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Abundance of palm frond borer *Phonapate frontalis* (Fah.) (Coleoptera: Bostrichidae) with reference to potential use of garlic extract for its control in Siwa Oasis, Egypt

Ahmed I. Imam

Abstract

Palm frond borer *Phonapate frontalis* F. (Coleoptera: Bostrichidae) has been recently detected as an economic pest of date palm orchards at Siwa Oasis, Egypt. The infestation symptoms appeared in the form of frond break and viscous oozes at the fracture points. The present study aimed to monitor the population fluctuation of *P. frontalis* adults, using light traps during 2016 season and to test the capability of the methanolic garlic extract to deter the beetles and consequently reduce frond breakage. The average monthly monitoring revealed minor *Phonapate* adult catches during January and November with maximum numbers during June–August. Coinciding with the surveillance of *Phonapate* adults, broken fronds were periodically monitored. The highest average breakage was noticed at the period extended from May to September. Accordingly, fortnight spraying program had been designed and commenced to cover such period. At the end of the proposed program, the corrected infestation percentages recorded about 43.11, 44.89, and 42.22% at 1000, 2000, and 3000 ppm of the methanolic garlic extract concentrations, respectively. Accordingly, garlic extract succeeded to diminish palm frond infestation through its capability to deter adult beetles. Engagement of cost competitive treatment as a *P. frontalis* niche (palm fronds) management tool in the proposed IPM program could support the sustainable pest management in the date palm orchards.

Keywords: Palm frond borer, *Phonapate frontalis*, Abundance, Niche management, Garlic extract, Egypt

Introduction

Date palm, *Phoenix dactylifera* L., is one of the most cultivated trees in the desert areas of many countries (Abass et al. 2016). As the global annual date production is estimated by about 7.4 million tons, Arab countries are considered as the lead producers by about 70% (FAOSTAT 2011). Out of which, Egypt comes on the head of the date producer list by about 11 million fruitful date palm trees with estimated production of about 1,115,000 tons annually (Erskine et al. 2003). Egyptian Oases at the western desert are one of the main date palm cultivation areas. In which semi-dry varieties are the dominant ones due to their adaptation to the prevailing environmental conditions (Riad 1993).

Insect pest invasion is one of the major detrimental factors that could threaten date palm production on both Egyptian and global levels. Out of date palm pest complex, palm borers are ranked as the most dangerous date palm attackers. Where the tunnels excavated within the internal palm tissues (trunk or frond or spathe) by larvae and/or adults that weaken the tree through hindering the passage of nutrients and water facilitate the opportunity of fungal or bacterial infestation and may cause the breakage of the infested parts. The chronic mode of infestation progress of most borer species beside the difficulty for early infestation detection, the rareness of detailed studies regarding this group of pests, and the unawareness of date palm farmers with the good agriculture practices to manage them may be another reasonable key for more exacerbated situation (Al-Deeb et al. 2012; and Khalaf et al. 2017).

Correspondence: aiimmam@yahoo.com

Desert Research Center, 1 Mathaf El-Matariya St., B.O.P: 11753 Matariya, Cairo, Egypt

Siwa is one of the Egyptian well-known oases globally. At Siwa Oasis, date palm trees are invaded by a group of economic insect pests that target different parts synchronizing different growing stages of the trees (Imam 2012). Among these herbivorous species, adults of the palm frond borer, *Phonapate frontalis* (F.) (Coleoptera: Bostrichidae), were recently recorded by the light trap and by their infestation symptoms (breaking of the palm green fronds) in May 2015 (Fig. 1). According to Al-Haideri and Al-Hafidh (1986), *P. frontalis* was not considered among the major economic pests of palm trees at the near east and North Africa. In contrary, at Al-Wahat regions, Libya, Al-Ogale (2003) recorded infestation rates of 10.2, 11.1, 9.6, and 10.3% during May, June, July and August months, respectively. *P. frontalis* adult is a nocturnal insect; its flight period is extended either from May to October (Khattab and Helal 1978) or from March to October (Al-Ogale (2003)) according to the monitored subspecies and the prevailing weather conditions. The highest catch of *Phonapate* adults was recorded between June and September. Adults of *P. frontalis* have the capability to mine tunnels within the green frond tissues and within which the couples are met for mating. A viscous liquid is oozed as a result of the tunnel excavation process. The beginning of frond breakage symptom was noticed in March with a remarkable increase in the breaking percentages at the period May–August, coinciding with the flight period of adults (Bitaw and Ben-Saad 1990).

Garlic, *Allium sativum* L., extract is one of the promising alternatives against arthropod pests (Karunamoorthi and Hailu 2014). Different forms of garlic extracts showed noticeable efficacy as eco-friendly protectants

against different species and stages of pests such as stored grain pests (Nwachukwu and Asawalam 2014).

The objective of the present study was to estimate the population fluctuation of the palm frond borer and to test the efficacy of methanolic garlic extract in either repel or deter *Phonapate* beetles and consequently reduce frond breakage.

Materials and methods

Study site

Siwa (Matrouh Governorate) is a natural depression situated at the northern corner of the Egyptian western desert, about 300 km from the Mediterranean coast. The oasis is one of the main date palm assemblage points in Egypt, especially the semi-dry “saidi” variety. Out of all Siwa’s villages, Al-Herak (29°11′ 56.36″ N and 25° 29′ 58.56″ E) date palm orchards showed aggressive attack of the palm frond borer. Accordingly, all the proposed studies were implemented therein.

Experimental design

Abundance of the palm frond borer

During 2016 date growing season, two light traps (Ultra violet Robinson’s vapor light trap) (Robinson and Robinson 1950) were installed in the middle of one date palm orchard that had about 100 palm trees of saidi variety. The palm trees under investigation are fruitful trees with about 12 years old and 1.5 to 2 m height. So, the trap was hanged on a 2 m holder to be in the level of date palm fronds. The farm receives all the traditional agriculture practices that implemented in the majority of Siwa date palm orchards. Monthly monitoring of the trap catches was carried



Fig. 1 Infestation symptoms and adult stage of the palm frond borer, *Phonapate frontalis*, at the date palm groves of Siwa Oasis (2015 season)

out throughout the year from January to December counting the number of collected *P. frontalis* adults.

During 2016 season, the periodical breakage of palm fronds was also recorded. In order to conduct this trial, 15 date palm trees were kept under investigation; all infested (broken) fronds that remained hanging on the trees from the previous season were cut before the onset of January 2016. The commencement, fluctuation, the ending, and the period of palm frond fracture were crucially noticed and recorded.

Preparation of methanolic garlic extract

Extraction process had been carried out according to Hafiz et al. (2012) with certain modifications. Fixed amount of dry and cleaned garlic bulbs (about 250 g) was well crushed using an electric grinder. The grinded garlic cake was transferred to a clean glass beaker and soaked in an adequate volume of pure methanol (about 750 ml) for 2 days to facilitate the extraction of the active compounds (ingredients) in the supernatant (liquid extract). The methanolic garlic solution was filtrated out, using a filter paper (Whatman no. 1), and the supernatant is subjected to a mild air current for evaporating the methanol. The obtained solid ingredient was weighted to estimate the extracted amount and then used to prepare three aqueous concentrations (3000, 2000, and 1000 ppm) to assess their potentiality to decrease the infestation percentages of *P. frontalis* in a comparative pilot experiment.

Bioassay test of garlic extracts

During 2017 date palm growing season, four palm tree demonstration plots, that had previous infestation history with frond borer, were selected at Al-Herak village. Each plot had about 15 fruitful trees, aged about 12 years

old, with about 50 m separating distance between the examined plots. The spraying schedule of the prepared aqueous garlic extract started from early April to the end of August biweekly. Spraying procedure was carried out through adjusting the outlet nozzle of the sprayer to produce a thin film of the solution to fulfill complete coverage of the whole targeted fronds (each tree received about 8 l). The recommended dose of Triton was added to the 20 l knapsack sprayer as a surfactant agent. The previously selected plots had been subjected to this scheduled program, while the fourth one received only the Triton solution to serve as a blank treatment. The broken fronds were counted and removed monthly (following the two sprays). By the end of the scheduled spraying program, infestation percentages were calculated and corrected (Henderson and Tilton 1955).

Statistical analysis

For statistical analysis of obtained data, one-way analysis of variance (ANOVA) was applied. Means were compared using Duncan's multiple range test by SPSS. Comparison was carried out with the least significant difference (LSD) test at $P \leq 0.05$ (IBM SPSS Statistics for Windows 2013).

Results and discussion

Surveillance of *P. frontalis* adults

Population fluctuation of *P. frontalis* adults was monitored under Siwa Oasis palm orchard conditions in 2016 date growing season (Fig. 2). The average monthly monitoring revealed minor *Phonapate* adult catches in January and November and with zero catches in December. The progress of the growing season showed fluctuated patterns of the flight activity of *P. frontalis* adults. Average catch period of *Phonapate* beetles recorded the

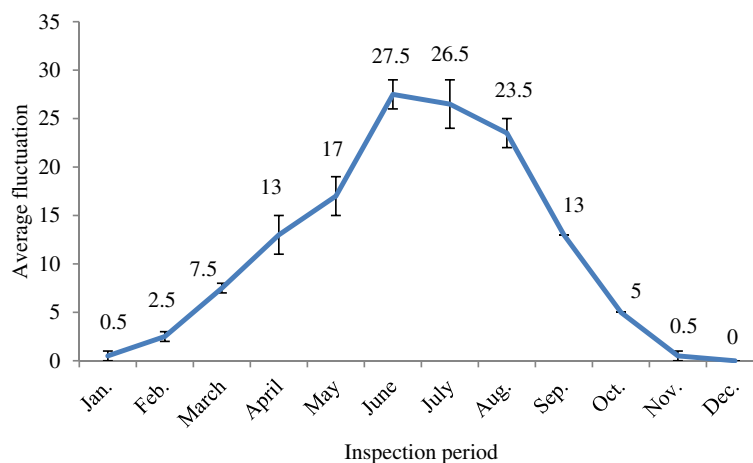


Fig. 2 Average monthly fluctuation of *Phonapate frontalis* adults (mean catch/2 traps ± SE) at Siwa date palm groves (2016 season)

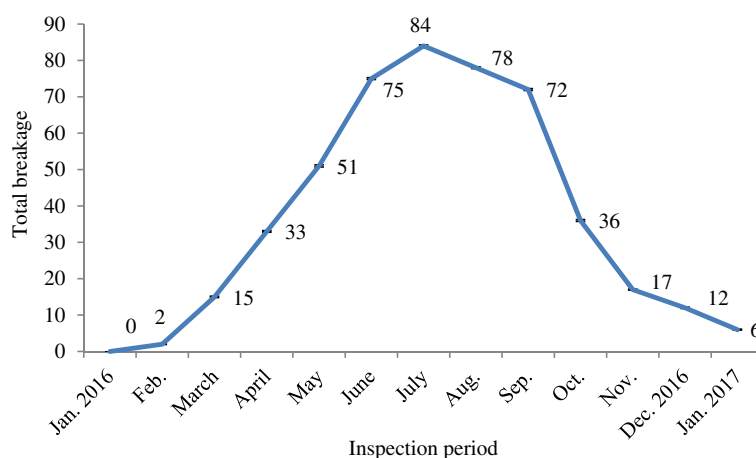


Fig. 3 Total monthly frond breakage/15 trees at Siwa date palm groves (from January 2016 to January 2017)

maximum from June to August, while proportional decline was the case in the remaining months (Fig. 2). Coincided with the surveillance of *P. frontalis* adults, frond breakage was also periodically recorded as a total frond breakage/15 trees (Fig. 3), and the average breakage/tree was graphically represented in Fig. 4. In this regard, the obtained data revealed that the average fronds breakage showed the highest values at the period extended from May 2016 to September (3.4 and 4.8 fronds breakage, respectively), with a maximum average breakage in July (5.6 fronds). The total frond breakage during the whole inspection period recorded was 481.

The present findings revealed that infestation symptoms of palm front borer were noticed near the tops of the previously formed fronds and never been recorded at the basal half of the fronds, i.e., the newly formed fronds showed zero infestation. *P. frontalis* infestation spot was also detected by Khalaf and Alrubiae (2016) on

the middle portion of the frond. Another noteworthy point was the equivalent distribution pattern of the infested fronds on the perimeters of the investigated tree canopies. The variation in the susceptibility of date palm varieties to *Phonapate* infestation was stated by Khalaf and Al-Taweel (2014) with higher tendency of the green fronds of the semi-dry “saidi” variety to break more than the other ones. Similar note was also observed at Siwa’s date palm groves. The chewing behavior of this bostrichid beetle induces powder-like material of the internal frond tissues that could extremely affect the photosynthesis process and also makes the fronds unsuitable for handcraft manufactures or wood industries (Liu et al. 2008 and Al-Deeb and Khalaf 2015). The deterioration of sapwood due to the excavation behavior of both larval and adult stages of *P. frontalis* beside the absence of vascular cambium or lateral meristem in the date palm tree (monocotyledonous species) may exacerbate the problem

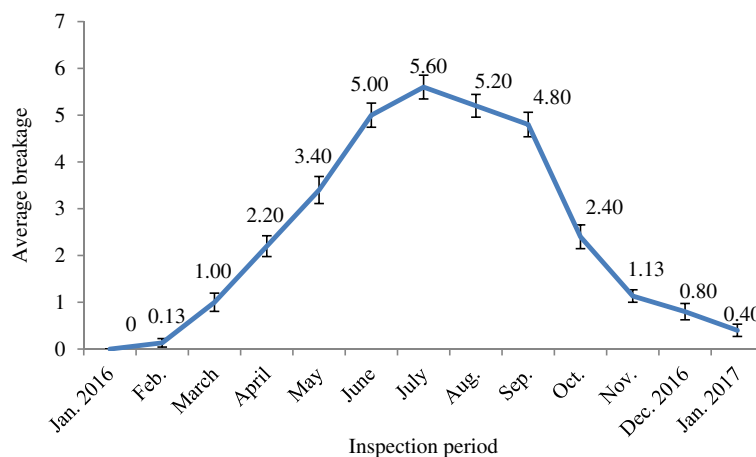


Fig. 4 Average monthly frond breakage/1 tree at Siwa date palm groves (from January 2016 to January 2017)

Table 1 Efficacy of methanolic garlic extract on the frond infestation percentages at Siwa date palm groves (2017 season)

Inspection date conc.	January	February	March	April	May	June	July	August	September	October	November	December	Total/year	Average/year*	Infestation (%)	Corrected (%)
Control	7	5	11	26	44	72	81	71	71	39	13	10	450	37.5 ± 8.5 ^a		
1000 ppm	7	8	11	20	22	40	32	38	30	22	16	10	256	21.33 ± 3.33 ^b	56.89	43.11
2000 ppm	8	10	13	22	28	36	30	28	36	19	12	6	248	20.67 ± 3.13 ^b	55.11	44.89
3000 ppm	7	11	20	32	22	30	26	34	28	28	17	5	260	21.67 ± 2.83 ^b	57.78	42.22

*Data represented by mean ± SE and means in the same column followed by the same letter are not significantly different

as there is no chance for the compensation or formation of newly vascular bundles instead of the destroyed ones (Broschat 2013). Flight activity of *Phonapate* borer showed relative compatible pattern with a lot of relevant published data. Where the nocturnal activity was stated by Al-Ogale (2003) and Ataia (2007). The earliest commencement of the flight period at Siwa's date palm groves comparing to the pre-mentioned studies could be returned to the relative warmness of Siwa Oasis due to its low topographic nature (Misak et al. 1997) and/or the intensive cultivation pattern of date palm orchards, especially in the old ones, that may modify the climate of date palm agro-ecosystem in favor of the early emergence of *P. frontalis* beetles. Flight activity period of *Phonapate* beetles showed more sense through its linkage with the excavated date palm fronds. In this regard, the obtained results revealed synchronized patterns between frond breakage and beetle activity in terms of the onset of frond fracture and beetle appearance, proportional progress, and peak period of both items in a time-dependent manner. The frond breakage at the period of zero beetle detection could be returned to effect of wind on the previously tunneled fronds (Al-Ogale 2003).

Bioassay test of garlic extracts

Table 1 shows the monthly break of palm fronds at each previously selected plots, both the untreated and the plots that received garlic extract concentrations. The tabulated data revealed the natural state of broken fronds at the first 3 months of the season. Where, the number of infested fronds in January, February, and March was the lowest comparing to the upcoming months, with a slight increase at the frond fracture patterns in March. Accordingly, the onset of fortnight spraying programs was synchronized with such frond breaking progress state. At the end of the first two sprays that implemented in April, infested frond showed further progress recording 20, 22, and 32 broken fronds by using 1000, 2000, and 3000 ppm garlic extract concentrations, respectively. Similar frond breakage trend was also recorded at the check plot (26 broken fronds). Thereafter, mild increase in the infested fronds was recorded in the treated plots, following the third and fourth sprays comparing to an obvious breakage of the control fronds. Both treated and check plots suffered the highest frond breakage at the period that extended from June to September. The average estimated breakage at this period (summation of the fractured fronds at the 4 months/4) was 73.75 at the control trial comparing to 35, 32.5, and 29.5 at the sprayed plots, respectively. This infestation reduction confirmed the potentiality of garlic extracts as a promising bio-candidate. The month of October coincided with low representation of *Phonapate* adults and frond breakage as well. The estimation of

total infested fronds, at the end of the season, revealed 450 infested fronds at the check treatment comparing to an obvious infestation decline, following the proposed spraying program. The corrected infestation percentages recorded about 43.11, 44.89, and 42.22% at the sprayed garlic concentrations, respectively. Table 1 illustrates that treatment with methanolic garlic extract has significantly reduced the infestation with frond borer ($F = 2.62$; $P = 0.04$).

According to this field study, the proposed program had been designed and implemented to cover the high risk period (the period of overestimated *Phonapate* beetles and consequently high broken fronds) to make the date palm fronds un- or less favorable as a harbor for the frond borer beetles (either tunneling or oviposition sites) via exploiting the repellent potentiality of garlic extract. Although insect repellency of certain natural compounds had been practically addressed, the scientifically approved trials were few (Sritabutra et al. 2011). According to the obtained data, garlic extract succeeded to diminish palm frond infestation through its capability to deter *P. frontalis* beetles (re-orienting the beetles away from the garlic contaminated fronds).

Expansion of environmental interventions at date palm groves of the Egyptian oases as safe alternatives than conventional ones will participate in the sustainable management of date palm pest complex.

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Availability of data and materials

Author confirms that all relevant data are included in the article and/or its supplementary information files.

Authors' contributions

I am the only author of this manuscript. So, I am responsible for all steps. The author read and approved the final manuscript.

Ethics approval

Not applicable.

Consent for publication

Not applicable.

Competing interests

The author declares that he has no competing interests.

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