factor that determine the longivety of life cycle. The controlled conditions of the incubator reduced developmental time, highlighting the importance of temperature and humidity in the life cycle of *C. cautella*, and the shape of the date fruit (e.g., cut, perforated, or whole) and its variety significantly influenced larval and pupal stages. Nutritional content and physical structure likely impacted feeding efficiency and development.

Conclusion:

These findings underscore the critical roles of environmental conditions, food type, and physical characteristics of date fruits in shaping the life cycle of *C. cautella*. Understanding these interactions can inform pest management strategies, including storage methods and environmental control, to mitigate infestations in date storage facilities. These findings can guide storage practices by emphasizing the importance of controlling environmental conditions and selecting date forms that minimize pest infestation. For example, storing whole dates in controlled environments may limit pest development and reduce losses. We recommend further studies involve on Investigate the chemical composition of date varieties to identify compounds influencing pest development and Explore integrated pest management (IPM) strategies combining environmental controls and resistant date varieties.

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