Available Online at ESci Journals
International Journal of Entomological Research
ISSN: 2310-3906 (Online), 2310-5119 (Print)
http://www.escijournals.net/IJER

DESCRIPTION AND QUANTIFICATION OF DAMAGE INCURRED BY THE LONGHORN DATE PALM STEM BORER *JEBUSAEA HAMMERSCHMIDTI* REICHE, 1877 (COLEOPTERA: CERAMBYCIDAE) ON DATE PALM (*PHOENIX DACTYLIFERA* LINNAEUS, 1753)

[a]Hamadttu A. F. El-Shafie*, [b]Maged E. A. Mohammed
[a] Date Palm Research Center of Excellence, King Faisal University, P.O. Box 400, Al-Ahsa-31982, Saudi Arabia.
[b] Agricultural Engineering Department, Faculty of Agriculture, Egypt.

A B S T R A C T

The objective of this study was to ascertain the damage inflicted by the longhorn date palm borer *Jebusaea hammerschmidti* Reiche on date palm, *Phoenix dactylifera* L. Close observations were made on randomly selected date palms in infested plantation located in Al-Ahsa oasis, Kingdom of Saudi Arabia during the period from October 2011 to December 2015. Damage information was gathered from field observation and laboratory close examination of infested palm parts. Larvae (grubs) were responsible for most of the damage, which was mainly found on trunks and frond bases. The main external diagnostic symptoms of damage were adult exit holes and light brown gummy exidute from the trunk that eventually turned into dark brown to black. Less obvious symptoms were presence of brown powdery tissues (frass) around infested palm, withering of fronds, and crown decline. Characteristic undulating feeding galleries appeared in cross section of the trunk and fronds bases as internal symptoms. The impact of damage on palm longevity, utilization of wood, and management of this pest are discussed.

Keywords: Longhorn beetle, Date palm, exit holes, feeding galleries, damage localization.

INTRODUCTION

Phoenix dactylifera Linnaeus, 1753 (the date palm) is a multipurpose crop with high economic value. There are over 100 million date palms worldwide of which, 60 per cent are in the Arab world (Siddiq and Greiby 2014). In addition to the production of highly nutritive dates, the date palm provides human with numerous useful products. Several authors gave comprehensive information on utilization of every single part of the date palm as one of the most important renewable material resources (Al-Gboori and Krepl 2010; Khiari et al. 2010). Plantations of date palms are considered as important environmental niches for local wildlife particularly in the oasis, where they play a central role in the desert ecological system. Due to its adaptation to the desert environment, date palms have been effectively used for the control of desertification and land reclamation in the Arabian Peninsula, especially in UAE (Chao and Kreuger 2007). The date palm trunk (stem or stipe) has a vertical, cylindrical, and columnar shape with brown color. It is covered with the bases of old dry fronds (leaves) that have died, thus has a rough texture that becomes smooth with the aging of palm. Anatomically, the trunk is composed of a wide central cylinder (Fig. 1), which contains tough, fibrous vascular bundles cemented in a matrix of parenchymatous tissues and an outer narrow sclerified tissue called the cortex. The trunk is more lignified near the outer margin (Tomlison 1961; Tomlison and Huggett 2012). Date palm is a monocotyledonous and has a single apical meristem with no lateral meristems or vascular cambium which produce additional xylem to the inside and phloem and bark to the outside in dicotyledonous plants (Broschat 2013). An adult date palm has about 100 to 125 green leaves or fronds. Four-year old fronds have 65% less efficiency of photosynthesis per unit area compared with one-year old leaves. The frond mid rib or petiole is

* Corresponding Author:
Email: elshafie62@yahoo.com

triangular in cross section with two lateral angles and one dorsal (Fig. 2). Dead old fronds are not shed naturally, but remain attached to the mother palm and are usually removed by the farmers in a practice called pruning (Nixon and Wedding 1956).

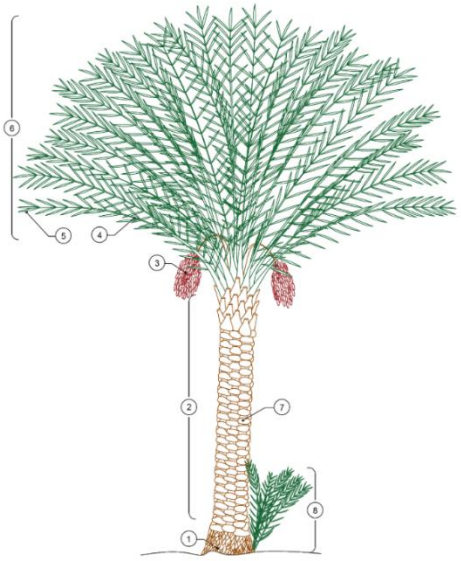

Figure 1. Schematic diagram showing the morphology of date palm; (1) aerial roots, (2) trunk or stem, (3) fruit bunch, (4) leaf or frond, (5) leaflet, (6) crown, (7) scars of frond base or petiole and (8) basal offshoot.

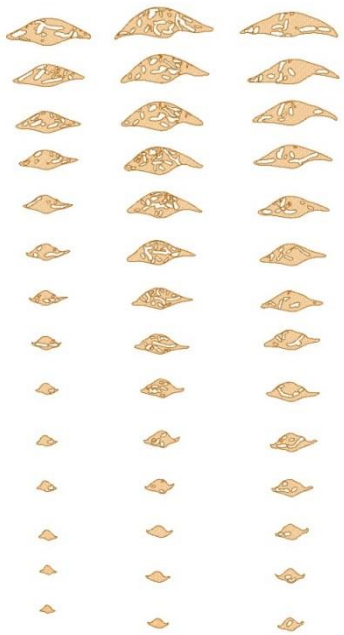

Figure 2. Samples of cross sections from the base of the frond up to 50 cm, taken to measure different damage parameters of the longhorn date palm borer.

Cultivation of date pam face major challenges, such as scarcity of water, poor management, and damages due to insect pests and diseases (El-Juhany 2010) The longhorn date palm stem-borer (LHB), *Jebusaea hammerschmidti* (Coleoptera: Cerambycidae) is an important borer pest in date palm groves in the Middle East, North Africa and India. The adult beetle has an elongate, cylindrical, robust body, with well-developed oval eyes and long slender legs. It has a reddish brown color and the body is covered by short pubescence. The beetle is characterized by having long, twelve-segmented antennae that may be as long as, or even longer than the body. It is monophagous on date palm, and regarded as a true pest for this tree in most date palm-growing countries (Al-Azawi 1986; Howard et al. 2001; Hill 2008). The beetle prefers to infest old palms or palms under stress due to neglect, poor growing conditions, or high salinity in irrigation water; however, it can also attack young and healthy palms (Aldryhim, 2008; El-Shafie, 2015). The LHB occurs wherever date palm (Phoenix dactylifera) is found in its native range (Sama et al. 2010). The beetle is recorded from Bahrain, Kuwait, Qatar, Libya, United Arab Emirates and Yemen Arab Republic (El-Haidari, 1981). It is also found in Iraq, Saudi Arabia, Algeria, Oman, Iran and India (Kinaway and Al-Siyabi 2012). The beetle is commonly called the palm stem borer (Carpenter and Elmer, 1978), date palm stem borer (Hammad et al., 1983; Aldryhim, 2008; Fayyadh et al., 2013) or date palm trunk borer (Blumberg, 2008). Understanding the nature of damage by LHB on date palm is of paramount importance in surveillance and monitoring of the beetle. In addition, description of damage can be utilized in setting economic threshold for this serious pest. The monetary evaluation of infested date palm orchard as well as the life expectancy of infested palms can also be worked out using damage information. Although the LHB is an old true pest of date palm, very little is known about its nature of damage or the impact of infestation on date palm yield and other utilizations. Therefore, the present investigation was initiated to describe and quantify the damage caused by the LHB on randomly selected date palms.

MATERIAL AND METHODS

The study site: All observations and data collection took place in King Faisal university Research station, Date Palm Research Center of Excellence experimentation blocks (Latitude: 25°16'24.37" N, Longitude: 49°42'27.82" E, Altitude 151 m) from October 2011 to December 2015.

During the period of the study, no insecticide treatment action was taken against any insect pest. The study site has a size of approximately 3.5 ha and around 322 date palms representing 15 different cultivars, the important of which are Khalas, Hilal, Sheshi, Shahal, Rushodia, Rothana and others. The collection of these palms was intended to preserve the germ plasm of these important Saudi date cultivars. Each date cultivar was planted in a separate row with 10 meter spacing between palms. All cultural practices were performed as per the recommended operations for date palm. Palms for the study were selected randomly within each row to accommodate the different cultivars. Selected palms were marked with spray paint and monitored for development of the beetle and symptoms of damage. The average age of studied palms was 30 years, however, young palms (5-12 years) from neighboring orchards were also observed for the damage by the borer.

Damage localization, symptoms and damage description

Detailed description of LHB damage was made through the following methods:

In-situ field observation and laboratory close examination of infested frond and trunk: Intensity of infestation by LHB was measured in term of number of holes per one meter long of the palm trunk. Further, holes were classified into open and sealed ones. Open exit holes indicate that adults have already emerged, while sealed exits (usually with brown chewed up palm tissues) indicate that adult beetles or pupae are still inside the trunk. The average circumference of infested palms was measured using tape meter and number of exit holes per meter long of the trunk as well as spatial distribution of these holes on the trunk was made. Description of damage was based on close observations of 60 randomly selected date palms, which were marked with clear paint.

Felling and dissection of severely infested palm: Cross and longitudinal sections of palm trunk and fronds were made using an electric saw to locate larval feeding galleries and study the within-palm spatial distribution of larvae and infestation. Frond samples for sectioning were selected from the region adjacent to the trunk (up to 51 cm from the frond base) of the leaves because the infestation by the longhorn beetle is concentrated in this region (Al-Deeb and Khalaf, 2015). Fourteen sections, each 3 cm thick, were made from this 51 cm long frond sample (Fig. 2). The length of the frond sample corresponds to the maximum length from the base where damage of the longhorn beetle could reach. Each cross and longitudinal sections of the frond was replicated three times to make a total of 42-sample size. Cross sections of the trunk were made from a meter long sample selected based on the external adult exit holes. All samples of the study were randomly selected from the study site described above.

Measurements of damage parameters: Samples of cross and longitudinal sections of trunk and frond were processed using professional digital camera (Canon EOS 600D 18.0 MP with 18-55 IS II Lens), Image processing program (ImageJ 1.48), and computer-aided design (CAD) software (Autocad 2015 x64). Each cross or longitudinal sections of the frond base and the cross sections of the trunk was photographed and transferred into corresponding line drawing. Then all necessary processing of sample pictures including measurements and calculation of damaged areas were made. The following equations were used to measure the different damage parameters:

$$DC_p = A_c / A_{ct} \ \%$$

$$DF_p = A_d / A_{ft} \ \%$$

$$DV_p = V_d / V_t \ \%$$

$$A_d = \sum_0^n a_n = a_1 + a_2 + \cdots + a_n$$

$$V_d = \sum_1^n V_n = l/2((A_{d1} + A_{d0}) + (A_{d2} + A_{d1}) + (A_{d3} + A_{d2}) \ldots + (A_{dn} + A_{d(n-1)}))$$

$$DT_p = A_t / A_{tt} \ \%$$

$$DE_p = A_e / A_{tt} \ \%$$

$DC_p = Damage\ Percentage\ on\ longitudinal\ section\ due\ to\ pupal\ chamber\ (\%)$
$A_c = Area\ of\ longitudinal\ section\ of\ pupal\ chamber\ (mm^2)$
$A_{ct} = Total\ area\ of\ longitudinal\ section\ which\ contain\ pupal\ chamber\ (mm^2)$
$DF_p = Damage\ percentage\ of\ the\ cross\ section\ area\ of\ the\ frond\ (\%)$
$A_d = Total\ area\ of\ cross\ section\ of\ the\ tunnels\ (mm^2)$
$A_{ft} = Total\ area\ of\ cross\ section\ of\ the\ frond\ (mm^2)$
$DV_p = Damage\ volume\ percentage\ of\ infested\ part\ of\ the\ frond(\%)$
$V_d = Damage\ volume\ of\ infested\ part\ of\ the\ frond\ (mm^3)$
$V_t = Total\ volume\ of\ the\ frond\ which\ contain\ infested\ part\ (mm^3)$
$V_n = Total\ volume\ of\ tunnels\ (mm^3)$
$l = Distance\ between\ two\ consecutive\ cross\ sections\ (mm)$
$DT_p = Damage\ Percentage\ of\ the\ cross\ section\ area\ of\ the\ trunk\ (\%)$
$DE_p = Percentage\ of\ external\ damage\ of\ the\ cross\ section\ area\ of\ the\ trunk\ (\%)$
$A_t = Total\ area\ of\ tunnels\ cross\ section\ of\ the\ trunk\ (mm^2)$
$A_e = Total\ area\ of\ of\ infested\ trunk\ (mm^2)$
$A_{tt} = Total\ area\ of\ of\ uninfested\ trunk\ (mm^2)$

Statistical analysis: Arithmetic means and standard deviation were used to describe central tendency and accuracy of damage parameters measurements.

RESULTS

The main damage of the longhorn beetle on date palm is located on the bases of frond (petioles) and the trunk, and accordingly the results are described under these parts.

Frond (leaf) damage: The infestation by LHB on date palms starts with egg laying by the mated females at the bases of petioles (areas of frond attachment to the trunk) which represent the most susceptible part due to its soft tissues. After egg hatch, emerging larvae feed, for a while, on the soft tissue at the base of the frond (petiole) before they either move upward in the frond mid rib or penetrate deep into the trunk. In both cases, developing larvae (the damaging stage) excavate tunnels in the basses of fronds while feeding. These characteristic tunnels are undulating and irregular and in severe infestation may merge in each other making large galleries, which appear in cross sections of the frond (Fig. 3).

The larvae of LHB excavate galleries in the trunk and frond bases for three main reasons:

- Feeding on pith and conductive tissues of the infested palm
- Construction of pupal chambers in which the larvae develop into pupae
- Preparation of exit holes for emergence of adult beetles

These excavated galleries or tunnels are usually filled with fine brown chewed tissues or frass, which may perhaps provide protection for the larvae. The larval period is the longest part of the beetle's life cycle and could last for 11 months. A single larva may cause considerable damage by tunneling in the base of fronds and in the trunk. It is extremely difficult to anticipate the internal damage due to a developing larva because of its random tunneling behavior. However, the pattern of feeding tunnels may indicate the level of infestation (Fig. 4). Before pupation, the larvae prepare exit holes through which adult would leave the palm, then excavate a pupal chamber where transformation into adult stage take place. The closer the pupal chambers to the external of the trunk or frond bases, the easier for adult beetles to exit. However, some adults of LHB may fail to make their way out of the tunnels and are usually trapped and died inside these tunnels. The excavation of feeding galleries and pupal chamber are the main causes of damage to the date palm tissues.

The average percentage of damage at the frond base due to construction of pupal chamber was 31.53 ± 6.72 %. The diameter of adult exit hole was 11.29 ± 1.52 mm, which opens to the exterior of frond with an average angle of 42.64 ± 8.96 degree (Table 1). A longitudinal section through the base of the frond and a detailed schematic diagram describing a pupal chamber are shown in Fig.5 and Fig. 6, respectively. The feeding tunnels of the larvae may assume different shapes and sizes as depicted in Fig. 7. Other important parameters of damage such as length and width of pupal chamber, average number of exit holes per frond base, and distance between exit hole and pupal

chamber are summarized in Table 1. The percentage of damage on a cross section of the frond, based on area and volume, was 26.62 ± 4.50 and 25.97 ± 4.37 % respectively. In addition, other parameters of damage are also presented (Table 2).

Trunk (stem) damage: Initially, the larvae of LHB start to feed at the periphery of the trunk and later they find their way straight to the middle of the stem after drying up of living tissues (Fig. 8). The adult exit holes are the main external symptoms by which the damage of LHB on date palm can be diagnosed. These holes are cylindrical, oblique, scattered on the petioles and trunk (Fig. 9), and are connected to the feeding tunnels. These exit holes can either be sealed with brown frass indicating the presence of a pupa or an adult or open meaning that adults have already emerged. Table 3 shows the different parameters of damage on the trunk which have been measured during this study. The infestation by the longhorn beetle has a noticeable effect on the trunk diameter, where a percentage of reduction (external damage) of 35.64 ± 7.16 % was recorded. The percentage of damage in cross section of the trunk due to larval feeding tunnels was 14.31 ± 4.71%. An average number of adult exit holes per meter long of the trunk were 105.00 ± 37.03.

The beetle is capable of infesting all parts of the date palm trunk from the base to the crown. However, the upper third of the date palm trunk (near the crown) is more susceptible to infestation than the middle or lower third. Maximum beetle activity is concentrated on the trunk near the crown where it shows a riddled appearance due to the boing of the larvae (Fig. 10). Generally, the repeated infestations with the stem borer, *J. hammerschmidti*, season after season lead to weakening of the trees due to the larval tunnels inside the stem. The infested palms become liable to breakage during windstorms, produce low yield of dates. In addition, the tunnels created in the palm trunk by the feeding activities of the larvae render the wood unfit for manufacturing or construction purposes. This pest is more serious and destructive in humid areas than dry ones and older trees are more susceptible to infestation than young one. However, the beetle may infest date palm, which is less than 5 years old and infestation may lead death and dry up of these young palms.

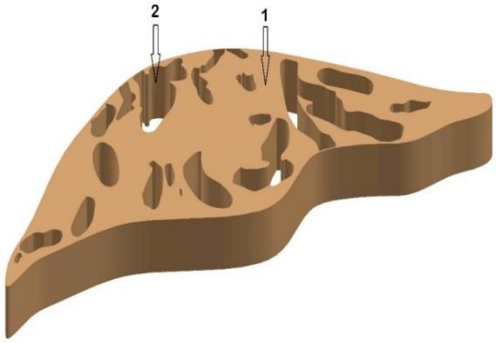

Figure 3. Three-dimensional picture of a cross section at the base of date palm frond illustrating the feeding galleries of longhorn larvae; (1) a single feeding tunnel, (2) many tunnels converging together forming a large cavity.

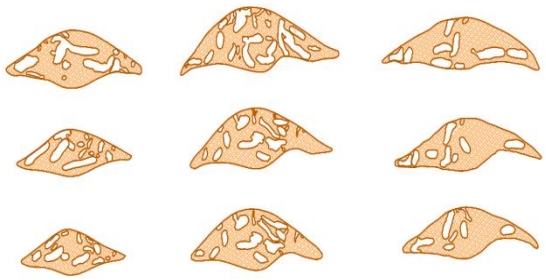

Figure 4. Cross sections of a date palm frond illustrating different levels of infestation as indicated by the feeding galleries, samples in the middle are heavily infested as compared with that on right and left.

Figure 5. Longitudinal section through the base of a date palm frond showing pupal chamber of the longhorn beetle.

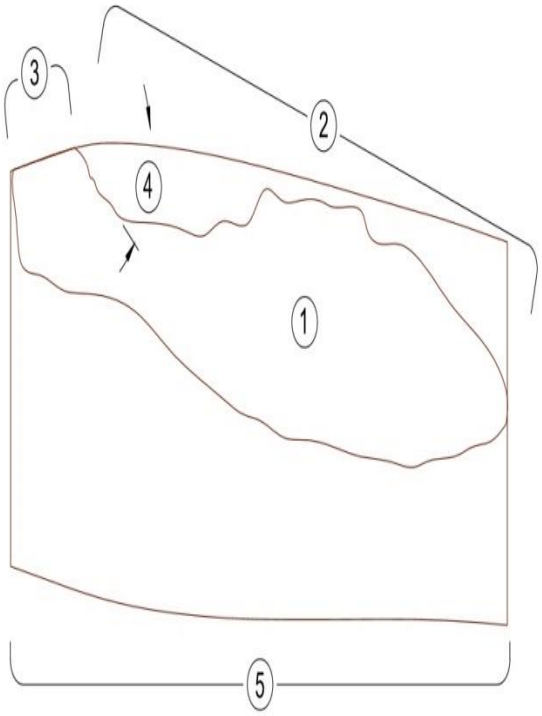

Figure 6. Outline drawing of a typical pupal chamber of the longhorn beetle; (1) pupal chamber, (2) total length of larval tunnel, (3) adult exit hole, (4) the tunnel connecting the pupal chamber with the exit hole, (5) Length of sampled frond base.

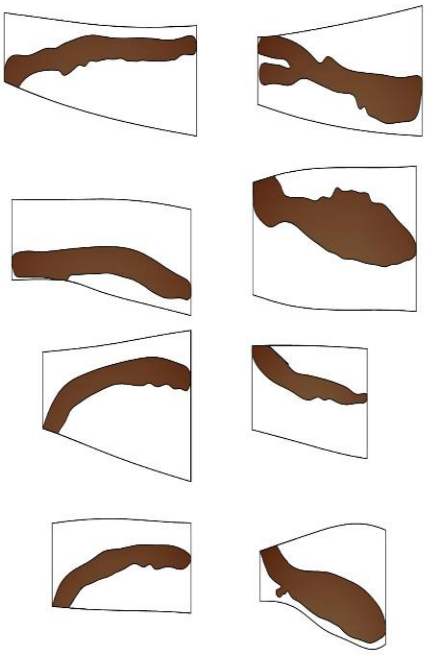

Figure 7. Different shapes and sizes of feeding tunnels excavated by the larvae of the longhorn beetle.

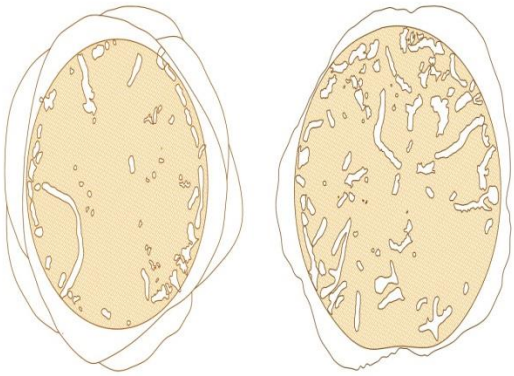

Figure 8. A transverse section through the trunk of a date palm, severely infested by the longhorn beetle, showing the irregularities of larval feeding tunnels. The picture on the left illustrate that the feeding galleries and pupal chambers concentrate at the peripheries of the trunk.

Figure 9. Adult exit holes or shot holes symptom representing a typical damage of the longhorn beetle on date palm trunk.

Figure 10. Riddles appearance of the trunk just beneath the crown (arrow) and withering of fronds due to severe and prolonged infestation by the longhorn beetle.

The LHB is primarily an internal tissue borer and new infestation is difficult to detect at an early stage. The infestation can only be detected when the late instar larvae open a symptomatic characteristic external exit hole for adult emergence. Severe infestation leads to the toppling of the crown or breakage of the trunk particularly during strong winds. During infestation, the palm will continue to yield, however, at a reduced rate. The infested tree can stand for several years, depending on the severity of infestation, until an external force such as wind or other mechanical forces break it.

Table 1. Damage parameters on date palm frond (longitudinal section) due to excavation of pupal chamber by the larva of longhorn beetle, *Jebusaea hammerschmidti*.

Parameter	Measurement Mean* ± SD
Diameter of adult exit hole (d), mm	11.29 ± 1.52
Total length of Larval tunnel (L), mm	106.96 ± 21.65
Percentage of (d/L), %	10.93 ± 2.50
Number of exit holes per frond base (N)	2.64 ± 1.45
Distance between exit hole and pupal chamber (D), mm	49.34 ± 14.62
Angle of the exit hole (E), degree)	42.64 ± 8.96
Area of exit hole (A), mm2	95.81 ± 45.06
Width of pupal chamber (W), mm	13.76 ± 5.04
Length of pupal chamber (L_p), mm	57.62 ± 11.70
Area of pupal chamber (A_c), mm2	1.49×103 ± 4.67×102
Damage Percentage due to pupal chamber (DC_p), %	31.53 ± 6.72

*Mean of 14 readings, SD is the standard deviation.

Table 2. Damage parameters due to infestation by the longhorn beetle, *Jebusaea hammerschmidti* on a cross section of date palm frond.

Parameter	Measurement Mean* ± SD
Damage percentage of the cross section area (DF_p), %	26.62±4.50
Volume damage percentage of infested part (DV_p), %	25.97±4.37
Length of infested part of frond (L_i), mm	390±95.4
Total volume of infested part (V_t), mm3	1.42×105±4.69×104
Damage volume of infested part (V_d), mm3	3.65×104±1.25×104

SD is the standard deviation.

Table 3. Damage parameters on a date palm trunk due to infestation by the longhorn beetle, *Jebusaea hammerschmidti*.

Parameter	Measurement Mean* ± SD
Number of exit holes per meter long of trunk	105.00 ± 37.03
Diameter of uninfested trunk (D_t), mm	477.07 ± 38.64
Diameter of infested trunk (D_{it}), mm	282.17 ± 11.17
Damage percentage of the cross section area (DT_p), %	14.31 ± 4.71
Percentage of external damage (DE_p), %	35.64 ± 7.16

Late infestation by LHB could be detected by the ease of pulling up dry petioles, which become friable at their bases. In addition, yellowing, dropping and drying up of frond may indicate infestation by the beetle (Fig. 10). Other less obvious symptoms include bleeding exudates on the stem at the sites where eggs have been laid, piles of frass (brown sawdust droppings) at the base of the infested palm and bulges in the trunk indicating the presence of a pupal chamber. The presence of the beetle cadaver around the date palm in the fibers at the

junctions of petioles and trunk, and inside the trunk and frond bases may serve as a good sign to confirm the LHB infestation.

DISCUSSION

The LHB is among the most serious pests of date palm in various date palm growing countries (Elmer et al. 1968; Carpenter and Elmer 1978; Hamad et al. 1981; Al-Deeb 2012). The present investigation revealed that the major damage inflicted on date palm by the LHB is the destruction of internal tissues due to feeding and boring activities. The destruction of vascular bundles, which represent the conductive tissues (Broschat 2013) by the burrowing activity of the grubs, leads to impairment of water, nutrients transport ((Al-Azawi 1986), and hence the overall performance of the date palm. Infested palm will continue to yield dates, however, at a reduced rate. It has been reported that the LHB infestation shortens the life of the palm and reduce yield (Gharib 1967). Damaging of fronds (leaves) by the feeding grubs will have a profound negative effect on yield because leaves represent the factories where photosynthetic products are manufactured. In this respect, Nixon and Wedding (1956) reported that under good cultural conditions, a leaf of a date palm could support the production of 1 to 1.5 kg of dates.

The average economic life of a date palm garden is 40-50 years; however, some are still productive up to 150 years (Chao and Kreuger 2007). This life expectancy would be negatively affected by LHB infestation. The date palm has good quality fibers, which provide mechanical support to the palm particularly in the peripheral zone. These fibers are used for many industrial purposes including reinforcement for composites (Fathi 2014).

The galleries and exit holes made by the developing larvae on trunk and fronds will remain permanent because the date palm has no cambium and wound healing mechanism. In this context, Broschat (2013) stated that the absence of cambium in date palm means that stem wounds, which would eventually be compartmentalized and grown over in dicot trees, are permanent. Thus, tunnels and feeding galleries excavated by LHB in the trunk would lower the economic value of date palm wood fibers.

To carry out important date palm crown services operation such as pollination, bunch tie-down, bunch covering, harvesting, and pruning, farmers need to climb the tree, in most date palm-growing countries (Chao and Kreuger 2007). They usually use the bases of old leaves (fronds) during climbing process and sit on these fronds, after dethoring, while on top of the tree. Infestation by LHB makes the frond bases fragile, liable to breakage, and hence being hazardous for the palm climbers. Infested palm with badly damaged trunk may represent real hazard in parking lots and recreation centers where date palms are planted as ornamentals. The risk of damaged palm falling down on humans, domestic animals, or properties increases with high infestation during windy weather.

The exit hole made by the larvae for adult emergence is usually filled with brown chewed tissues (frass). This behavior is presumably to protect the pupating larvae from ants' attacks and other similar predators. Usually one larva is found per frond base, however, in case of large fronds, which provide enough food, more than one larva is found. In all cases, the average number of exit holes per frond base never exceeded three. Some of the exit holes and tunnels are free of living larvae, and are usually found at the lower part of the trunk. These unoccupied tunnels should be considered when planning for chemical control of this pest (Al-Deeb and Khalaf 2015). It is not necessary to treat such exit holes unless one is certain of the existence of living larvae, pupae or newly emerged adults. The probability of date palm wood being attacked by wood decaying fungi, namely *Aspergillus niger*, Penicillium spp., and Cladosporium spp. also increases with LHB infestation. In addition to the above mentioned, the exit holes and dead palm cells predispose the palm to colonization by rhinoceros beetles and termites which act together to kill the infested palm.

Normally the trunk of a date palm has an equal girth throughout after it has been fully extended (Zaid and de Wet 2002). Infestation by LHB can lead to girdling and narrowing of the trunk just below the crown indicating the areas on the trunk where most of the feeding activities of the developing grubs occur. It is worth mentioning that nutritional stress, particularly drought can lead to reduced trunk diameter or shrinkage (Zaid and de Wet 2002). However, shrinkage due to LHB can be easily differentiated from that of water stress by the numerous perforations made by the beetle. The average circumference of an infested date palm has great implications on the impact of LHB damage. Palms with wide diameter can withstand more

damage compared to palms with narrower diameter. The presence of numerous adult exit holes on the external of the trunk negatively affect the aesthetic value of date palms intended for use as ornamental in landscaping or residential areas.

The infestation by the LHB is chronic and develops slowly compared to the infestation by the red palm weevil. In date palm plantations, thousands of palms may be infested and the concealed damage progress simultaneously and may last for several years. When most of the internal supporting tissues of the palm have been damaged, palms will start to break off, particularly during windy weather leading eventually to complete loss of the plantation.

Conclusions

The DPB is becoming an important pest of date palm causing economic damages in many areas where dater palm is grown. The damage inflicted on date palm by the DPB is chronic and develops slowly over the years; however, repeated infestations usually weaken the palm, reduce yield, shorten the longevity, and may eventually lead to its death. Improving the growing conditions of palms can mitigate the impact of infestation by this pest. The cryptic nature of larvae makes it very difficult to control using chemical insecticides; however, management efforts can be directed against the adults, which have short life span (15-20 days) and appear only during Mid-April to July. Future management of DPB should rely on improved cultural practices, mass trapping of adults through light traps, timely use of selected insecticides and integration of biological control in IPM program. To develop an effective IPM program against this pest, we need to understand its biology, ecology and semiochemical communication. Because no effective control method is available to date, the beetle will remain to pose a real threat to the expansion of date palms cultivation in the years to come. High levels of palms mortality can occur over time. Thus, LDPB can be described as slow palm killer. Among the 15 different cultivars studied, no single one seems to be resistant against this notorious borer. Severely infested palms may represent a real hazard in recreation centers and residential areas particularly during windy weather, where they may fall on people or their properties. Understanding the nature of damage of the LHB is of paramount importance in surveillance and monitoring of the beetle. In addition, the nature of damage can be utilized in setting economic threshold for this serious pest on date palm. Quantifying the damage by the LHB can facilitate the monetary evaluation of infested orchards as well as the determination of life expectancy of individual palms. Knowledge about the localization of LHB damage may help in developing sampling techniques, sampling plan, and an economic threshold level adaptable to the farmers for integrated management of this notorious pest.

Acknowledgements

The authors thank Dr. Abdel Kader Sallam, Mr. Abdel Mageed Al-Behian, Mr. Mubarak bin Hindi, and Mr. Ibrahim Bou khowa for their help in field collection and preparation of samples. The logistic support provided by the Date Palm Research Center of Excellence, King Faisal University is sincerely acknowledged.

REFERENCES

Al-Azawi, A. F. 1986. A survey of insect pests of date palms in Qatar, Date Palm Journal, 4 (2): 247-266.

Al-Deeb, M. A. 2012. Date palm insect, mite pests, and their management. In A. Manickavasagan, M. Mohamed Essa, & E. Sukumar (Eds.), Dates production, processing, food, and medicinal values (pp. 113–128). Boca Raton: Taylor & Francis.

Al-Deeb, M. A. and M.Z. Khalaf. 2015. Longhorn stem borer and frond borer, p.63-72. In: Wakil, W., Faleiro, J.R. and Miller, T. A. (eds.). Sustainable pest management in date palm: Current status and emerging challenges, 1ST edition, Springer International Publishing, DOI: 10.1007/978-3-319-24397-9_4.

Aldryhim, Y. 2008. Date Palm Stem Borer, Pseudophilus testaceus Gah. (=Jebusea hammershmidti Reiche) (Coleoptera: Cerambycidae). Encyclopedia of Entomology.Pp1155-1156. http://link.springer.com/referenceworkentry/10.1007/978-1-4020-6359-6_834.

Al-Gboori, B. and V. Krepl. 2010. Importance of date palms as a source of nutrition. Agricultura Tropica ET Subtropica, 43 (4), 341-347.

Autocad 2015 x64. Available at www.autodesk.com/product/autocad (accessed 20 August 2016).

Blumberg, D. 2008. Date palm arthropod pests and their management in Israel. Phytoparasitica, 36(5), 411–448.

Broschat, T. K. 2013. Palm morphology and anatomy. The environmental Horticulture Department, Florida

Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. ENH1212 available at: https://edis.ifas.ufl.edu/ep473. Accessed 24 April 2016.

Carpenter, J. B. and H. S. Elmer. 1978. Pests and diseases of the date palm. United States Department of Agriculture. Agricultural Handbook, No. 527. Pp. 42.

Chao, C. C. and R. R. Krueger. 2007. The date palm (Phoenix dactylifera L.): overview of biology, uses, and cultivation, HortScience 45, 1077–1082.

El-Haidari, H. S. 1981. New records of mites and insects infesting date palms in the Near East and North Africa, Date Palm Journal 1 (1), 133-134.

El-Juhany, L.I. 2010. Degradation of date palm trees and date production in Arab countries: causes and potential rehabilitation. Australian Journal of Basic and Applied Sciences, 4(8), 3998-4010.

Elmer, H. S., J. B. Carpenter and L. J. Clotz. 1968. Pests and diseases of the date palm. Part I: Mites, insects and nematodes. F. A. O. Plant Protection Bulletin, 16, 77-91.

El-Shafie, H. A. F. 2012. Review: list of arthropod pests and their natural enemies identified worldwide on date palm, Phoenix dactylifera L. Agriculture and Biology Journal of North America 3, 516-524.

El-Shafie, H. A. F. 2015. Biology, Ecology, and Management of the Longhorn Date Palm Stem Borer Jebusaea hammerschmidti (Coleoptera: Cerambycidae). Outlooks on Pest Management 26(1), 20-23.

Fathi, L. 2014. Structural and mechanical properties of the wood from coconut palms, oil palms and date palms. PhD. Dissertation, University of Hamburg Pp. 248. Available at: ediss.sub.uni-hamburg.de/volltexte/2014/6922/pdf/Dissertation.pdf Accessed 21 April 2016.

Fayyadh M. A., A. Z. Abdalqader, A. A. Fadel, E. A. Muhammed, A. A. Manea, M. A. Jaffer and A. A. Fadel. 2013. Formulation of biopesticide from Beauveria bassiana as part of biological control of date palm stem borer (Jebusaea hammershmidti). AAB Bioflux 5(2), 84-90.

Gharib, A. 1967. Pseudophilus testaceus Gah = Jebusaea hammerschmidti Reiche (Coleoptera, Cerambycidae). Applied Entomology and Phytopathology 25: 21-26.

Hammad, S. M., A. A. Kadous and M. M. Ramadan. 1981. Studies on insects and mites attacking date palm in the Eastern Province of Saudi Arabia. Proceedings of Saudi Biological Society, 5: 251-268.

Hammad, S. M., A. A. Kadous and M. M. Ramadan.1983. Predators and parasites of date-palm insects in Al-Hassa and Al-Qatif regions, (Eastern province, Saudi Arabia. Proceedings of the first symposium on the date palm, March 23-25, 1982. Kingdom of Saudi Arabia. Pp. 322-341.

Hill, D. S. 2008. Pests of crops in warmer climates and their control. Springer. The Netherland. Pp. 708.

Howard, F. W., D. Moore, R. M. Giblin-Davis and R. G. Abad. 2001. Insects on Palms. CAB International, Wallingford, UK.

Khiari, R., M. F. Mhenni, M. N. Belgacem and E. Mauret. 2010. Chemical composition and pulping of date palm rachis and posidonia oceanica- a comparison with other wood and nonwood fiber sources. Bioresource Technology 101, 775-780.

Kinaway, M. and A. Al-Siyabi. 2012. Major arthropod pests of date palm in Arab countries. Proceeding of the first regional conference on the management of date palm pests. Al-Ain, 23-25 Sept. UAE. Pp. 43-62. http://www.aoad.org/PalmDConf2013.pdf.

Nixon, R. W. and R. T. Wedding. 1956. Age of date leaves in relation to efficiency of photosynthesis. American Society for Horticultural Science Proceeding 67, 265-269.

Sama, G., Buse, J., Orbach, E., Friedman, A., Rittner, O. and Chikatunov, V. (2010) A new catalogue of the Cerambycidae (Coleoptera) of Israel with notes on their distribution and host plants. Munis Entomology and Zoology, 5: 1-50.

Siddiq, M. and I. Greiby. 2014. Overview of date fruit production, postharvest handling, processing, and nutrition. In Dates: postharvest science, processing technology and health benefits. 1st edition. Edited by M. Siddiq, S. M. Aleid, and A. A. Kader. John Wiley and Sons, Chichester, United Kingdom. Pp. 1–28.

Tomlinson, P. B. 1961. Anatomy of the monocotyledons-II Palmae (Ed. Metcalfe, C.R.): 10-63. Clarendon Press, Oxford.

Tomlinson, P. B., and B. A. Huggett, B. A. 2012. “Cell Longevity and Sustained Primary Growth in Palm

Stems." American Journal of Botany 99, 1891–1902.

Zaid, A. and P. F. de Wet. 2002. Botanical and systematic description of the date palm, p. 18-48. In: A. Zaid (ed.). Date palm cultivation. Food and Agriculture Organization Plant Production and Protection Paper no. 156. Food and Agriculture Organization of the United Nations, Rome, Italy.