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Mohammad Ali Al-Deeb
United Arab Emirates University, Department of Biology, Al-Ain, P.O. Box 15551 United Arab Emirates

Hamda Ateeq Al-Dhaheri
Al-Ain Municipality, Department of Municipal Affairs, Al-Ain, United Arab Emirates

Correspondence
Mohammad Ali Al-Deeb
United Arab Emirates University, Department of Biology, Al-Ain, P.O. Box 15551 United Arab Emirates

Use of a pheromone-baited trap to monitor the population of the lesser date moth *Batrachedra amydraula* (Lepidoptera: Batrachedridae) in the UAE

Mohammad Ali Al-Deeb and Hamda Ateeq Al-Dhaheri

Abstract
The lesser date moth, *Batrachedra amydraula*, is a serious insect pest of young developing date fruits. In the United Arab Emirates (UAE) it is responsible for major losses in the annual yield of dates. The objectives of the current study were: (1) to determine the population peak of the *B. amydraula* using a pheromone-baited trap and (2) to study the relationship between trap catch and average daily temperature. The population dynamics of *B. amydraula* in date palm plantations were monitored in 2014 and 2015 using delta sticky traps baited with a female sex pheromone [Z-5-Decenyl acetate (40%), Z-5-Decen-1-ol (40%), and Z,Z-4,7-Decadienyl acetate (20%)]. In both years, the highest trap catch occurred in April. The population progressively declined to zero by the end of May in 2014 and by the first week of June in 2015. There was a strong negative correlation between the average daily temperature and the number of *B. amydraula* moths captured in pheromone traps. In conclusion, the current study reported *B. amydraula* population fluctuations as well as it determined its peak. This information helps date palm growers to design effective management programs.

Keywords: Date palm tree, Batrachedra amydraula, pheromone, population dynamics, trap

Introduction
The lesser date moth, *Batrachedra amydraula* Meyrick (Lepidoptera: Batrachedridae) is an important pest of date palms (*Phoenix dactylifera* L.) that damages young developing fruits, leading to severe yield loss [1]. It is one of the most serious insect pests affecting date palm production in the United Arab Emirates (UAE) [2] and some other date-producing countries, including the Sultanate of Oman [3], Iraq [4], Saudi Arabia [5], Pakistan [6], and Yemen [7]. The vernacular name of this insect is 'Humeira', which is an Arabic word meaning red or reddish-brown color [1]. Based on some field studies, *B. amydraula* has three overlapping generations annually [8, 5]. Larvae feed on the newly formed inflorescences and young fruits, entering from the calyx end [1]. Larvae progressively consume the contents of the fruit, leaving only the outer skin, which appears dry and reddish-brown in color. The damaged fruits either fall to the ground or remain attached to the bunch stalks. *Batrachedra amydraula* is controlled by several chemical [4, 7, 9] and non-chemical [10, 11] methods. In 2011, the sex pheromone released by the females of *B. amydraula* was identified as a mixture of four compounds: (4Z,7Z)-4,7-decadien-1-yl- acetate, Z4-decen-1-yl acetate, Z5-decen-1-yl acetate, and decyl acetate [12]. These were novel compounds among the other known moth sex pheromones and it was the first identified pheromone for the family Batrachedridae. A reevaluation of the sex pheromone of the *B. amydraula* using feral female moths revealed that the optimal attractive blend was a mixture of three components: (Z4,Z7)-4,7-decadien-1-yl acetate, Z5-decen-1-yl acetate, and Z5-decen-1-ol, in a ratio of 1:2:2 [13]. The three-compound blend gave an approximately fivefold higher trap catch of *B. amydraula* males compared with the previously evaluated binary blend [13]. *Batrachedra amydraula* female sex pheromone lures using the three-compound blend were effective in capturing males under field conditions in Iraq [14].
Despite the damage caused by the lesser date moth in the UAE, there are not any studies on the population dynamics of this pest. The lack of knowledge on the numbers of *B. amydraula* during the season is impeding the design of an effective integrated pest management (IPM) program against this insect. The objectives of the current study were: (1) to determine the population peak of the *B. amydraula* using a pheromone-baited trap and (2) to study the relationship between the trap catch and the average daily temperature.

Materials and Methods

Study Location and Design of Experiment

Trapping of *B. amydraula* was carried out in two farms in 2014 and in only one farm in 2015, because one of the farms used in 2014 was not available. Eight traps were installed per farm. Farms were located in Al-Jimi Oasis in Al-Ain, UAE. In 2014, the first farm was ≈ 250 x 100 m containing 220 date palm trees (10-15 yr of age), which were planted in parallel rows running the length of the farm. The distance between trees was fixed (6-7 m). The second farm was ≈ 200 x 100 m containing 215 date palm trees (15-20 yr of age). The distance between trees was slightly variable (4-8 m). As mentioned above, in 2015 traps were installed only in the first farm in 2014. In both years the experimental design was a randomized complete block. Each farm was divided into four equal blocks and two traps were installed per block. Traps were placed on trees that were selected randomly in each one of the four blocks. Tree selection was done at the beginning of the study and was not altered subsequently during the growing season. Flood irrigation was applied on the farms using spring water running through a traditional canal system, known locally as a ‘Falaj’. The farms were chosen on the basis of their known history of infestation with *B. amydraula*. Weather data including average, highest, and lowest daily temperatures were obtained from a nearby meteorological station.

Pheromone Trap Design and Installation

Plastic delta traps (Alpha Scents Inc., West Linn, Oregon, USA) (Fig. 1) were used to capture *B. amydraula* moths in 2014 and 2015. Each trap contained a red plastic triangular prism-shaped body and a sticky insert card. The pheromone was released from a pheromone dispenser (rubber septum) placed inside the trap on the sticky insert card. Every pheromone dispenser contained a female sex lure (HumairahLure™) of *B. amydraula*. The lure composition was Z-5-Decenyl acetate (40%), Z-5-Decen-1-ol (40%), and Z,Z-4,7-Decadienyl acetate (20%). Each trap was installed on a date palm tree at a distance of 15 cm from the fruit bunch. The average trap height was 2 m above the ground and the minimum distance between traps was 100 m. The pheromone dispenser was replaced with a fresh one every 30 days. Traps were checked weekly and sticky cards were replaced with new ones. Traps were not checked on two dates in 2014. Collected sticky cards were taken to the laboratory and all insects on every card were counted manually using a hand held tally counter. In both years trapping was carried out until reaching the zero catch level in all traps.

Data Analysis

Statistics were performed using GraphPad® Prism version 5.01 for Windows®, GraphPad Software (La Jolla, California, USA). Arithmetic means and standard errors were calculated for trap catch. Pearson’s correlation analysis was conducted between trap catch data (in 2014 and 2015) and average daily temperatures. In addition, the coefficient of determination r^2 was calculated. In all testes the significance level was set at $P = 0.05$.

Results

In 2014, the first trap catch (49.3 insects per trap) of *B. amydraula* moths occurred on 19 April (Fig. 2). The moth population reached its peak (179.5 insects per trap) on 26 April, after which the catch declined gradually. Moths completely disappeared by 14 June and no catch was recorded in traps. The average catch during the 2014 season was 86.1 insects per trap. In 2015, the first trap catch (87.5 insects per trap) was recorded on 23 March and the population peaked (261.5 insects per trap) on 6 April (Fig. 3). Subsequently, there was a gradual decline in moth numbers and the population reached the zero level on 27 May. The average catch during the 2015 season was 124.5 insects per trap.

There was a strong negative correlation between the average daily temperature and the number of *B. amydraula* moths captured in pheromone traps (Pearson’s, $r=-0.61695$; $n = 15$; $P=0.0143$). The coefficient of determination was $r^2 = 0.3806$ (Fig. 4).

Fig 1: *B. amydraula* pheromone-baited trap. (A) Trap fixed on a date palm tree. (B) Sticky insert card, which is placed inside the trap, showing captured *B. amydraula* moths. All photos credited to Mohammad Ali Al-Deeb.

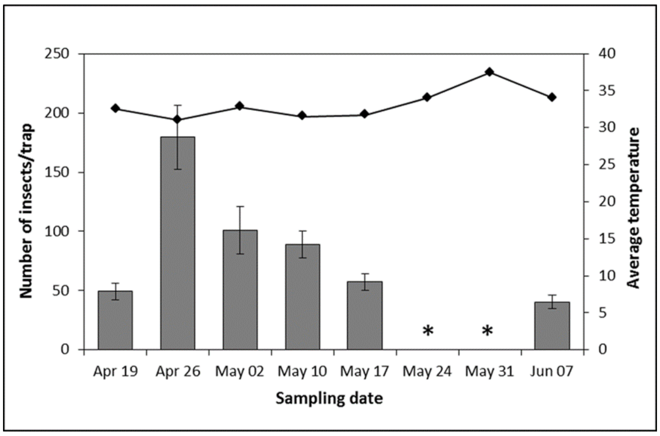

Fig 2: Pheromone-baited trap catch of *B. amydraula* male moths in Al-Ain, UAE in 2014. The sampling dates represent the end dates of each trapping period. The solid line shows the average temperature (°C) in each trapping interval. Bars: mean (±SE) number of captured moths in each trapping period. * Dates on which traps were not checked.

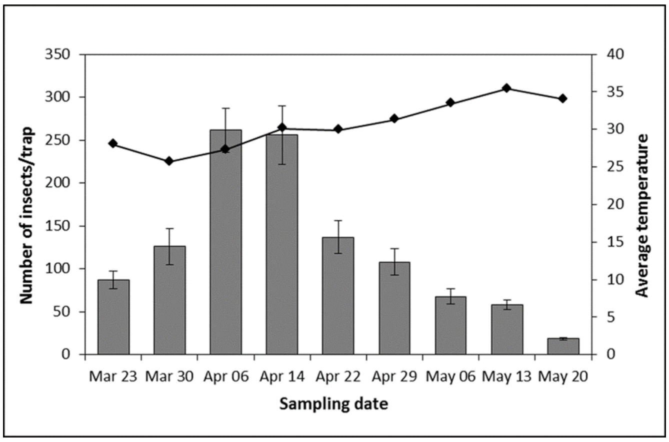

Fig 3: Pheromone-baited trap catch of *B. amydraula* male moths in Al-Ain, UAE, in 2015. The sampling dates represent the end dates of each trapping period. The solid line represents the average temperatures (°C) in each trapping interval. Bars: mean (±SE) number of captured moths in each trapping period.

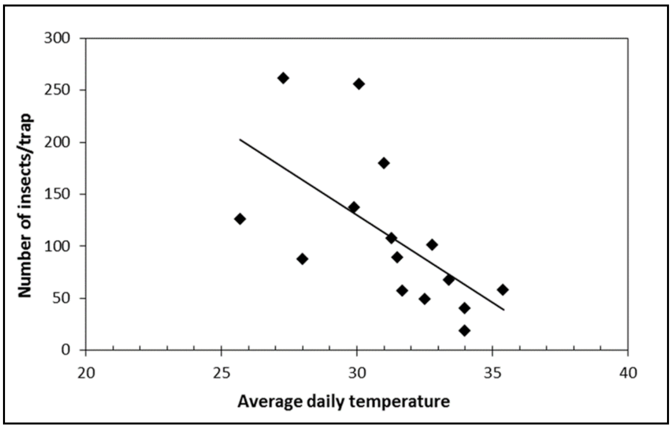

Fig 4: Scatter plot showing a strong negative correlation (r = −0.61695, n = 15, P = 0.0143, r^2 = 0.3806) between average daily temperature (°C) and the number of *B. amydraula* adults captured in pheromone sticky traps in date palm farm at Al-Ain, UAE in 2014 and 2015.

Discussion

The use of a delta sticky trap baited with a female sex lure [Decenyl acetate (40%), Z-5-Decen-1-ol (40%), and Z,Z-4,7-Decadienyl acetate (20%)] was effective in monitoring population dynamics of *B. amydraula*. Based on trap catch, males of *B. amydraula* appeared in the spring in 2014 and 2015 and the population reached its peak in April. The increase in temperature (>30 °C) had an adverse effect on insect numbers, as indicated by the strong negative correlation between the insect numbers and the average daily temperatures. The correlation was more visible in 2015 data where the difference between the maximum and minimum temperatures was 10 °C, whereas it was 6 °C in 2014. The r^2 value showed that 38% of the total variation in trap catch could be explained by a linear relationship with the average daily temperature. It was noticed that the highest daily temperature exceeded 40 °C on the two days preceding the dates on which the trap catch was zero (43 °C on 7 June 2014 and 42 °C on 20 May 2015). Another factor that probably contributed to the decline in the insect numbers over time was the change in the fruit developmental stage because *B. amydraula* is known to attack newly formed inflorescences and fruits rather than mature fruits [15, 16]. Some field studies [8, 5], which were not conducted in the UAE, indicated that *B. amydraula* has three overlapping generations per year. However, because of the overlap between *B. amydraula* generations and not coupling trap catch data of this study with the life stages of the insect inside the infested fruits, the current study was not able to pinpoint the beginning and the end of each generation rather it monitored the total activity time. The results of the current study are in agreement with a previously published report, which also used delta traps baited with a female sex pheromone and reported effectiveness in monitoring fluctuations in *B. amydraula* populations in Iraq [14]. That study evaluated the efficacy and longevity of *B. amydraula* female sex pheromone lures under field conditions. Also, it reported that traps, which were installed 3 m above the ground, were more efficient than those suspended at 6 m and that the effectiveness of the traps in capturing male moths varied during the season (average 11.33, maximum 20 insects per week). Both of the current study and the one conducted in Iraq [14] used a three-compound pheromone blend with a similar ratio among constituents, but the current study reported much higher trap catch rates in 2014 and 2015 (average, 86.1 and 125.5 insects per week; maximum, 179.5 and 261.5 insects per week, respectively). It is possible that the differences seen in the numbers of captured moths could be due to differences in lure dispensing rates. Moreover, weather conditions play a role in a pheromone trap efficacy because temperature can influence pheromone dispensing rates [17]. In addition, the variability in trap catch could be attributable to differences in the initial size of the *B. amydraula* populations between the two study sites. Because the UAE is located in the desert biome the results of this study demonstrates trapping under desert agroecosystem conditions. To our knowledge, the current study is the first published record on the use of a *B. amydraula* pheromone trap in the UAE using a lure with a three-compound blend.

An insect damage is classified as direct if the pest destroys the marketable part of the plant. Accordingly, *B. amydraula* causes direct damage to date palm trees when it destroys the fruits. It has been reported that each *B. amydraula* larva damages three to four fruits during its lifetime by feeding on a portion of each fruit [1]. As a result, the number of captured *B. amydraula* moths in a trap represents approximately three to four fold of the number of damaged fruits. In fact, the actual number of the damaged fruits is always much higher than what is indicated by a trap because the trap contains the *B. amydraula* female sex pheromone and therefore it only captures male moths (the number of captured moths does not represent the fruits damaged by female moths). The pheromone-baited trap is a monitoring tool for date palm growers to track the presence of the *B. amydraula* in their date palm farms and also to indirectly monitor the progress of fruit damage over time. However, in order to avoid yield loss caused by *B. amydraula* a good integrated pest management (IPM) program ought to be set up [10]. The current study can contribute to a successful IPM of *B. amydraula*. The population dynamics data can help date palm growers in the UAE to determine the time of the season that is most suitable for the deployment of natural enemies in the field when biological control is practiced. In addition, because several studies reported the use of insecticides against *B. amydraula* [4, 7, 9], chemical control - when justifiably needed - can also benefit from the current study in terms of timing by applying insecticides on the plants before reaching the population peak of *B. amydraula*, which should result in avoiding the occurrence of severe fruit damage. It should be mentioned that trapping of *B. amydraula* reduces the number of male moths, which consequently reduces mating and egg fertilization during the trapping season and subsequently the number of emerging moths in the following season.

Conclusion and Recommendation

The current study shows the population dynamics of the lesser date moth, *B. amydraula*, in the UAE. Also, it shows that a pheromone-baited trap containing a three-compound blend can be utilized in monitoring *B. amydraula* moths under the field conditions of a desert agroecosystem such as the one in the UAE. In addition, it suggests its use in the mass trapping of this pest as an environmentally-safe management tool.

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