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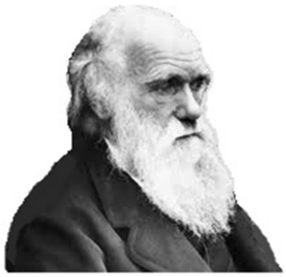

World News of Natural Sciences

An International Scientific Journal

WNOFNS 19 (2018) 9-18 EISSN 2543-5426

Firmness and calyx covering an arsenal against *Oryzaephilus surinamensis* (Linné, 1758) (Coleoptera: Silvanidae) infestation in stored dates (*Phoenix dactylifera* L.)

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ABSTRACT

Three date cultivars were sourced from the open market, sterilized and infested with *Oryzaephilus surinamensis* L. in a no-choice infestation experiment to determine emergence and weight loss. Emergence of *O. surinamensis* in Jigawa cultivar with and without calyx was significantly higher ($P \leq 0.05$) than emergence in Mali and Deglet Noor with and without calyx, just as emergence in Mali cultivar without calyx was significantly ($P \leq 0.05$) higher than emergence in Deglet Noor with and without calyx. Based on cultivar, Deglet Noor gave the least emergence of *O. surinamensis*, with the highest in Jigawa cultivar. There was a highly significant ($P \leq 0.05$) weight loss in Jigawa date cultivar compared with weight loss in both Deglet Noor and Mali date cultivars. Moreover, dates without calyx had significantly higher ($P \leq 0.05$) weight loss compared with dates with calyx. Finally, pulpy dates appeared to be the most susceptible cultivars, whereas firm dates were the least susceptible date cultivars. Conclusively, the results showed that Deglet Noor cultivar with calyx had the least emergence of *O. surinamensis*, as well as loss in weight, and is, therefore, recommended to store-owners for prolonged storage.

Keywords**:** *Oryzaephilus surinamensis*, *Phoenix dactylifera*, insect pest infestation, calyx

(Received 07 May 2018; Accepted 23 May 2018; Date of Publication 24 May 2018)

1. INTRODUCTION

Date palm is probably the most ancient cultivated tree crop in the world (Riad, 2006) in as much as its culture is depicted in ancient Babylonian inscriptions, including the famous Hammurabi code, which contained laws pertaining to date matters (Chao and Krueger, 2007). The earliest record from Mesopotamia shows that date culture was probably established as early as 3000 BCE (Chao and Krueger, 2007), and, because of this long history of date cultivation and the wide distribution and exchange of date cultivars, the exact origin of the date is only a speculation, with varied opinions suggesting ancient Mesopotamia or western India (Wrigley, 1995; Frank, 2000; Weston and Patti, 2000).

Phoenix dactylifera L. is a dioecious tree crop with male and female flowers growing on separate trees (Kgazal *et al*., 1990). Its cultivation is concentrated between latitudes 10° and 30° north of the Equator, mainly in arid regions of the Middle East and North Africa (Chandra *et al*., 1992) and on about 2.9 million acres of land in 35 countries of the world (Al-Seeni, 2012; Bhat and Al-Daihan, 2012). Date palm is considered to be the most important source of food for both humans and animals in the arid zones of the world (Besbes *et al*., 2004). Date palm was one of the first five fruit trees to be domesticated along with olive, grapevine, fig, and pomegranate (Jaradat, 2011) which led to an increase in fruit and pulp quality (Jaradat, 2011). Dates as fresh fruits rank number five in the list of tropical/sub-tropical fruits after citrus, mangoes, bananas, and pineapples, while as dried fruit, dates easily top the list (Popoola, 2013; Trematerra, Sciarretta, 2004).

The palm tree is highly regarded among researchers from various disciplines (Sadeghi and Kuhestani, 2014) due to its nutritional (Moter, 1991), health (Ammar *et al*., 2009) medicinal (Wolfe and Liu, 2007; Soobrattee *et al*., 2008), industrial (Trematerra *et al*., 2016) aphrodisiac (Ammar *et al*., 2009), cultural and religious (Augsburger *et al*., 2002; Chao and Krueger, 2007) values, among others. In spite of these desirable attributes, dates, like so many agricultural produce are susceptible to infestation by arthropod pests such as *O. surinamensis*.

The Food and Agriculture Organization (FAO, 2013) estimated that 32% of all food produced in the world in 2009 was lost to insect pests which are rightfully called "kleptomaniacs" or stealthy thieves of food commodities (Lale, 2010). This loss poses a major threat to food security (Chamchalow, 2003), especially in dates, where over 30% of the production can be potentially lost to pests. Estimates show that each year in the tropics, 25 to 40% of stored agricultural produce is lost due to insect feeding activities in storage (Oerke, 2006).

The saw-toothed grain beetle is one of the most important insect pests that infests stored dates (Al-Deeb, 2012) and it has been described as a hazardous pest of stored agricultural and some industrial products such as packaged chocolates (Trematerra *et al*., 2016) and it is a very irrepressible insect pest species (Klys, 2012). Insect infestation and damage caused by insect feeding on the dates is one of the primary causes of postharvest losses in quality and quantity where *O. surinamensis* has been particularly implicated (Kader and Hussein, 2009). These losses occur after harvest and sometimes, along with fungal contamination, result in dates fermenting thereby reducing their nutritional value and quantity (Abdul Al-Husin, 1985).

Oryzaephilus surinamensis is a small, flat insect measuring 1.7 to 3.2 mm long (Rees, 1996) that moves rapidly (Mason, 2015) and likes to hide in-between commodities and in crevices, openings and under tree barks (Sengupta *et al*., 1984). It feeds as a secondary pest, though recent studies show that it swings between primary and secondary pest (Pricket *et al*., 1990; Lale, 2002). Control of this beetle is made difficult by its longevity, being recorded to live up to 7 months (Mason, 2015), and some time up to 3-5 years in extreme cases (Howe, 1956; Kilpatrick *et al*., 2004). Females lay about 400 eggs either singly or in batches (Khamrunissa *et al*., 2006). Oviposition drops after 2 months (Mason, 2015).

O. surinamensis shows resilience by surviving under harsh environmental conditions (Mason, 2015). This study was carried out to determine the differential emergence and weight loss of stored dates to infestation by *O. surinamensis* (Photo 1).

Photo 1. *Oryzaephilus surinamensis* (Linné, 1758)

2. MATERIALS AND METHODS

2. 1. Preparation of Mixed Cultivar Culture of three date cultivars

Three locally sourced date cultivars, Jigawa, Deglet Noor and Mali were used for this experiment. A Mixed Cultivar Culture (MCC_1) was prepared for breeding initial insect pest population of mixed/unknown age and sex under prevailing ambient temperature and relative humidity of 30±2 °C and 85±5%. The prepared culture included 50g of each of the three date cultivars. This was put in 1-Litre Kilner jars covered with muslin cloth, secured with rubber bands and perforated lids (for ventilation). MCC_1 was kept undisturbed in the laboratory to enable insects to emerge which gave rise to *O. surinamensis* F_1 generation of unknown age. A second Mixed Cultivar Culture (MCC_2) of the three date cultivars was prepared in equal proportion was heat-sterilized at 60 °C for 2 in an electric hot air oven and kept in 1-L Kilner jars as described in MCC_1.

Ten pairs of adult *O. surinamensis* from MCC_1 F_1 generation were transferred into MCC_2 and allowed to mate and oviposit for 8 days after which they were gently sieved out in a glass box leaving only their freshly laid eggs. The eggs were kept for 30 days to allow complete the life cycle in order to obtain F_2 generation of *O. surinamensis* of known age.

2. 2. Sterilization/disinfestation of the three date cultivars

Two kilograms each of date cultivar was weighed and sterilized in a hot air oven at 60 °C for 2 hours after which they were removed and cooled in a desiccator for 8 hours. Both the Kilner jars and pieces of muslin clothes were also sterilized in dry air oven at 60 °C for 2 hours in order to kill pre-existing eggs and any life stage of insects and mites that may be present. Following disinfestation of the three date cultivars, 200g of each of the six samples was put in coded and sterilized glass jars and replicated 5 times. The experiment was laid in a Completely Randomised Design (CRD) on a work bench in a laboratory.

2. 3. Sexing of *O. surinamensis*

Adult *O. surinamensis* were collected from MCC_2 and stupefied in a refrigerator at 7 °C for 5-10 minutes (Busvine, 1971), after which 4-6 adult *O. surinamensis* were picked at random and put in a petri dish. A dissecting microscope was used to determine their sex. Males have a spine-like projection on the hind femur, which is absent in the females. Five pairs of sexed adults of known age were introduced into each coded glass jar containing 200g date sample. Adult *O. surinamensis* were left to oviposit for 8 days and removed as described above. *O. surinamensis* adult emergence and weight loss were recorded

2. 4. Determining firmness of dates

Three date cultivars, Jigawa, Deglet Noor and Mali were obtained and tested for firmness. Randomly picked date samples were introduced onto a semi-automatic penetrometer for 10 seconds and readings of penetration for each date cultivar was recorded. This procedure was replicated 5 times for each date cultivar.

3. DATA ANALYSIS

Data were analysed with Minitab statistical package using Analysis of Variance (ANOVA). Significance was tested at the 5% probability level. In the *post hoc* test, means were separated using Tukey method.

4. RESULTS

Table 1. Mean penetration (mm) of a semi-automatic penetrometer after 10 seconds.

Date cultivar	Mean penetration
Mali	2.3
Jigawa	2.0
Deglet Noor	1.2

Means that do not share a letter within a column are significantly ($P \leq 0.05$) different by Tukey's method

Table 1 shows the distance covered by a semi-automatic penetrometer in three date cultivars after a period of 10 seconds. Penetration was significantly ($P \leq 0.05$) higher in Mali and Jigawa date cultivars compared with penetration in Deglet Noor after the same time period.

Figure 1 shows the role of morphological characteristics of dates infested with *O. surinamensis* for 32 days on emergence. The result shows that mean insect emergence on date cultivars without calyx was significantly ($P \leq 0.05$) higher than date cultivar with calyx. The result also shows that Jigawa cultivar without calyx had significantly ($P \leq 0.05$) higher insect emergence and the least was on Deglet Noor with calyx. Overall Jigawa cultivar with and without calyx had higher insect emergence and the least insect emergence was in Deglet Noor cultivar.

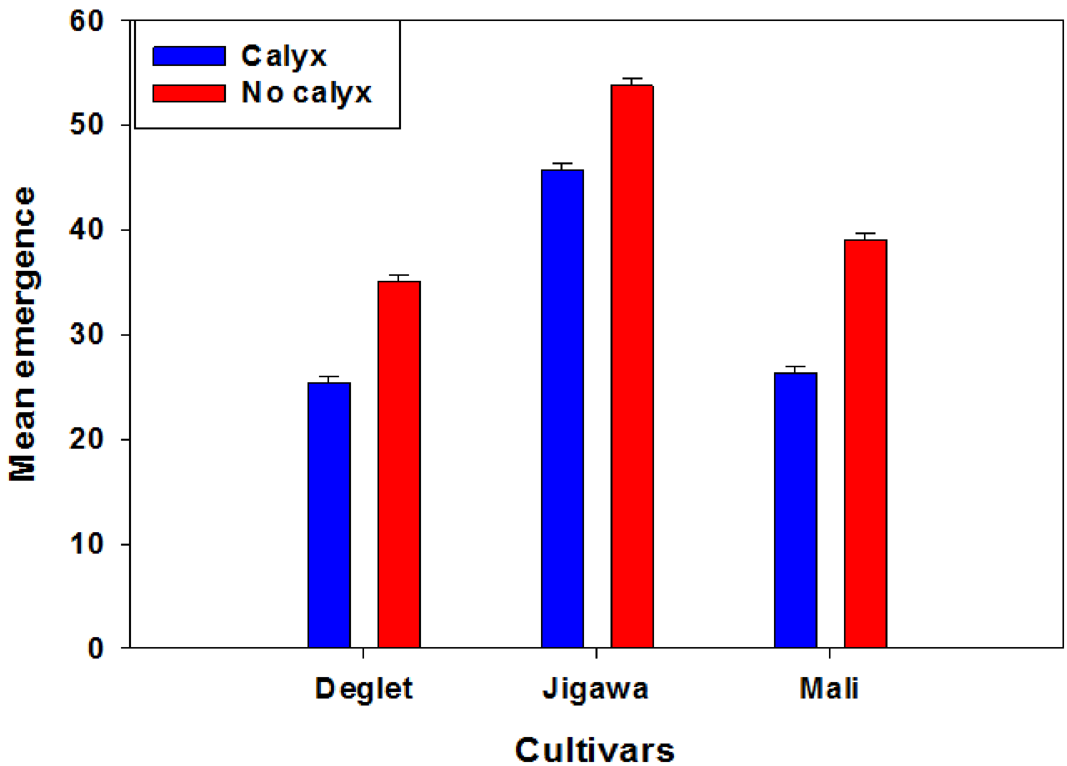

Fig. 1. Mean *O. surinamensis* adult emergence on dates with and without calyx

The role of morphological difference of each date cultivar on emergence pattern of *O. surinamensis* for eleven weeks shows that emergence commenced at week 4 in all the date cultivars (Fig. 2). There was steady emergence in all the cultivars up to the 8th week. Jigawa date cultivar without calyx had the highest emergence peak and the least emergence peak was on Deglet Noor cultivar with calyx. In the overall, *O. surinamensis* emergence was in the order Jigawa cultivar without calyx > Jigawa cultivar with calyx > Mali cultivar without calyx > Deglet Noor cultivar without calyx > Deglet Noor cultivar with calyx and Mali cultivar with calyx. All dates without calyx had significantly ($P \leq 0.05$) higher *O. surinamensis* adult emergence than those with calyx.

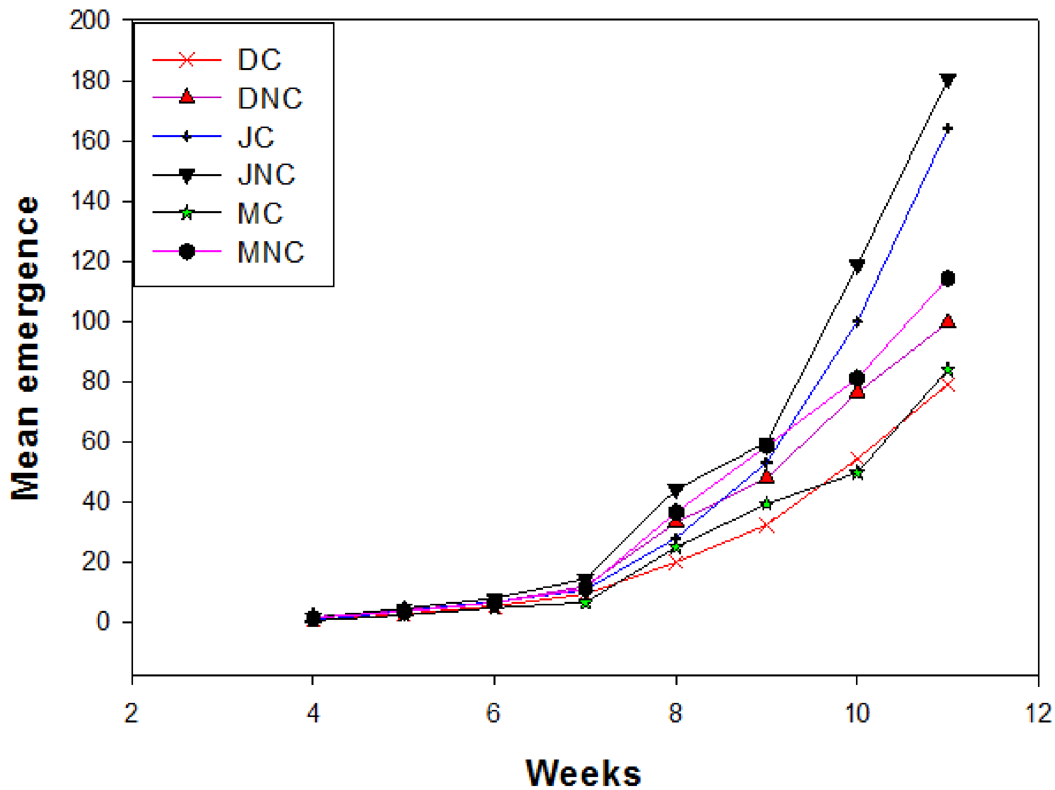

Fig. 2. Mean *O. surinamensis* adult emergence across eleven weeks

Key: DC= Deglet Noor with Calyx; DNC = Deglet Noor without Calyx; JC = Jigawa with Calyx; JNC = Jigawa without Calyx; MC = Mali with Calyx; MNC = Mali without Calyx.

Table 2. Mean *O. surinamensis* weekly emergence and weight loss of three date cultivars

Cultivar	**Weekly emergence**	**Weight loss (g)**
	Mean	
Jigawa	49.8	4.2
Mali	32.7	2.1
Deglet Noor	30.2	1.8
Means that do not share a letter in a column are significantly (P<0.05) different by Tukey method at the 95% confidence level		

Table 2 shows mean emergence of *O. surinamensis* in three date cultivars. The result shows that insect emergence in Jigawa date cultivar was significantly ($P \leq 0.05$) higher than insect emergence in Mali and the least *O. surinamensis* adult emergence was recorded in Deglet Noor date cultivar. In the same vein, loss in weight as a result of infestation by *O. surinamensis* was significantly ($P \leq 0.05$) higher in Jigawa date cultivar and the least was in Deglet Noor date cultivars.

Weight loss in three date cultivars with and without calyx due to *O. surinamensis* infestation is shown in Fig. 3. The result shows that loss attributed to *O. surinamensis* was significantly ($P \leq 0.05$) higher in date cultivars without calyx than in those with calyx. The figure also shows that Jigawa cultivar without calyx had the highest weight loss followed by Jigawa cultivar with calyx and the least weight loss was in Deglet Noor cultivar with calyx.

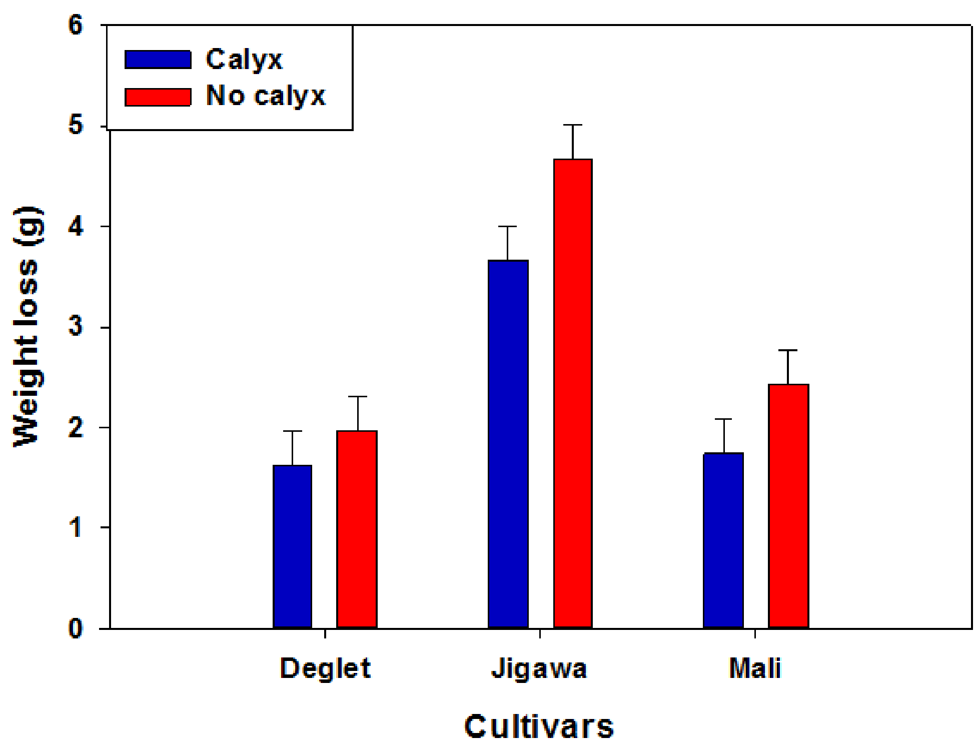

Fig. 3. Mean weight loss (g) of three date cultivars infested with *O. surinamensis*

5. DISCUSSION

The result from the study showed *O. surinamensis* emergence was highest in cultivars that do not have their calyces intact, which agrees with Al-Hafidh *et al*. (1987) that dates without calyx coverings are mostly infested with insects. It has been suggested that the calyx, which is a structure that covers the point of the date where it attaches to the stalk (spikelet or peduncle) when removed, predisposes dates to infestation (Buba *et al*., 2013).

The study also establishes the role of combining date cultivar and calyx status on *O. surinamensis* infestation. The firmer Deglet Noor with calyx covering which minimized the entry points to the pests conferred greater protection against *O. surinamensis* infestation. This could be due to earlier reports that secondary insect pests such as *O. surinamensis* require an opening or injury in order to successfully initiate and establish infestation (Laszczak-Dawid *et al*., 2008; Trematerra and Throne, 2012). On the other hand, a pulpier Jigawa date cultivar without calyx covering had higher *O. surinamensis*. This might be attributed to soft kernel and the entry point provided by absence of a calyx covering thus initiated and established infestation successfully.

Weight loss in dates that were infested by *O. surinamensis* corresponded to emergence levels where the more emergence recorded, the more insect feeding activities and weight loss were incurred. This finding was accentuated that feeding activities of insect pests cause a quantitative decrease in commodities. The study therefore suggests two most important factors that predispose stored dates to *O. surinamensis* infestation as cultivar and lack of calyx (entry point).

6. CONCLUSION

This study showed that *O. surinamensis* readily infested stored dates and carried out feeding activities which resulted in a loss of weight of the dates. Infestation was severe especially in poor quality date cultivars and those that had no calyces. This is because presence of calyx was shown to greatly suppress adult *O. surinamensis* emergence. Combining firm cultivar like Deglet Noor and calyx cover will give the best protection from insect pest infestation. Breeding for good, firm cultivars and carefulness in harvest so as not to remove the calyx is therefore highly recommended.

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