



Population Dynamics and Seasonal Abundance of the Beetle *Oryctes owariensis* Beavois, 1807 (Coleoptera: Scarabaeidae: Dynastinae) in Raphia Palms in Bayelsa State, Nigeria

Ukoroije, Rosemary Boate^{1*} and Abalis, Richard Otoyor¹

¹*Department of Biological Sciences, Niger Delta University, Wilberforce Island, P.O.Box 071, Bayelsa State, Nigeria.*

Authors' contributions

This work was carried out in collaboration between both authors. Author URB designed the study, wrote the protocol, managed the literature searches and wrote the first draft of the manuscript. Author ARO performed the statistical analysis and managed the analyses of the study. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJOB/2020/v9i330087

Editor(s):

(1) Dr. P. Dhasarathan, Anna University, India.

Reviewers:

(1) João Anderson Fulan, Federal University of Amazonas, Brazil.

(2) Thomas Aneni, Nigerian Institute for Oil Palm Research, Nigeria.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/57385>

Original Research Article

Received 14 March 2020

Accepted 20 May 2020

Published 29 June 2020

ABSTRACT

Oryctes owariensis (Coleoptera: Scarabaeidae) beetle is a destructive insect pest of both raphia and oil palms, causing damage to the fronds and trunk thus leading to low yields and subsequent death of infested palms. This study was aimed at monitoring the seasonal abundance of the beetle using visual lure or light traps suspended on poles around raphia palm farms designed as experimental sites (Locations A, B, C and D) for a duration of two years (2018 and 2019) in Bayelsa State. Four sampling seasons were engaged in the study: Four months of dry (January-April) and four months of wet (June- September) yearly. The lamps were powered seven consecutive nights monthly. Beetles trapped were counted daily and the numbers recorded. The result showed that the beetle had one generation per year, was nocturnal with seasonal activity spreading out from dusk to dawn. Adult population was highest within the dry sampling months of March to April as the insects mate for breeding, the wet months June and July recorded drastic fall

*Corresponding author: E-mail: rukoroije@gmail.com;

in the number of trapped beetles while August and September recorded no catch. A total of 283 beetles were captured during the dry season against 8 trapped at the wet. Therefore, the high efficiency of the light traps as capture/ monitor tools in ascertaining the seasonal abundance of *Oryctes owariensis* beetle in raphia palm farms is a possibility for use in Integrated Pest Management Programs for controlling the pest population before they reach the economic threshold level.

Keywords: *O. owariensis*; nocturnal; population; generation; sampling season.

1. INTRODUCTION

Oryctes owariensis of the family Scarabaeidae and class Dynastinae is a holometabolous insect with life cycle transcending from egg, larva, pupa and adult stages [1]. All life stages of the beetle are edible and considered special delicacy in Bayelsa State, Niger Delta region of Nigeria, Africa and other parts of the world. The beetle is known as one of the destructive insect pest of palms basically raphia, coconut and oil palm trees which according to [2,3], cause remarkable damage and yield reduction of up to 10%. Its activity causes damage to the fronds and trunk of palms with eventual palm death while the holes deposited in the palms serve as entry point for lethal secondary action of other destructive insect pest like *Rhynchophorus phoenicis* and pathogens like nematodes [4].

Palms are predominantly the main host of this scarab beetle which uses them for larval development [5]. Alternate host plant species of *Oryctes* species include rotting straw, coconut husks, cacao pulp waste and refuse from sugarcane factories, rice mills, saw mills and various other types of agricultural products processing [5]. According to Gressitt, [6], Bedford, [7], date palm and other palms grown for ornamental purposes such as *Roystonea regia*, *Livistoma chinensis* and *Corypha umbraculifera* are recorded host plants. *Oryctes* species are also pests of cultivated plants such as pineapple, sugarcane, pandanus and banana [8]. Patrick [9] reported that the larvae of *Oryctes* species fed on ash root and decayed matter, compost heaps and rotting logs. *Oryctes* species breed in rotting vegetation, manure heaps [4,10], dunghills and refuse dumps [11,12,13,14]. Nishida and Evenhuis, [3] pointed out that there are natural factors that keep the beetle population under control in its native habitat, hence its introduction into insular habitats without these natural control factors allow for quick spread and reproduction of the beetle thus becoming serious pest. However, its edible property allows for its increased population to serve for higher food usage rather than as pest.

Many insects are attracted by bright colours hence, insect light trap is a very efficient tool used in insect pest management in organic agriculture as it mass-traps both sexes of insect pests thereby reducing the carryover pest population [15]. Insect traps are used to monitor insect population typically using food, visual lures (which indulges light, bright colour and shapes to attract insects) and chemical attractants/ pheromones (attract only a particular sex of insect). Light traps with or without ultraviolet light, attract insects with light sources ranging from fluorescent lamps, mercury vapour lamps, black lights [16], or light emitting diodes [17]. Light trap does attract both flying and terrestrial insects [18,19] and are used to survey nocturnal insects whose abundance are influenced by temperature, humidity and type of lamp [20]. Lale, [8] stated that adult *Oryctes* beetle are nocturnal, crepuscular in habit and strongly attracted to light in the night especially when it is ultra violet enriched. Beetles are attracted to lights at a long range but are repelled by it at short range [20]. Also favourable results of trapping could be obtained using a 250 watts Osram mercury vapour lamp placed at a height of 2.5 m in an open space near a palm farm. According to Mariau, [21], large catch of *Oryctes* beetles are obtained usually around April when the rain is not at its peak because rainy seasons are not preferred by the beetles. Venard-Combes and Mariau, [22] reported that *Oryctes* beetles moved mainly during the first hours of darkness and during the periods of absence of moon. The aim of this research is to monitor population dynamics and seasonal abundance of the beetle specie *Oryctes owariensis* using light traps for incorporation in Integrated Pest Management Program.

1.1 Scope of Study

This research worked within the confines of a single species (*Oryctes owariensis*), a scarab beetle of the genus *Oryctes* (Coleoptera: Scarabaeidae: Dynastidae).



Fig. 1. *O. owariensis* showing dorsal and ventral views
Source: authors

2. MATERIALS AND METHODS

2.1 Experimental Design

Survey design employing the use of halogen lamps as visual lures as by Mariau, [21], Venard-Combes and Mariau, [22] was engaged in the study. Beetles trapped/captured from the four locations (A, B, C, D) were counted and the total numbers recorded daily and monthly throughout the sampling seasons of wet and dry.

2.2 Experimental Sites

Four different locations A, B, C and D were engaged in the study, all respectively situated around Yenagoa and Southern Ijaw Local Government area of Bayelsa State. The study

sites/locations were predominated by raphia palm farms.

Southern Ijaw is a Local Government Area of Bayelsa State, Nigeria. Its headquarters are in the town of Oporoma (or Osokoma) in the north of the area at Latitude: 4°48'10.19"N and Longitude: 6°04'26.40" E. It is the second largest Local Government in Nigeria (Landscape) after Toro Local Government of Bauchi State. The people and their language are known as Izon. It has Institutions like The Niger Delta University (NDU) and the states airport in Amassoma and Federal Polytechnic Ekowe in Ekowe. The area has a coastline of approximately 60 km on the Bight of Benin. Yenagoa is a Local Government Area in Bayelsa State, Nigeria at Latitude: 4°55'17.39" N Longitude: 6°15'30.60" E Nigeria Zip Codes [23].

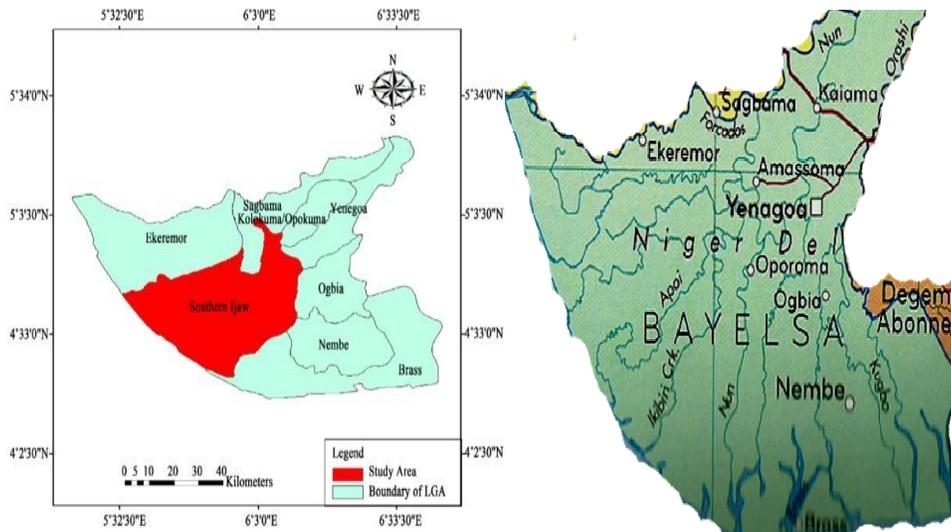


Fig. 2(a-b). Map of Bayelsa State of Nigeria showing Southern Ijaw and Yenagoa local government areas; study areas at Yenagoa and Amassoma, Source: Oluyemi et al. [24], Nigeria Zip Codes [23]

2.3 Research Duration

The study lasted a period of two years duration (2018 and 2019) with four sampling seasons of two wet (June – September) and two dry (January – April) that is four months each.

2.4 Methodology

The population studies and or seasonal abundance of *O. owariensis* beetle were studied via adoption of the procedures of [22]. Two light trapping devices typically of visual lures using bright colour halogen lamps (250 watts) were mounted on wooden poles measuring twelve feet (12ft) high around two locations of raphia palm tree farms beside the green house at Niger Delta University Wilberforce Island (Location A) and Edepie town (Location B). White plastic basin containing cotton wool smeared with formalin was place directly under the lamps into which the beetles were trapped. Similarly, adopting the methodology of Mariau, [21], two halogen lamps of 250 watts each were respectively mounted on two stakes in two other locations of raphia palm farms along Amassoma road (Locations C and D) all in Bayelsa State to facilitate trapping of the beetles. White cotton fabric measuring 12 by 12 feet were spread below the lamps to attract the adult beetles which were captured in a basin containing cotton lint concentrated with formalin placed directly beneath the lamps. The light traps all operated from 7 p.m-7 a.m daily for a period of seven consecutive days (22nd-28th) throughout

the sampling season of eight months of dry (January- April) and wet (June - September) seasons each year within the duration of two years (2018-2019). The adult beetles trapped each day and month from the various locations were counted and the numbers recorded throughout the sampling period.

2.5 Data Analysis

Total beetle captured on daily basis were collated and presented graphically. Aggregate number of beetle captured during the dry and wet sampling seasons were also calculated and presented in graphs. All charts were plotted using Microsoft excel version for window 2010.

3. RESULTS AND DISCUSSION

The number of *O. owariensis* beetle captured during the dry sampling season is presented on Figs. 3-6 while Figs. 5-8 represent number of beetle capture for the wet sampling season. The result depicting the number of catches from days 22nd-28th and the total number of beetles caught for the month of January is represented by Fig. 1 below. From the graph, there is no definite pattern to the number of beetle caught on each day. However, location D had the highest number of catch (12), seconded by locations C and A with ten (10) apiece while location B (5) recorded the least number of beetles caught. This brings the total beetle catch for January at 37.

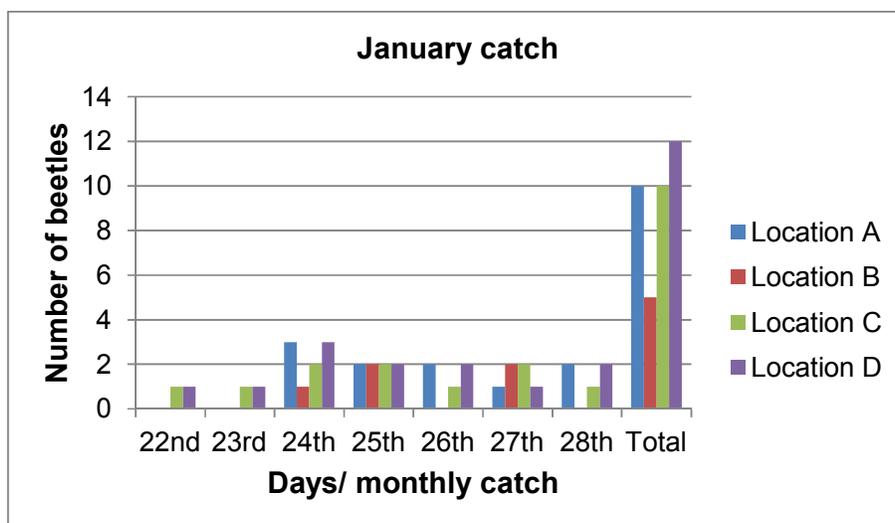


Fig. 3. Number of beetles captured for the month of January

Fig. 4 shows the number of catch from days 22nd-28th and the total number of beetles caught for the month of February. From the graph, there is no definite pattern to the number of beetle caught on each day. However locations C and D had the highest number of catch (16) each, followed by location A (15) and location B with (9). Total number of beetle captured was 56.

had the highest number of catch (20) each, then location A (16) which was closely followed by location B with (14). Total number of captured beetle was 70.

Fig. 5 shows the number of catch from days 22nd-28th and the total number of beetles caught for the month of March. From the graph, there is no definite trend as to the number of beetles caught on each day. However locations C and D

The result of *Oryctes owariensis* beetle caught for the month of April is represented on Fig. 6. From the graph, there is no definite pattern to the number of beetle caught on each day. However location C had the highest number of catch (37), succeeded by location D (33), then A (30) while location B (20) recorded the least number of beetles captured, bringing the total number to 120.

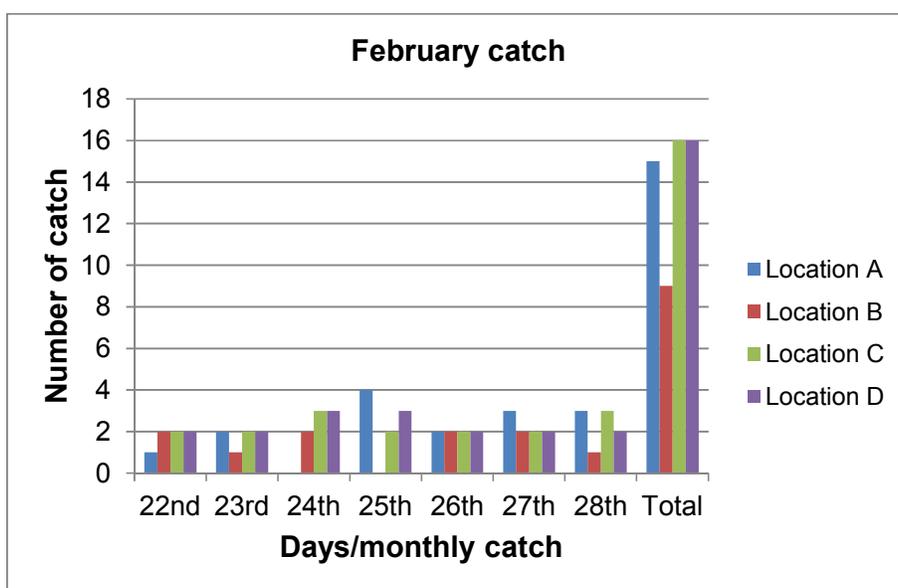


Fig. 4. Number of beetles captured for the month of February

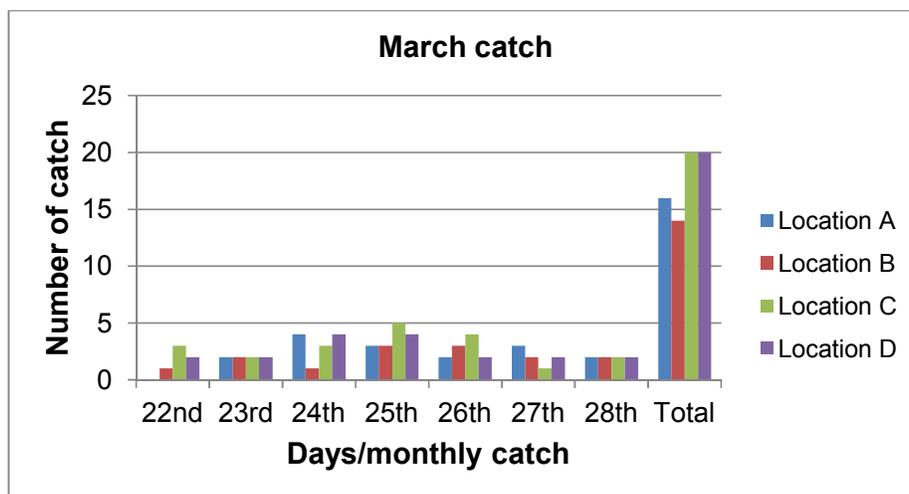


Fig. 5. Number of beetles captured for the month of March

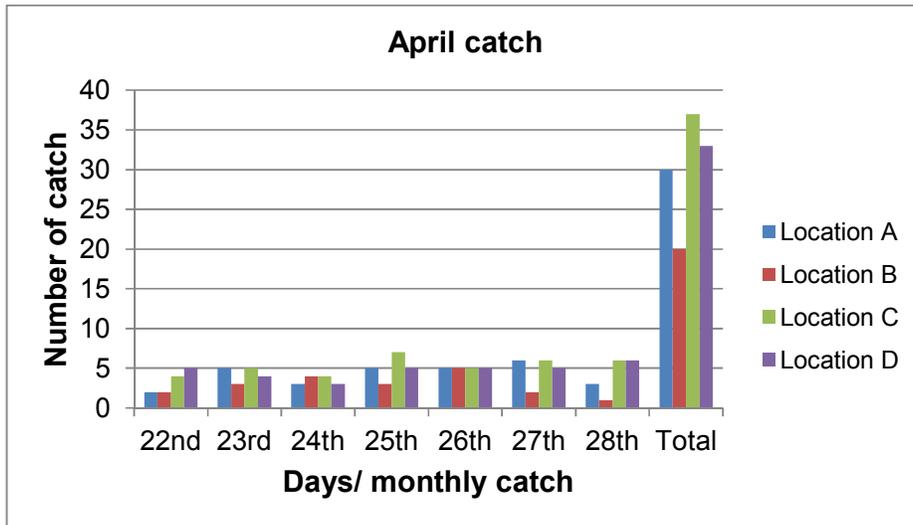


Fig. 6. Number of beetles captured for the month of April

Figs. 7-9 represent the number of beetle capture for the wet sampling season. There was drastic fall in the number of beetle captured from each location. Fig. 7 represents the number of *Oryctes owariensis* beetle caught for the month of June. From the graph, there is no definite pattern to the number of beetle caught on each day. However location C had the highest number of catch (2), succeeded by location A and D with (1) apiece

and finally B (0) without any beetle capture. Total number of beetle captured was 4.

The result of *Oryctes owariensis* beetle caught for the month of July is represented on Fig. 8. Location A had the highest number of catch (2), followed by locations B and C with (1) respectively and then D (0) without any beetle capture. Total number of captured beetle was 4.

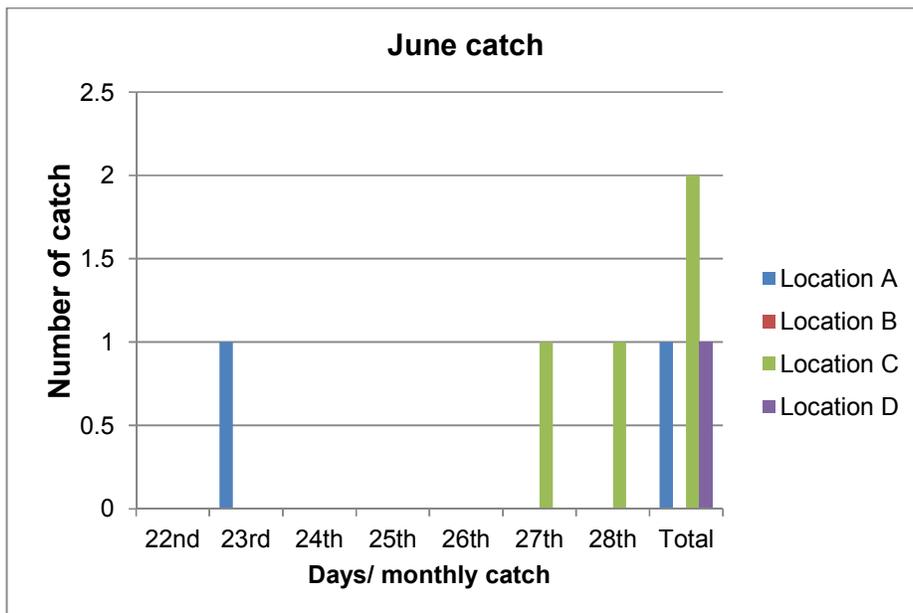


Fig. 7. Number of beetles captured for the month of June

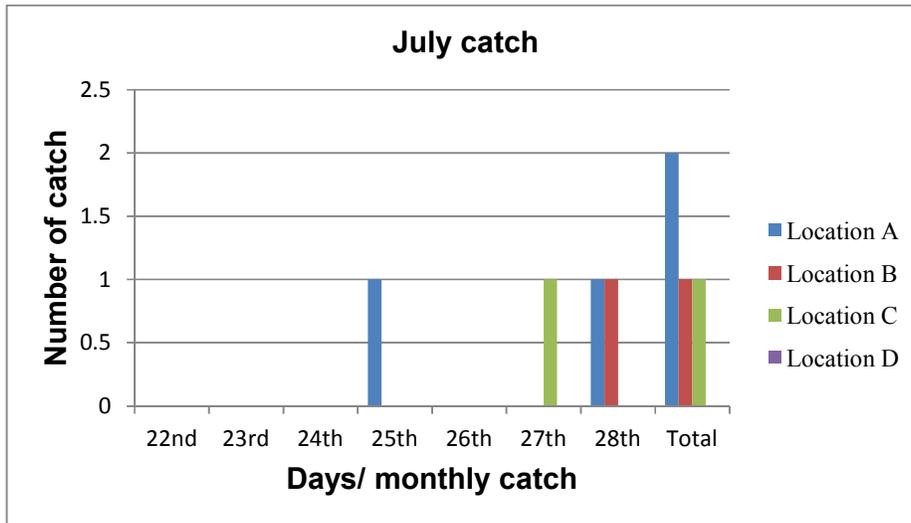


Fig. 8. Number of beetles captured for the month of July

Fig. 9 represents the number of beetle capture for the month of August. No beetles were captured for the month of August in all the locations. Same situation occurred in the month of September.

The total number of *O. owariensis* beetle captured at the different locations (A-D) for the months of January to April representing the dry sampling season and the months of June-September representing the wet sampling season are presented on Figs. 10 and 11.

From the graph (Fig. 10), Location A recorded 10, 15, 16, and 30 beetle capture giving a total of 71 beetles for months January-April. Location B

had 5, 9, 14 and 20 totaling 48 beetles. Location C gave 10, 16, 20 and 37 totaling 83 beetles while Location D had 12, 16, 20 and 33 totaling 81 beetles captured during the dry sampling season. Total number of beetle captured during the dry sampling season was 283.

Fig. 11 gives the number of beetle capture for the wet sampling season of June to September. Location A recorded 1, 0, 2 and 1 beetle capture giving a total of 4 beetles for months January-April. Location B and D had just 1 beetle capture apiece while Location C gave 2 and 1 totaling 3 beetles. Total number of beetle captured during the wet sampling season was 8.

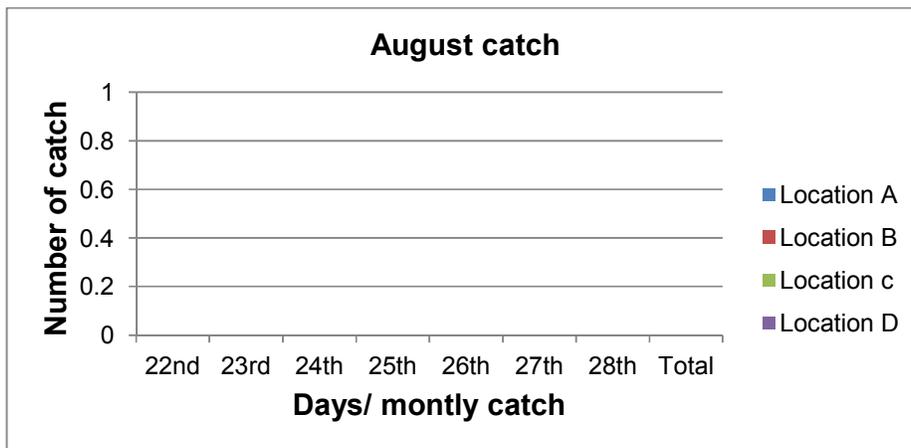


Fig. 9. Number of beetle captured for the month of August and September

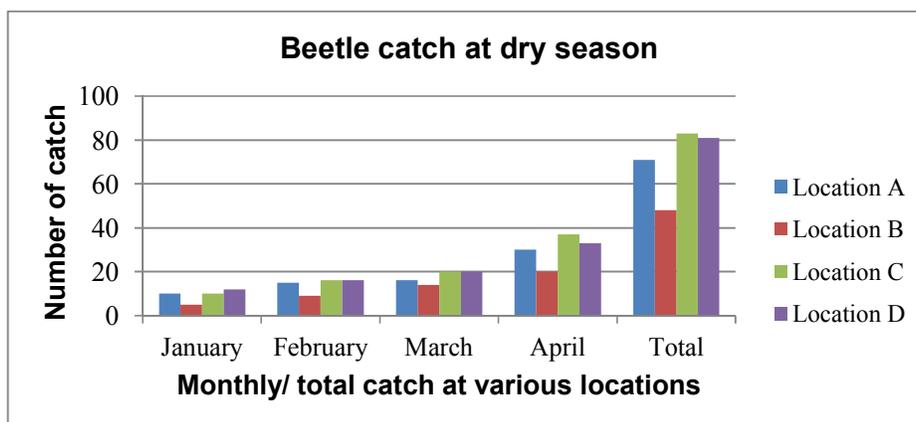


Fig. 10. Number of beetle capture at dry sampling season

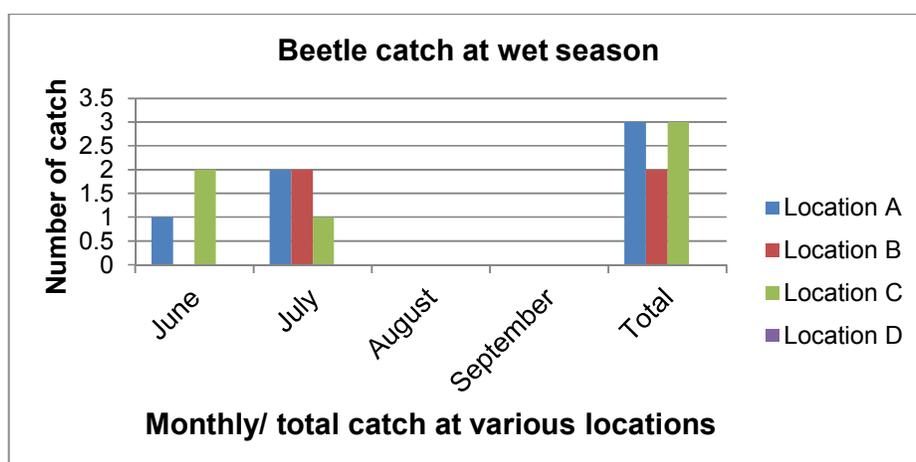


Fig. 11. Number of beetle capture at wet sampling season

Fig. 12 shows the graphical representation of the total monthly catch throughout the period of experimentation. The months and their number of beetle capture are as follows: January (37), February (56), March (70), April (120), totaling 283 beetles captured during the wet sampling season and June (4), July (4), August (0) and September (0), totaling 8 for beetles captured during the dry sampling season giving a cumulative total of 291 beetles captured throughout the sampling seasons.

Fig. 13 gives the total number of adult beetles captured during the wet and dry sampling seasons. A total of 170 beetles were captured during the dry season of the first sampling year (2018) and 113 recorded the second year (2019). While the wet sampling seasons had 5 and 3 beetles captured respectively.

3.1 Discussion

Light traps are used as means of monitoring beetle populations as well as control them physically [25]. Mohammed et al. [26] reported the use of light trap as monitor and capture tool to ascertain the population, seasonal abundance and control of beetles in palm farms.

3.1.1 Nocturnal habit

The result of this study showed that *O. owariensis* beetle are nocturnal and were successfully captured using the light trap confirming the statements of authors like [8,16,20,27,28]. They variously affirmed that *Oryctes* beetles were nocturnal, crepuscular in habit and are strongly attracted to light that was ultraviolet rich and positioned at a long range. This was further supported by the reports of

[29,30] and several other authors who worked independently on different species of beetles in the genus *Oryctes* confirming them all to be nocturnal in behavior. Also in nights of no or less moonlight, the beetle capture was higher than nights of full moonlight indicating that moonlight negatively affected the availability of the beetle for light trap catch since the beetles were night flyers. This observation corroborates the report

provided by Mariau, [21], Venard-Combes, [22] that *Oryctes* beetles moved mainly during the first hours of darkness and during the period of absence of moon. According to Rochat et al., [31,32], Hallett et al. [33], Gries et al. [34], males of the genus *Oryctes* produce aggregate pheromones that help conspecifics locate one another on palm trees thus increasing attraction of beetles at the light.

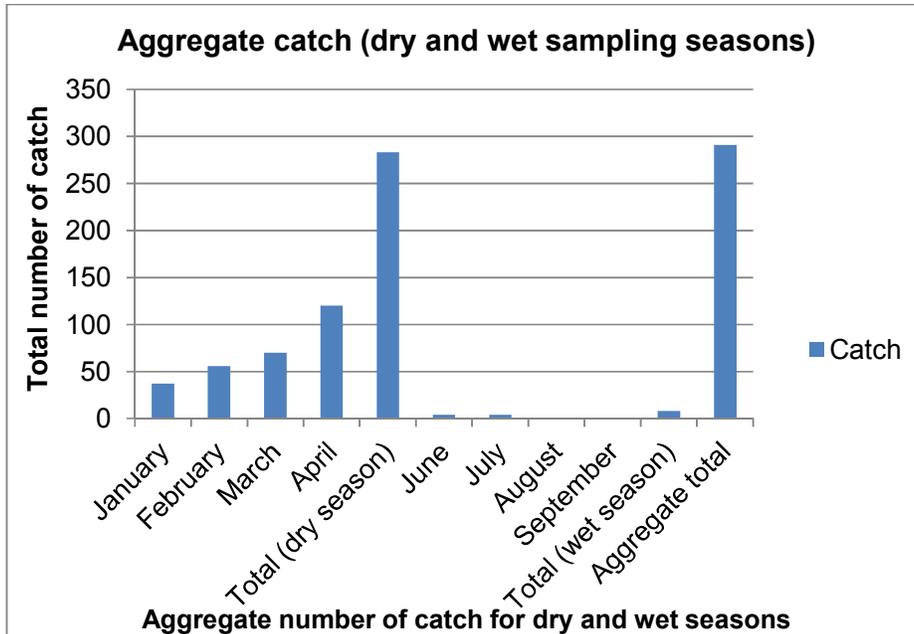


Fig. 12. Aggregate catch (Dry and Wet seasons)

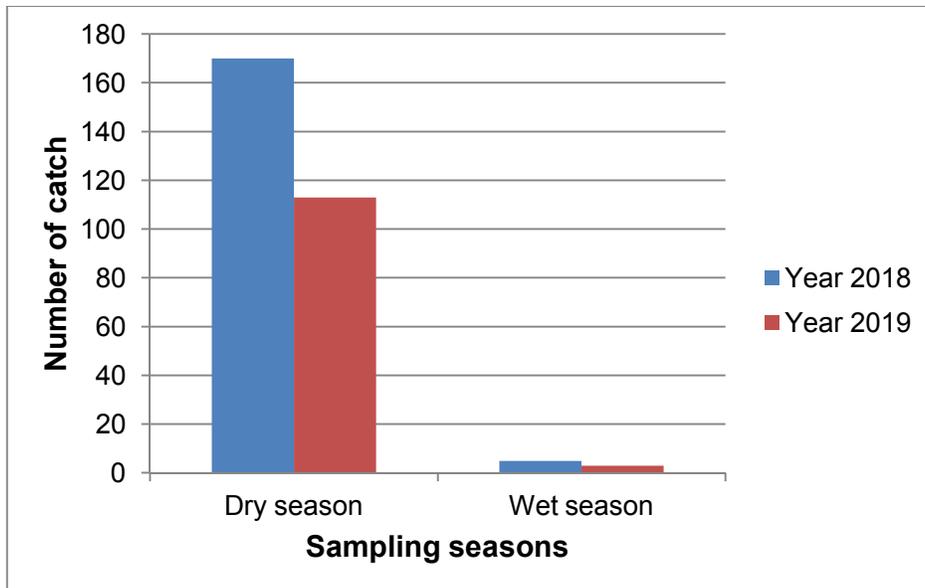


Fig. 13. Total number of beetle captured during the sampling seasons

3.1.2 Generation

Oryctes owariensis beetle like all other species of the genus *Oryctes* was univoltine with a single generation per year as the males and females appear at the breeding site during the dry season to mate. This is also in conformity with the observation obtained by Al-Deeb and Enan, Al-Deeb et al., Al-Sayed and Al-Tamiemi, Friederichs and Demandt, Zaid et al. [25,27,35,36,37] regarding the generation of beetles of the genus *Oryctes* and their infestation on palms.

3.1.3 Population dynamics and seasonal abundance

The result depicting the number of catches from days 22nd-28th and the total number of beetles caught for the months of January – April representing the dry sampling season and the months of June – September representing the wet sampling season had no definite pattern to the number of beetle caught on each day and month. However the dry sampling season recorded the highest number of beetle catch (location C), seconded by location D, then A while location B recorded the least number of beetles caught. Also the month of April had the highest number of captured beetle (120), followed by March (70), February (56) and January (37), totaling 283. This is in conformity with the observation of Mariau, [21], who stated that large catch of *Oryctes* beetles are obtained in the dry/warm season usually around April when the rain is not at its peak since rainy seasons are not preferred by the beetles. This result is further corroborated by those of Hussain, [12], Al-Deeb and Enan, [35], Buxton, [38], Khalaf et al. [39] who reported that adult population of *Oryctes* beetle increased from the month of March where beetles arrived the breeding site of palms for the purpose of mating usually in the month of January and peaked in April. Most authors who worked on other species of the genus *Oryctes* reported a peak in the month of June-July [29] in Iraq and [40] in Iran which are usually warmer seasons for temperate regions. Ehsine et al. [28], Al-Sayed and Al-Tamiemi [36], Soltani, [41], also confirmed the increase in the number of *Oryctes* beetle captured during the dry season or warmer part of the year and a drastic decrease in the number of beetles at the cold/wet part of the year. According to Hussain [20], Jonason et al. [42] variability in the prevalence, seasonal abundance and distribution of an insect are necessitated by

abiotic factors such as geographical location, temperature, humidity, weather, time of year and light type/ source which also is in line with this study since June-July are usually summer season equivalent to the dry season of March-April in Nigeria located in the tropics. Hussain, [20] further buttressed this point by reporting that warm nights are usually favourable for insect capture and in the tropics over here most nights are warm especially during the dry seasons, hence the prevalence of more beetle for capture at such nights.

For the wet sampling season, there was drastic fall in the number of beetle captured from each of the locations. The catch for June and July was 8 beetles in total while the months of August and September had zero record. This observation is in conformity with that obtained by authors like [27] who reported a sharp decline in the number of beetle captured at the end of September. This result also aligns with that stated by Mohammed et al. [26] who investigated the seasonal abundance of *Oryctes agamemnon* of date palm using light traps of differing colour. They reported that no adults were captured at the end of September. Mariau, [21], Chen et al. [43] disclosed that wet seasons are not preferred by the beetles, reason been that rainfall directly increased the development time of both herbivorous insect species with prolonged extension of the development of the immature stages. Chen et al. [43], Suttle et al. [44], Zhu et al. [45] further reported that rain downpours directly affected the survival of insects and indirectly affected plants which are the habitat of plant eating insect species hence are plant mediated. They observed in their study that rains led to reduction in the concentration of sugar in plants and further induce the production of glucosinolate, a phyto constituent or volatile plant metabolite that seriously impaired and disrupted trophic interactions thus destabilizing communities up the food chain. Again the emission of the plant metabolite, affected the insect ability of locating host plants when these changes concern specific cues important for foraging behavior especially of higher trophic level arthropods (predators and parasites) mediated by the volatiles emitted in response to herbivory Dicke [46]. Similarly, Koberi and Amani, [47], Dobkin et al. [48], Kamata and Igarashi, [49] demonstrated that heavy rains dislodged insects from the plants and also affected the microclimatic conditions. Furthermore, heavy rains not only affected the development but also the behavior of insects and

other arthropods while seasonal change in rainfall across years can cause reduction in herbivore abundance with subsequent shift (simplification) in trophic structure and thence the seasonal abundance and population dynamics of insects Moran et al. [50], Fink and Volkl, [51].

3.1.4 Light trap

The aggregate total of 291 beetles were attracted using the visual lure halogen light traps and captured from the four sampling locations throughout the sampling seasons. The results obtained by the experimentation showed that the beetle *O. owariensis* is attracted and responsive to bright light especially at nights. This is in cohort with the report by [15] that many insects are attracted by bright colours making insect light trap a very efficient tool for use in insect pest management in organic agriculture since it mass-traps both sexes of insect pests thereby reducing the carryover pest population. Concurrently, the specie of beetle is both flying and terrestrial insect that does get attracted to light trap which is in conformity with the statement of [18,19,20] that beetles are attracted to lights at a long range but are repelled by it at short range. The beetle specie was successfully monitored using the visual lure light trap which according to [20] is used to survey nocturnal insects whose abundance are influenced by temperature, humidity and type of lamp. This is further buttressed by the observation of Lale, [8] that adult *Oryctes* beetle are nocturnal, crepuscular in habit and strongly attracted to light in the night especially when it is ultra violet enriched. According to Bedford, [52], *Oryctes* beetles secrete pheromones that are widely used in attracting and or trapping the insect pests of palms. Hallett et al. [33], Moran et al. [50], Said et al. [53], demonstrated that male beetles of the genus *Oryctes* emit four chemical compounds such as ethyl 4- methyloctanoate, 4- methyloctanoic, 4- methyloctanyl acetate and 4- methyloctanol which combine with the natural odour of palms to effectively attract both male and female sexes of the beetles with females usually predominating.

4. CONCLUSION

The technique of using light trap in monitoring the both sexes of scarab beetle populations and their seasonal availability have been long practiced and used by several authors especially due to its positive outcome. The high efficiency and success incurred by the utilization of the

visual lure halogen light traps in capturing and or catching the adult beetles cannot be overemphasized therefore it stands as a possibility for use in Integrated Pest Management Program of the beetle.

5. RECOMMENDATION

Owing to the success recorded by this study, the authors do hereby recommend the incorporation of visual lures such as halogen light trap in the Integrated Pest Management Program (IPM) for the monitor, survey, prevention, management and or control of the population of the insect, *O. owariensis*. Furthermore, the use of chemical attractants and pheromone traps should be researched upon to ascertain their efficacy in the monitor and survey of the raphia palm beetle *O. owariensis* Beavois.

ACKNOWLEDGEMENT

The authors wish to acknowledge all the project students who made this research a huge success. Also to the farmers at the various palm farms for their great assistance and to everyone who directly and/or indirectly assisted in every way wise in fulfilling this reality, we say thank you.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Ukoroije, Bawo. Morphological studies of the life stages of *Oryctes owariensis* Beavois beetle (Coleoptera: Scarabaeidae). SSRG International Journal of Agriculture and Environmental Sciences. 2019;6(4):24-27.
2. Nair CPR. Ecology of *Oryctes rhinoceros*. ISSG Database/Specie/ecology. 1986;173.
3. Nishida GM, Evenhuis NL. Arthropod pests of conservation, significance in the pacific. A preliminary assessment of selected groups. In Invasive Species of the Pacific: A Technical Review and Draft Regional Strategy: South Pacific Regional Environment Programme. Samoa. 2000;142.
4. Bedford GO. Biology, ecology and control of palm rhinoceros beetles. Annual Review Entomology. 1980a;1(26):213.
5. Graham I. Food Australian. 41:564-566. In: Food Insects Newsletter. 1989;3(2).

6. Gressitt JL. The coconut rhinoceros beetle (*Oryctes rhinoceros*) with particular reference to the Palau Islands. Bulletin of the Bernice P. Bishop Museum. 1953;212: 157.
7. Bedford GO. Biology, ecology and control of palm rhinoceros beetle. Annual Review Entomology. 1980b;2(25):309-339.
8. Lale NES. Dictionary of entomology. Mole Publications Nigeria Limited. Maiduguri, Nigeria; 1996. ISBN: 978.32369-2-x.
9. Patrick C. Identification, images and information for insects, spiders and their kin for the United States and Canada Specie *Xyloryctes jamaicensis*- Rhinoceros beetles- Bug guide. Net. Iowa State University Entomology. 2004;8:100-216.
10. DeFoliart GR. Hypothesizing about palm weevil and palm rhinoceros beetle larvae as traditional cuisine, tropical waste recycling and pest and disease control on coconut and other palms- Can they be integrated? Food Insect Newsletter. 1990;3(2):1-6.
11. Fazoranti JO, Ajiboye DD. Some edible insects of Kwara State, Nigeria. America Entomologist. 1993;39(2):113-116.
12. Hills DS. Agricultural insect pests of the tropics and their control. Cambridge University Press, London: Cambridge. 1983;2:516,766.
13. Kalshoven LGE, Laan PAV. Pest of crops in Indonesia Jakarta: P. T. Ichtier Van Hoev, Jakarta. 1981;463-468.
14. Leefman S. De Klappertor (*O. rhinoceros* L.). Inst. Plantenziekten Meded. 1920;1:1-156.
15. Vaithlingam C. Role of insect light trap in organic agriculture. The Hindu. 2018;22: 38.
16. Epsky ND, Morrill WL, Mankin RW. Traps for capturing insects. In Capinera, J. L. (Ed.). Encyclopaedia of Entomology. Dordrecht: Springer. 2008;3887-3901.
17. Price B, Baker E. Night life; A cheap, robust, LED based light trap for collecting aquatic insects in remote areas. Biodiversity Data Journal. 2016;4(e7648): 1-18.
18. Farrow RA. A modified light-trap for obtaining large samples of night-flying locusts and grasshoppers. Australian Journal of Entomology. 1974;13(40):357-360.
19. Robinson HS. On the behavior of night-flying insects in the neighbourhood of a bright source of light. Proceedings of the Royal Entomological Society of London A. 1952;27(1-3):13-21.
20. Hussain AA. Notes on borers of date palms in Iraq. Bulletin of Entomological Research. 1963;54:345-348.
21. Mariau D. Les fluctuations des populations d' *Oryctes* en Cote d' Ivoire. Oleagineux. 1967;22(7):451-454.
22. Venard-Combes P, Mariau D. *Augosoma centaurius* Fabricus (Coleoptera: Scarabaeidae). A serious pest of coconut in Africa. Descriptions, Biology and Method of Control. 1983;38(12):651-657.
23. Nigeria Zip Codes. My Area's codes: Bayelsa State Map Showing Local Government Areas. Copyright © 2020.
24. Oluyemi AA, Abiodun KE, Devine OE, Peter A, Opaminola ND. Socio-economic implications of recurrent flooding on women development in Southern Ijaw Local Government Area, Bayelsa State, Niger Delta Area of Nigeria. Journal of Geoscience and Environment Protection. 2016;4:33-46.
25. Zaid A, De Wet PF, Djerbi M, Oihabi A. Diseases and pests of date palm, pp. 227-242 In Zaid A. (Ed.) and de Wet PF. Date palm cultivation. Chapter I: Botanical and systematic description of the date palm. FAO Plant Production and Protection Paper. Rev. 2002;1:156.
26. Mohammed E, M'hammed SB, Mohammed C. Seasonal and nocturnal activities of the rhinoceros borer (Coleoptera: Scarabaeidae) in the North Saharan Oases Ecosystems. Journal of Insect Science. 2014;14(1):256.
27. Al-Deeb MA, Mahmoud ST, Sharif EM. Use of light traps and differing light color to investigate seasonal abundance of the date palm pest, *Oryctes agamemnon arabicus* (Coleoptera: Scarabaeidae). J. Econ. Entomol. 2012;105:2062-2067.
28. Ehsine M, Bekadhi MS, Chaieb M. Bio-ecologic observations on rhinoceros beetle *Oryctes agamemnon* (Burmeister 1847) on the palm dates Oasis of Rjim Maatoug in South-Western Tunisia. J. Arid Land Stud. 2009;19:379-382.
29. Bedford GO, Al-Deeb MA, Khalaf MZ, Mohammadpour K, Soltani R. Dynastid beetle pests In Wakil et al. (Eds.). Sustainable Pest Management in Date Palm; Current Status and Emerging Challenges, Sustainability in Plant and Crop Protection. Springer International Publishing Switzerland. 2015;73-108.

30. Khalaf MZ, Alrubeae HF, Al-Taweel AA, Naher FH. First record of Arabian rhinoceros beetle, *Oryctes agamemnon arabicus* Fairmaire on date palm trees in Iraq. *Agriculture and Biology Journal of North America*. 2013;4:349-351.
31. Rochat D, Morin JP, Kakul T, Beaudoin-Ollivier L, Prior R, Renou M, Malosse I, Stathers T, Embupa S, Laup S. Activity of male pheromone of the Melanesian rhinoceros beetle *Scapanes australis*. *J. Chem. Ecol.* 2002;28:479-500.
32. Rochat D, Mohammadpoor K, Maloosae C, Avand-Faghieh A, Lettere M, Beauhaire J, Morin JP, Pezier A, Renou M, Abdollahi GA. Male aggregation pheromone of date palm fruit stalks borer *Oryctes elegans*. *J. Chem. Ecol.* 2004;30:378-407.
33. Hallett RH, Perez AL, Gries G, Gries R, Pierce HD Jr, Yue J, Oehlschlager AC, Gonzalez LM, Borden JH. Aggregation pheromone of coconut rhinoceros beetle, *Oryctes rhinoceros* (L.) (Coleoptera: Scarabaeidae). *J. Chem. Ecol.* 1995;21:1549-1570.
34. Gries G, Gries R, Perez AL, Oehlschlager AC, Gonzalez LM, Pierce HD Jr., Zebeyou M, Kouame B. Aggregation pheromone of the African rhinoceros beetles, *Oryctes monoceros* (Olivier) (Coleoptera, Dynastidae) *Zeitschrift für Naturforschung C: A J. Biosci.* 1994;49:363-366.
35. Al-Deeb MA, Enan MR. First record of a phoretic astigmatid Mite *Sancassania* sp. (Acaridae: Astigmata) on *Oryctes agamemnon* (Coleoptera: Scarabaeidae) in UAE. *Int. J. Agric. Biol.* 2010;12:157-160.
36. Al-Sayed AE, Al-Tamiemi SS. Seasonal activity of the fruit stalk-borer, *Oryctes agamemnon* (Burm.) (Coleoptera: Scarabaeidae) in Sultanate of Oman. *Egypt. J. Agric. Res.* 1999;77:1597-1605.
37. Friederichs K, Demandt. Westeres uber indischen Nashornkafer (*Oryctes rhinoceros* L.). *Zeitschr. F. Angrew. Ent.* 1922;8:295-324.
38. Buxton PA. Insect pest of dates and the date palm in Mesopotamia and elsewhere. *Bulletin of Entomological Research.* 1920;11:287-303.
39. Khalaf MZ, Al-Taweel AA. Palm borers in Iraqi environment: Species, damages, methods of control. Republic of Iraq: Ministry of Science and Technology, Agricultural, Research Directorate. 2014;31.
40. Fasihi MT. A study on the population dynamism of sympatric species of *Oryctes agamemnon* and *O. elegans*. Bushehr: Agricultural and Natural Resources Center. Annual Report of Project. 2011;11.
41. Soltani R. The rhinoceros beetle *Oryctes agamemnon arabicus* in Tunisia: Current challenge and future management perspectives. *Tunisian Journal of Plant Protection.* 2010;5:179-193.
42. Jonason D, Franzen M, Ranius T. Surveying moths using light trap: Effects of weather and time of year. *PLoS One.* 2014;9(3):e92453.
43. Chen C, Harvey JA, Biere A, Gols R. Rain downpours affect survival and development of insect herbivores: The specter of climate change? *Ecology.* 2019;100(11):1-10, eo2819.
44. Suttle KB, Thomsen MA, Power ME. Species interactions reverse grassland responses to changing climate. *Science.* 2007;315:640-642.
45. Zhu H, Wang D, Wang L, Fang J, Sun W, Ren B. Effects of altered precipitation on insect community composition and structure in a meadow steppe. *Ecological Entomology.* 2014;39:453-461.
46. Dicke M. Plant phenotypic plasticity in the phytobiome: A volatile issue. *Current Opinion in Plant Biology.* 2016;32:17-23.
47. Kobori Y, Amano H. Effect of rainfall on a population of the diamondback moth, *Plutella xylostella* (Lepidoptera: Plutellidae). *Applied Entomology and Zoology.* 2003;38:249-253.
48. Dobkin DS, Olivieri I, Ehrlich PR. Rainfall and the interaction of microclimate with larval resources in the population dynamics of checkerspot butterflies (*Euphydryas editha*) inhabiting serpentine grassland. *Oecologia.* 1987;71:161-166.
49. Kamata N, Igarashi Y. Influence of rainfall on feeding behavior, growth and mortality of larvae of the beech caterpillar, *Quadricalcarifera punctatella* (Motschulsky) (Lep, Notodontidae). *Journal of Applied Entomology.* 1994;118:347-353.
50. Moran VC, Hoffmann JH, Basson NCJ. The effects of simulated rainfall on cochineal insects (Homoptera, Dactylopiidae): Colony composition and survival on cactus cladodes. *Ecological Entomology.* 1987;12:51-60.
51. Fink U, Völkl W. The effect of abiotic factors on foraging and oviposition success

- of the aphid parasitoid, *Aphidius rosae*. *Oecologia*. 1995;103:371–378.
52. Bedford GO. Biology and management of palm dynastid beetles: Recent advances. *Annu. Rev. Entomol.* 2013;58:353-372.
53. Said I, Hasain N, Abdullah Z, Couzi P, Ouhichi M, Denon M, Rochat D. Identification of the aggregation pheromone of the date palm root borer *Oryctes agamemnon*. *J. Chem. Ecol.* 2015;4:446-457.

© 2020 Boate and Otoyar; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:
The peer review history for this paper can be accessed here:
<http://www.sdiarticle4.com/review-history/57385>