BioOne COMPLETE

Pollination Activity of Elaeidobius kamerunicus (Coleoptera: Curculionoidea) on Oil Palm on Hainan Island

Authors: Yue, Jianjun, Yan, Zhen, Bai, Cheng, Chen, Zetan, Lin, Weifu, et al.

Source: Florida Entomologist, 98(2) : 499-505

Published By: Florida Entomological Society

URL: https://doi.org/10.1653/024.098.0217

BioOne Complete (complete.BioOne.org) is a full-text database of 200 subscribed and open-access titles in the biological, ecological, and environmental sciences published by nonprofit societies, associations, museums, institutions, and presses.

Your use of this PDF, the BioOne Complete website, and all posted and associated content indicates your acceptance of BioOne's Terms of Use, available at www.bioone.org/terms-of-use.

Usage of BioOne Complete content is strictly limited to personal, educational, and non - commercial use. Commercial inquiries or rights and permissions requests should be directed to the individual publisher as copyright holder.

BioOne sees sustainable scholarly publishing as an inherently collaborative enterprise connecting authors, nonprofit publishers, academic institutions, research libraries, and research funders in the common goal of maximizing access to critical research.

Downloaded From: https://bioone.org/journals/Florida-Entomologist on 28 Mar 2024
Terms of Use: https://bioone.org/terms-of-use

Pollination activity of *Elaeidobius kamerunicus* (Coleoptera: Curculionoidea) on oil palm on Hainan island

Jianjun Yue[1,2], Zhen Yan[1,3], Cheng Bai[1], Zetan Chen[1*], Weifu Lin[4], and Fangzhen Jiao[1,3]*

Abstract

Elaeidobius kamerunicus Faust (Coleoptera: Curculionidae), the pollinating weevil, is the most efficient insect pollinator of oil palm, *Elaeis guineensis* Jacq. (Arecales: Arecaceae). In this experiment, the pollinating activity of *E. kamerunicus* was observed in an oil palm field in Hainan, China, in order to further understand the dynamics of the weevil's behavior on inflorescences. Both male and female inflorescences emitted an anise-like fragrance. Female inflorescences appeared to reward the weevils with copious nectar production, whereas male inflorescences appeared to do so with both nectar and pollen. The number of weevils visiting an inflorescence was assessed by the use of a sticky trap encircling it, and by counting the weevils present on samples of spikelets of inflorescences. The weevil population peaked on the 3rd day of anthesis on male inflorescences, and on the 2nd day of anthesis on female inflorescences. Weevil activity recorded on the day of highest abundance during anthesis revealed an inactive period during 07:00–08:00, substantial activity during 11:00–12:00, and peak activity during 17:30–18:00. The number of female adult weevils was always much greater than the number of males, both on male and on female inflorescences. Separation of anthesizing male inflorescences into 7 consecutive stages each 1 d long and use of sticky traps baited with anthesizing male flowers that were placed around inflorescences on the plant were optimal techniques for obtaining reliable data on the numbers of pollinating weevils. To increase the population of *E. kamerunicus* in Hainan, some steps should be taken including releases of adult weevils in oil palm plantations, and control of the weevil's predators and parasites, such as rats and harmful nematodes.

Key Words: anthesizing male inflorescence; *Elaeis guineensis*; pollinating weevil; pollinating activity; spikelet; sticky traps

Resumen

Elaeidobius kamerunicus Faust (Coleoptera: Curculionidae), el gorgojo de polinización, es el insecto polinizador más eficiente de la palma de aceite, Elaeis guineensis Jacq. (Arecales: Arecaceae). En este experimento, se observó la actividad polinizadora de E. kamerunicus en un campo de la palma de aceite en Hainan, China con el fin de comprender mejor su dinámica. Se evaluó el número de gorgojos que visitan las inflorescencias mediante el uso de trampas adhesivas que rodean las inflorescencias, y contando los gorgojos presentes en muestras de espiguillas. Las inflorescencias machos durante el antesis fueron atractivas para los gorgojos durante 6 días, en comparación con 5 días para las inflorescencias femeninas. La población de gorgojos alcanzó su punto máximo en el tercer día de antesis en inflorescencias machos, y en el segundo día de antesis en inflorescencias femeninas. La actividad de los gorgojos registrada en el día de mayor abundancia durante la antesis reveló un período de inactividad entre 07:00–08:00 y la actividad constante entre ambos 11:00–12:00 y 17:30–18:00. El número de hembras adultas de gorgojos siempre fue mayor que el número de machos, tanto en las inflorescencias machos y hembras. Para aumentar la población de E. kamerunicus en Hainan, se deben tomar algunas medidas que incluye la liberación de adultos de gorgojos en las plantaciones de palma de aceite, y el control de depredadores y parásitos del gorgojo, como las ratas y nematodos nocivos.

Palabras Clave: inflorescencias machos durante el antesis; *Elaeis guineensis*; gorgojo de polinización; actividad de polinización; espiguilla

Elaeidobius kamerunicus Faust (Coleoptera: Curculionoidea) is identified as the most efficient insect pollinator of oil palm (Syed 1979; Ponnamma et al. 2006a). *Elaeidobius kamerunicus* was introduced from Africa into the oil palm growing regions of Asia and the Pacific in the early 1980s (Caudwell 2001) and into the oil palm plantations of India during 1985 (Ponnamma et al. 2006b). Introduction of the weevil into oil palm plantations increased fruit set and dramatically raised the yield of oil palm (Ponnamma 1999; Caudwell 2001). Also, the introduction of *E. kamerunicus* in Malaysia has increased pollination and fruit production (Syed 1982; Basri et al. 1983; Chiu et al. 1986). In general, the impact of the introduction of *E. kamerunicus* in Southeast Asia has been highly favorable (Corrado 1985; Donough & Law 1987; Wahid et al. 1987). The nematode *Elaeolenchus parthenonema* **n. g., n. sp.** (Nematoda: Sphaerularioidea: Anandranematidae **n. fam.**) is harmful

[1]Environment and Plant Protection Institute, Chinese Academy of Tropical Agricultural Sciences, Haikou, Hainan 571101, China
[2]Hainan Forestry Research Institute, Haikou, Hainan 571100, China
[3]College of Environment and Plant Protection, Hainan University, Haikou, Hainan 570228, China
[4]Rubber Research Institute, Chinese Academy of Tropical Agricultural Sciences (RRI-CATAS), Haikou, Hainan 571101, China
*Corresponding authors; E-mail addresses: (Cheng Bai): chengbai2001@163.com; (Zetan Chen): czt975@21cn.com

Downloaded From: https://bioone.org/journals/Florida-Entomologist on 28 Mar 2024
Terms of Use: https://bioone.org/terms-of-use

to the weevil (Poinar et al. 2002), but the *Bacillus thuringiensis* products Lepcon-1, Bafog-1 (S), and Ecobac-1 (EC) have been proven innocuous to the weevil (Ahmad et al. 2012). The weevils prefer the inflorescence of oil palm (*Elaeis guineensis* Jacq.; Arecales: Arecaceae) for oviposition (Adaigbe et al. 2011), indicating they have a close relationship to this species. Females live longer than males (Allou 2004; Tuo et al. 2011), and this is significant for the artificial production of progeny. Climatic conditions have an obvious effect on the population dynamics and activity of *E. kamerunicus* (Chee & Chiu 1998). Therefore, we paid attention to climate as a factor in these experiments.

In the 1960s to 1980s, oil palm seeds were introduced from Malaysia and Papua New Guinea to China and planted mainly in Hainan, Yunnan, and Guangdong Provinces (Lin 2010). Currently, the planted oil palm area is about 42,000 ha on Hainan Island. In China, the pollinating curculionid *E. kamerunicus* was first recorded in oil palm plantations on Hainan Island. However, to date the population dynamics of *E. kamerunicus* in this part of China have not been studied in detail. This information is crucial to understand pollination efficiency of the weevils in relation to oil palm production. In the present paper, we report on the pollination activity of *E. kamerunicus* on oil palm on Hainan Island, China.

Materials and Methods

EXPERIMENTAL SITE

The experiment was conducted in an oil palm plot, located in Baodao Xincun of Danzhou City, Hainan Province, China (19.52°N, 109.46°E) in the years of 2012 to 2013. In Oct 2013, the average temperature was 25.3 °C in Danzhou (the maximum was 27.0 °C and the minimum was 22.5 °C based on Danzhou meteorological stations on Hainan Island). This site belongs to the Rubber Research Institute, Chinese Academy of Tropical Agricultural Sciences. The oil palm plantation, located on flat ground, is mainly used for scientific research. Nine-year-old oil palms were used for the experiment. The total plantation area was 50 ha, and the palms were triangle-planted with 10 m distance. The altitude of Danzhou is about 100–200 m. The soil is latosol. Danzhou has a tropical monsoon climate with an annual average temperature of 23.1 °C, rainfall of 1,486 mm, and sunshine for 2,072 h.

QUANTIFICATION OF WEEVIL ACTIVITY ON MALE AND FEMALE INFLORESCENCES

Experiments were conducted on male and female inflorescences of *E. guineensis* separately. Five plots were designed, and an inflorescence from each of palm in each plot was chosen. Experiments were repeated 5 times. The distance between plots was 30 m. The inflorescences were about 2 m above the ground.

We divided the period of anthesis of male inflorescences into 7 d. On the 1st day, about 25% of male flowers were fully open and functional, and this fraction increased to about 50% on the 2nd day and to 100% on the 3rd and subsequent days. This classification was based on the method of Chiu et al. (1986). However, we divided the period of anthesis of female inflorescences into 6 d, i.e., the 1st, 2nd, 3rd, 4th, 5th, and 6th day of anthesis. Sticky traps were applied for catching *E. kamerunicus*. The trap was 21.7 cm in diameter and 26.3 cm in height. It was folded into a cylinder surrounding an inflorescence with the outside surface coated with a sticky gel (Fig. 1). The traps were collected in individual plastic bags and brought to the laboratory. *Elaeidobius kamerunicus* adults were washed from these traps with xylene on the same day, and the numbers of males and females were counted.

NUMBERS OF WEEVILS THAT EMERGED PER SPIKELET DURING THE PERIOD OF ANTHESIS

On the male inflorescences, samples were collected from the field for assessing the adult weevil numbers. Five plots were designed, and an inflorescence from each palm in each plot was chosen. Six complete spikelets were subjected to stratified sampling from 6 sections of the male inflorescence. Experiments were repeated 5 times. The number of adults per spikelet was observed at monthly intervals. The insects from the month with the highest population density were chosen for other experimental purposes.

NUMBERS OF *E. KAMERUNICUS* VISITING MALE INFLORESCENCES DURING THE ANTHESIS PERIOD

To determine the number of weevils that visited male inflorescences during the anthesis period, we designed 5 plots. An inflorescence from each palm in each plot was chosen. Experiments were repeated 5 times. Sticky traps were installed at 09:00, and collected and replaced with a new one every 24 h until the male inflorescences had completely wilted.

NUMBERS OF *E. KAMERUNICUS* PER SPIKELET DURING THE ANTHESIS PERIOD

To determine the number of weevils per spikelet on the male inflorescence during the anthesis period, samples were taken at 11:00, and 6 complete spikelets were subjected to stratified sampling each from 6 sections of the male inflorescence. The selection of 6 spikelets per inflorescence was based in some part on the method of Chiu et al. (1986). Each collected spikelet was placed in an individual plastic bag, and the numbers of male and female weevils were counted. Collection of spikelets continued until the male inflorescences were completely wilted.

NUMBER OF *E. KAMERUNICUS* VISITING MALE INFLORESCENCES ON THE 3RD DAY OF ANTHESIS

To determine the number of *E. kamerunicus* visiting male inflorescences on the 3rd day of anthesis, sticky traps were installed at 06:00, and collected every hour (every half an hour during the active peak period of *E. kamerunicus*), and each trap was then replaced with a new one. Such collection continued until the end of the 3rd day of anthesis.

NUMBER OF *E. KAMERUNICUS* PER SPIKELET ON THE 3RD DAY OF ANTHESIS

To determine the number of *E. kamerunicus* per spikelet on the 3rd day of anthesis of male inflorescences, samples of spikelets were taken at 07:00, and 6 complete spikelets were subjected to stratified sampling every hour (every half an hour during the active peak period of *E. kamerunicus*) from 6 sections of the male inflorescence. The selection of 6 spikelets per inflorescence was based in part on the method of Chiu et al. (1986). The spikelets were collected in individual plastic bags, and the numbers of male and female weevils were counted. Such collection continued until the end of the 3rd day of anthesis.

NUMBER OF *E. KAMERUNICUS* VISITING FEMALE INFLORESCENCES DURING THE ANTHESIS PERIOD

To determine the number of *E. kamerunicus* visiting female inflorescences during anthesis, sticky traps were installed at 09:00, and collected after 24 h. A new trap to replace the old one was then installed

Downloaded From: https://bioone.org/journals/Florida-Entomologist on 28 Mar 2024
Terms of Use: https://bioone.org/terms-of-use



Fig. 1. Sticky trap applied for catching *Elaeidobius kamerunicus,* pollinating weevils. The trap was 21.7 cm in diameter and 26.3 cm in height. It was folded into a cylinder surrounding an *Elaeis guineensis* inflorescence with the sticky gel–coated surface on the outside.

around each inflorescence. Such collection continued until the female inflorescences had completely wilted.

NUMBER OF *E. KAMERUNICUS* VISITING FEMALE INFLORESCENCES ON THE 2ND DAY OF ANTHESIS

To determine the number of *E. kamerunicus* visiting female inflorescences on the 2nd day of anthesis, sticky traps were installed around the female inflorescences at 06:00 and collected every hour, but every half an hour during the active peak period of *E. kamerunicus*. A new trap to replace the old one was then installed around each inflorescence. Such collection continued until the end of the 2nd day of anthesis.

STATISTICAL ANALYSIS

Statistical analyses were performed using SAS 9.1 (SAS Institute, Cary, North Carolina, USA) as described by Ron (2007).

Results

NUMBERS OF WEEVILS THAT EMERGED PER SPIKELET DURING THE PERIOD OF ANTHESIS

Two high peaks of adult weevil emergence per spikelet occurred with 1 in Apr and 1 in Oct in both 2012 and 2013. The greatest values observed in various months were as follows: Oct > Nov > Apr (Fig. 2).

NUMBERS OF *E. KAMERUNICUS* VISITING MALE INFLORESCENCES DURING THE ANTHESIS PERIOD

Adult weevils (both females and males) were most abundant on male flowers on the 3rd day of anthesis when all the florets had opened. The number of female weevils was always greater than that

Downloaded From: https://bioone.org/journals/Florida-Entomologist on 28 Mar 2024
Terms of Use: https://bioone.org/terms-of-use

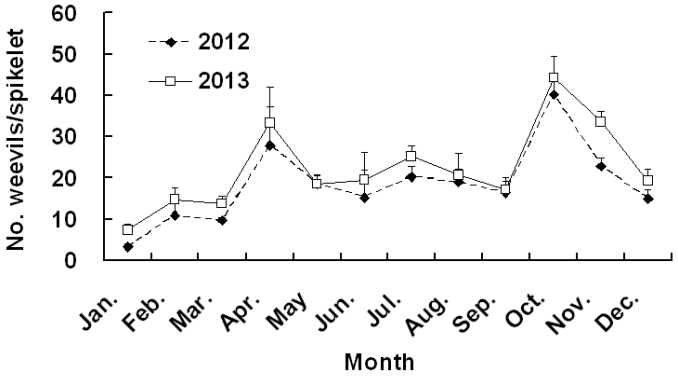


Fig. 2. Number of *Elaeidobius kamerunicus* pollinating *w*eevils that emerged per spikelet of the inflorescences of the African oil palm each month during anthesis. Each data point is presented as the mean ± SE.

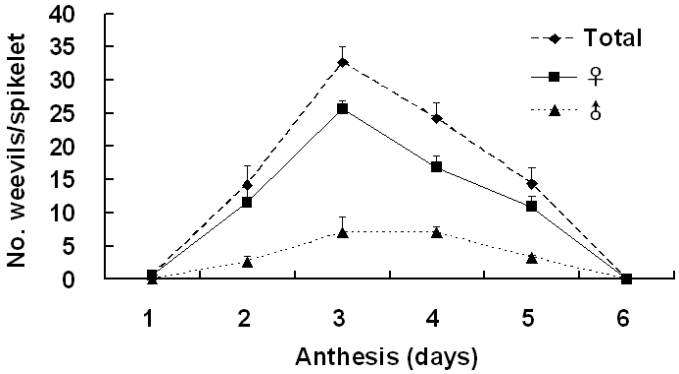


Fig. 4. The number of *Elaeidobius kamerunicus* pollinating weevils per spikelet on each of the first 6 d of the anthesis period of male inflorescences of the African oil palm. Each data point in the figure is presented as the mean ± SE.

of the males (Fig. 3). There were no weevils on the male inflorescences on the 1st day of anthesis when about 25% of the florets had opened. The number of adult weevils increased on the 2nd day when 50% of the florets had opened. On the 3rd day, the total number of the weevils reached a maximum of 599 adults. The number of adult weevils progressively declined on the male inflorescences on the 4th and 5th days to 420 and 95, respectively. Only one adult weevil was seen on the inflorescence on the 6th day. No weevils were collected on the 7th day. By this time, the male flowers had withered and a small fraction of the male spikelets were moldy.

NUMBERS OF *E. KAMERUNICUS* PER SPIKELET DURING THE ANTHESIS PERIOD

Adult weevils were most abundant on male spikelets on the 3rd day of anthesis when all the florets had opened, and the number of female weevils was always greater than that of the males (Fig. 4). There were few adult weevils on the male spikelets on the 1st day of anthesis when 25% of the florets had opened. The total number of adult weevils increased to 14 per spikelet on the 2nd day when 50% of the florets had opened. On the 3rd day, the weevils reached a maximum of 33 per spikelet, and the spikelets were covered with golden yellow pollen. The number of the adult weevils declined on the 4th and 5th days, and so did the amount of pollen. No adult weevils were caught on the 6th day, and by this time the spikelets had withered and the basal parts of the male spikelets were moldy.

NUMBER OF *E. KAMERUNICUS* VISITING MALE INFLORESCENCES ON THE 3RD DAY OF ANTHESIS

On the 3rd day of anthesis, the adult weevils were very active between both 11:00 and 12:00 and between 17:30 and 18:30, slightly active between 13:00 and 15:00, slightly active between 09:00 and 10:00 and between 16:00 and 17:30, and inactive between 07:00 and 08:00 (Fig. 5). The number of weevils visiting male inflorescences began to increase between 09:00 and 10:00. The total number of weevils reached a maximum of 515 at 11:30, of which 400 were females and 115 were males.

NUMBER OF *E. KAMERUNICUS* PER SPIKELET OF INFLORESCENCES ON THE 3RD DAY OF ANTHESIS

On the 3rd day of anthesis, the adult weevils were very active on spikelets between 17:00 and 18:00, active between 11:00 and 12:00, and inactive between 07:00 and 08:00 (Fig. 6). Only a few individuals visited the male spikelets between 09:00 and 10:00. The total number of weevils peaked at 17:30 with 36 adults per spikelet.

NUMBER OF *E. KAMERUNICUS* VISITING FEMALE INFLORESCENCES DURING THE ANTHESIS PERIOD

Adult weevils were most abundant on female flowers on the 2nd day of anthesis, and the number of adult females was always greater

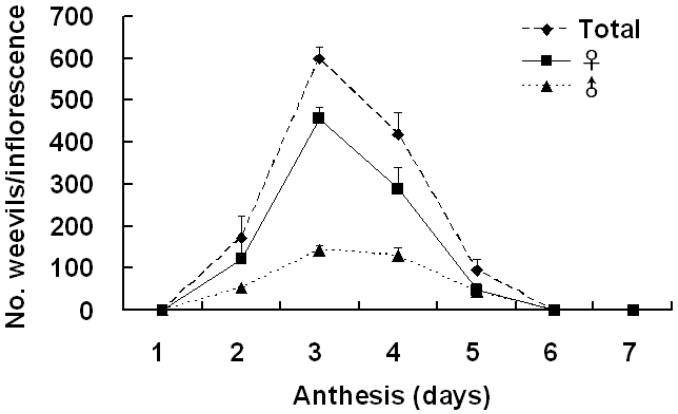


Fig. 3. The number of *Elaeidobius kamerunicus* pollinating weevils visiting male inflorescences on each of the 7 d of during the anthesis period of the African oil palm. Each data point in the figure is presented as the mean ± SE.

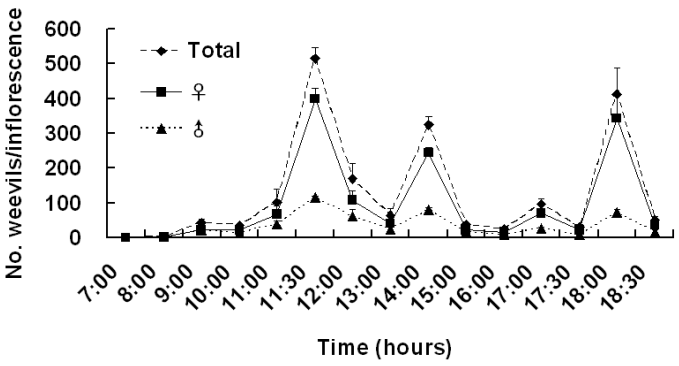


Fig. 5. The number of *Elaeidobius kamerunicus* pollinating weevils visiting male inflorescences at various hours of the 3rd day of anthesis of male inflorescences of the African oil palm. Each data point in the figure is presented as the mean ± SE.

Downloaded From: https://bioone.org/journals/Florida-Entomologist on 28 Mar 2024
Terms of Use: https://bioone.org/terms-of-use

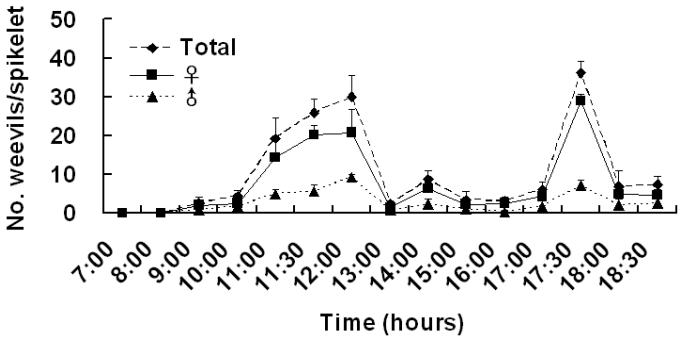


Fig. 6. The number of *Elaeidobius kamerunicus* pollinating weevils per spikelet at various hours of the 3rd day of anthesis of male inflorescences of the African oil palm. Each data point in the figure is presented as the mean ± SE.

than that of males (Fig. 7). Twenty-eight adult weevils were found on the 1st day. On the 2nd day, when all the florets had opened, the total number of the weevils reached a maximum of 651. The number of adult weevils declined sharply during the 3rd, 4th, and 5th days. No weevils were seen on the 6th day, when the flowers had become black and a small number had become moldy.

NUMBER OF *E. KAMERUNICUS* VISITING FEMALE INFLORESCENCES DURING THE 2ND DAY OF ANTHESIS

Adult weevils were very active between 10:00 and 12:00, active between 17:00 and 18:30, and inactive between 07:00 and 09:00 on the 2nd day (Fig. 8). The total number of weevils peaked at 11:00, when it reached a maximum of 544. At 18:00, the number of individuals that visited female flowers was 298. The number of the weevils was less than 30 between 13:00 and 16:00. Only a few individuals visited female flowers between 07:00 and 09:00.

Discussion

Anthesizing male inflorescences were attractive to the weevils from day 1 to day 6 (Figs. 3 and 4). Adult weevils were most abundant on male flowers on the 3rd day of anthesis, when all the florets had opened. The number of females was always greater than the number of males on male inflorescences. Small numbers of *E. kamerunicus* gathered on the male inflorescences during the 1st and 5th days of anthesis, as had been reported previously by Dhileepan (1994). Ponnamma (1999) and Syed (1982) reported that the males of *E .kamerunicus* tended to aggregate and adult weevils were most abundant on male flowers on the 3rd day of anthesis. In this study, we conducted more detailed observations and obtained results similar to those reported by these earlier workers.

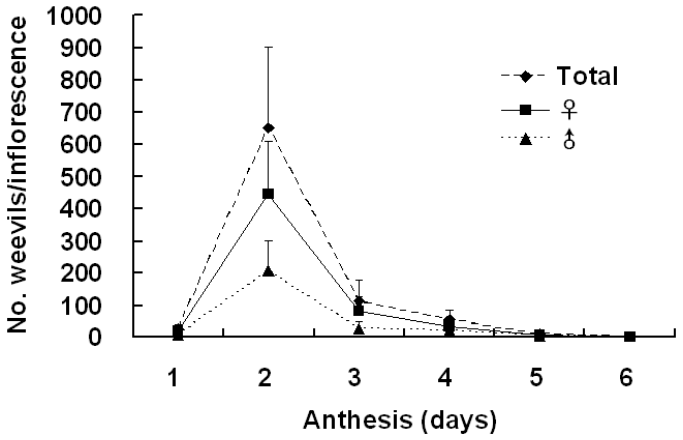


Fig. 7. The number of *Elaeidobius kamerunicus* pollinating weevils visiting female inflorescences on each of the 6 d of the anthesis period of the female inflorescence of the African oil palm. Each data point in the figure is presented as the mean ± SE.

The density of the pollinating weevil per anthesizing male spikelet on Hainan Island was less than that in Cameroon (Syed 1982). This could be because *E. kamerunicus* on Hainan Island is adversely affected by natural enemies including spiders, mites, ants, nematodes, and rats. Previous studies reported that the weevil population was affected by predators. Rats and ants are known to feed on the larvae of the pollinating weevil (Liau 1984; Saúl et al. 1998; Ponnamma et al. 2006a). During this study, we occasionally caught spiders, ants, and rats on the sticky traps. In the laboratory, we observed infestation of the weevils by mites and nematodes. To increase the population of *E. kamerunicus* in Hainan Island, measures to control natural enemies, i.e., mites, ants, nematodes, and rats, must be addressed.

We demonstrated that adult weevils were most abundant on the female flowers on the 2nd day of anthesis. This finding is similar to that of Hala et al. (2012) but differs from the results of Syed (1979, 1982), who reported that the adult weevil population increased to a maximum on the female inflorescences during the 2nd and 3rd days of anthesis. The differences between our observations and those reported by Syed (1979, 1982) could perhaps be due to differences in climate and location.

Elaeidobius kamerunicus was more abundant on male inflorescences than female inflorescences, and this is similar to the results of Hala et al. (2012). Our examinations were more detailed than those of Tuo et al. (2011). Adult weevils were more likely to stay on the spikelets for mating and oviposition at dusk, and this finding agrees with that of Tuo et al. (2011). We noted that the male flowers released a distinct anise-like odor, which seemed to be strongest on the 3rd day of anthesis. Female flowers also emitted a distinct anise-like odor, which seemed strongest on the 2nd day of anthesis. Perhaps the anise-like odor attracted the adult weevils. The number of adult weevils at 11:00 was 1.8 times greater than at 18:00, possibly because the adult weevils were feeding on the nectar in the flowers. We found that female flowers had much nectar at 11:00. Our experimental results demonstrate that the adult weevils were active between 11:00 and 12:00 and between 17:30 and 18:00, and inactive between 07:00 and 08:00, irrespective of whether they were present on male or female inflorescences. Other workers reported that the activity of the oil palm pollinating weevil was substantial between 16:00 and 18:00, and the number of *E. kamerunicus* was greatest between 12:30 and 14:30 and smallest around noon (Chiu 1984; Chinchilla et al. 1991; Ponnamma 1999). Their results differ from our findings reported in this study. These differences might be due to differences either in the behavior of *E. kamerunicus* or in the physiology of the African oil palm under the influence of climatic factors that differ in the various countries where this crop is produced.

In this study, we discovered that *E. kamerunicus* weevils aggregated on male inflorescences during the 1st to 6th day of anthesis, and on the female inflorescences during the 1st to 5th day of anthesis. Weevil abundance peaked on the 3rd day of anthesis on male inflorescences when all florets were open, and on the 2nd day of anthesis on female inflorescences. Activity of the weevils recorded on the day of highest abundance during anthesis showed an inactive period between 07:00 and 08:00, and consistent activity occurred between 11:00 and 12:00 and between 17:30 and 18:00. In this study, we conducted much more

Downloaded From: https://bioone.org/journals/Florida-Entomologist on 28 Mar 2024
Terms of Use: https://bioone.org/terms-of-use

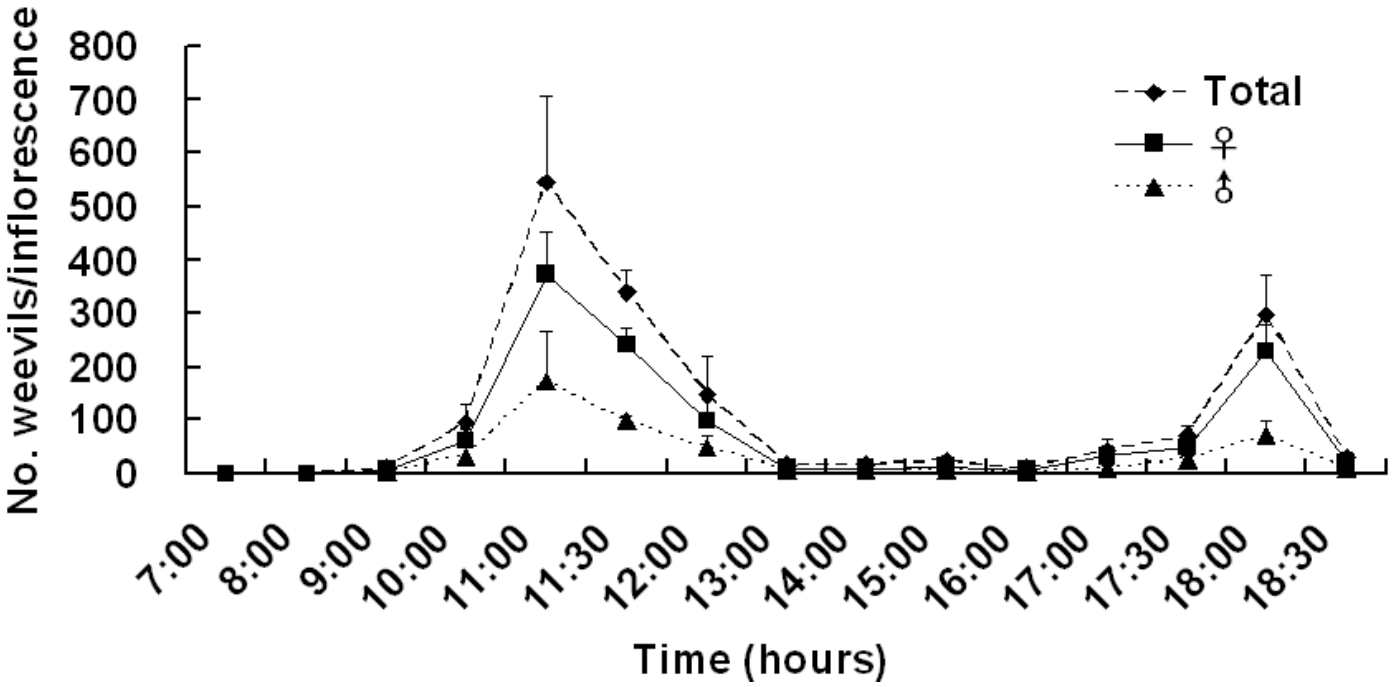


Fig. 8. The number of *Elaeidobius kamerunicus* pollinating weevils visiting female inflorescences at various hours of the 2nd day of anthesis of the female inflorescence of the African oil palm. Each data point in the figure is presented as the mean ± SE.

detailed observations than have been reported previously. Sticky traps incorporating anthesizing male flowers as bait or sampling weevil-covered spikelets of the anthesizing male inflorescence are 2 sampling methods for estimating the weevil population. The 2nd method was reported by Chiu et al. (1986) to be more reliable than the 1st method. In this study, we found that the separation of anthesizing male inflorescences into 7 stages and encircling the inflorescences with sticky traps was an optimal procedure for obtaining reliable data.

Acknowledgments

This work was supported by the Specialized Fund for the Basic Research Operating Expenses Program of the Central Public Welfare Scientific Research Institute funds (No. 1630022011037) and 211 Project for Hainan University. We are grateful to RRI-CATAS for providing the oil palm plantation for the experiment.

References Cited

Adaigbe VC, Odebiyi JA, Omoloye AA, Aisagbonhi CI, Iyare O. 2011. Host location and ovipositional preference of *Elaeidobius kamerunicus* on four host palm species. Journal of Horticulture and Forestry 3: 163-166.

Ahmad MN, Ali SRA, Masri MMM, Wahid MB. 2012. Effect of Bt products, Lepcon-1, Bafog-1 (S) and Ecobac-1 (EC), against the oil palm pollinating weevil, *Elaeidobius kamerunicus*, and beneficial insects associated with *Cassia cobanensis*. Journal of Oil Palm Research 24: 1442-1447.

Allou K. 2004. Contribution à l'étude du cycle de reproduction d'insectes Coléoptères Curculionidae pollinisateurs (*Elaeidobius kamerunicus*, *E. plagiatus*) et ravageurs (*Prosoestus minor*, *P. sculptilis*) du palmier à huile en Côte d'Ivoire. Diplôme d'étude approfondie en Entomologie générale à l'Université de Cocody, Ivory Coast. 46 pp.

Basri MW, Halim AH, Hitam AH. 1983. Current status of *Elaeidobius Kamerunicus* Faust and its effects on the oil palm industry in Malaysia. Palm Oil Research Institute of Malaysia 6: 39.

Caudwell RW. 2001. Insect pollination of oil palm—time to evaluate the long-tem viability and sustainability of *Elaeidobius kamerunicus*? Planter 77: 181-190.

Chee KH, Chiu SB. 1998. A study of *Elaeidobius kamerunicus* in West Kalimantan oil palm plantations. Planter 74(872): 587-595.

Chinchilla L, Carlos M, Richardson DL. 1991. Pollinating insects and the pollination of oil palms in Central America. ASD Technical Bulletin 2: 1-18.

Chiu SB. 1984. Some aspects of the ecology of *Elaeidobius kamerunicus* Faust, the pollination weevil of oil palm, with emphasis on developing sampling technique. M.S. thesis, University Pertanian Malaysia, Selangor, Malaysia. 114 pp.

Chiu SB, Khoo KC, Hussein MY. 1986. A method for estimation of the natural population of the pollinating weevil, *Elaeidobius kamerunicus* Faust of oil palm, pp. 453-470 *In* Hussein MY, Ibrahim A [eds.], Biological Control in the Tropics. Penerbit University Pertanian, Selangor, Malaysia.

Corrado F. 1985. La conformation des rcimes de palmier huile (*Elaeis guineensis*) dans quelques plikantations de Colombia. Oleagineux 40: 173-187.

Dhileepan K. 1994. Variation in populations of the introduced pollination weevil (*Elaeidobius kamerunicus*) (Coleoptera: Curculionidae) and its impact on fruit set of oil palm in India. Bulletin of Entomological Research 84: 477-485.

Donough CR, Law IH. 1987. The effect of weevil pollination on yield and profitability at Pamol Plantations. Proceedings of the 1987 International Palm Oil/Ojlil Palm Conference. Kuala Lumpur, Malaysia. 11 pp.

Hala N, Tuo Y, Akpesse AAM, Koua HK, Tano Y. 2012. Entomofauna of oil palm tree inflorescences at La Mé experimental station (Côte d'Ivoire). American Journal of Experimental Agriculture 2: 306-319.

Liau SS. 1984. Predators of the pollination weevil, *Elaeidobius kamerunicus* Faust (Curculionidae) in Malaysian oil palm estates, pp. 41-49 *In* Proceedings of Symposium on Impact of the Pollination Weevil on the Malaysian Oil Palm Industry. Palm Oil Research Institute of Malaysia, Kuala Lumpur, Malaysia.

Lin WF. 2010. Current situation of Chinese oil palm planting utilization and prospect of analysis. China Agriculture Science and Technique Press. Beijing, China, pp. 16-24.

Poinar, GO, Jackson TA, Bell NL, Wahid MB. 2002. *Elaeolenchus parthenonema* **n. g., n. sp.** (Nematoda: Sphaerularioidea: Anandranematidae **n. fam.**) parasitic in the palm-pollinating weevil *Elaeidobius kamerunicus* Faust, with a phylogenetic synopsis of the Sphaerularioidea Lubbock, 1861. Systematic Parasitology 52: 219-225.

Downloaded From: https://bioone.org/journals/Florida-Entomologist on 28 Mar 2024
Terms of Use: https://bioone.org/terms-of-use

Ponnamma KN. 1999. Diurnal variation in the population of *Elaeidobius kamerunicus* on the anthesising male inflorescences of oil palm. Planter 75: 405-410.

Ponnamma KN, Sajeebkhan A, Asha V. 2006a. Adverse factors affecting the population of pollinating weevil, *Elaeidobius kamerunicus* Faust and fruit set on oil palm in India. Planter 82: 555-557.

Ponnamma KN, Asha V, Sajeebkhan A. 2006b. Progeny emergence in *Elaeidobius kamerunicus*. Planter 82: 333-336.

Ron C. 2007. Learning SAS by Example: A Programmer's Guide. SAS Institute Inc., Cary, North Carolina, USA.

Saúl SS, Carlos F, Ortiz G. 1998. Oil palm pests and pollinators in Tabasco, Mexico. ASD Oil Palm Papers 18: 25-28.

Syed RA. 1979. Studies on oil palm pollination by insects. Bulletin of Entomological Research 69: 213.

Syed RA. 1982. Insect pollination of oil palm, feasibility of introducing *Elaeidobius* spp. into Malaysia, pp. 263-289 *In* Oil Palm in Agriculture in the Eighties. The Incorporated Society of Planters, Kuala Lumpur, Malaysia.

Tuo Y, Koua HK, Hala N. 2011. Biology of *Elaeidobius kamerunicus* and *Elaeidobius plagiatus* (Coleoptera: Curculionidae), main pollinators of oil palm in West Africa. European Journal of Scientific Research 49: 426-432.

Wahid MB, Masijan Z, Halim AH, Mohid D. 1987. The population census and the pollination efficiency of the weevil *Elaeidobius kamerunicus* in Malaysia. A status report, 1983–1986. Proceedings of the 1987 International Oil Palm/Palm Oil Conferences. Kuala Lumpur, Malaysia. 32 pp.

Downloaded From: https://bioone.org/journals/Florida-Entomologist on 28 Mar 2024
Terms of Use: https://bioone.org/terms-of-use