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Original Communication

Preliminary study on the occurrence of pollinator insect species on oil palm *Elaeis guineensis* and relationship of the major pollinator *Elaeidobious kamerunicus* to oil palm yield in Ghana

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ABSTRACT

A preliminary study was carried out on the "occurrence of the oil palm pollinator insect species on oil palm and the relationship of the major pollinator insect species *Elaeidobious kamerunicus* to oil palm yield in Ghana". The result showed that pollinator insect species that occurred on oil palm inflorescences were mainly coleopterans. Not all the insect species that were commonly found occurred on both the male and female inflorescences. The common insect species encountered were: *Elaeidobious plagiatus, E. singularis, E. kamerunicus, E. bilineatus, E. subvittatus, Microporum congolenses, M. dispar, Atheta* sp, *Prosoestus sculptilis* and *P. minor. Elaeidobious subvittatus* occurrence was the most common insect species monthly, on the male inflorescence throughout the years 2007, 2008 and 2009. *E. kamerunicus* occurrence was also the most frequent among the pollinator insect species found on the female inflorescence. *E. plagiatus, E. singularis, E. bilineatus, E. subvittatus, M. congolenses, M. dispar, Atheta* sp., *P. sculptilis* and *P. minor* occurrence on female oil palm inflorescence was low. Their individual contribution to successful female oil palm pollination was therefore very low. *P. sculptilis* and *P. minor* did not occur on the male inflorescence. Likewise *E. bilineatus, M.congolenses, Atheta* species and *E. plagiatus* rarely occurred on the female inflorescence. There was a positive correlation between occurrence of *E. kamerunicus* and mean oil palm fresh fruit bunch weight in 2008 and 2009. The highest fresh fruit bunch weight was obtained in December, 2009 and lowest in January, 2006.

KEYWORDS: pollinator insect species, oil palm, pollination, *Elaeidobious kamerunicus*, yield

INTRODUCTION

The oil palm *Elaeis guineensis* Jacq is a very important commercial tree crop in Ghana. The plant is entomophilous [1, 2] and various insect species had been noted to play a significant role in its pollination [3]. Pollinator insect species presence on oil palm plantations can give some good indications of the biodiversity in the field and sustainability of oil palm yield in terms of quantity and spread of palm fruit production. This is especially important in areas such as plantations where there are extensive and intensive use of pesticides against some major insect pests especially the key pest, which in Ghana and some West African countries, is the oil palm leafminer, *Coelaenomenodera lameensis* [4].

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Various insect species had been found to be associated with oil palm pollination and inflorescences. Among the insect species are *Mystrops costaricensis* and *Elaeidobious subvittatus* in South America, *E. kamerunicus, E. plagiatus*, *E. subvittatus* and *Atheta* sp. in Ghana [3], and *Mystrops and Elaeidobious* species in Columbia [5]. These insect species could potentially increase the fruit set in the dry season to 80%. It is the recognition of significant role played by pollinator insect species in oil palm fruit set which played a major role in the introduction of *E. kamerunicus* into Malaysia in 1980 [6, 7] and into Costa Rica in 1986 [8]. In Malaysia, periodic occurrence of poor pollination and yield loss in certain locations were associated with low weevil populations [9]. Also, in parts of East Malaysia, poor fruit set due to poor pollination was attributed to insufficient weevils [10].

In Ghana, although various species of the oil palm pollinating insect species are known [11], their fluctuation in numbers throughout the year with respect to male and female oil palm inflorescences had not been analysed sufficiently and their importance highlighted. Also, the influence of some of the pollinator insect species to oil palm yield had not been investigated or documented. This paper therefore reports on the yearly occurrence of the oil palm pollinator insect species on oil palm inflorescences and the relationship of the major pollinator insect *E. kamerunicus* to oil palm yield in Ghana.

MATERIALS AND METHODS

The study was carried out from January, 2006 - December-2009 at the CSIR-Oil Palm Research Institute, near Kade in the Eastern Region of Ghana. The area lies in the forest zone of Ghana and optimal for oil palm production as categorized by [12]. Palms aged 15 years and 13 years occupying plot size of 21.72ha and 13.30ha respectively were used.

Monthly collection of pollinator insect species were done in the morning between 10-11 am, by cutting one female oil palm inflorescence on plot K30 on the 2nd day of receptivity from a palm after securely enclosing the inflorescence in a polyethylene bag. Similarly, 4 male inflorescence spikelets in anthesis on a palm on field K29 were cut and enclosed securely in a polyethylene bag. The bags were brought to the laboratory and the trapped insects killed by placing a swap of cotton wool-soaked ethyl acetate in the sealed bags overnight. The dead insects were shaken-free from the inflorescences into the bags the following day, and the content in the bags poured separately into two 8mm diameter petri dishes. The dishes were labeled appropriately as insects from male or female inflorescence, after sieving the pollen from the insects and removing the debris using a pair of forceps. The insects were then washed in 70% ethanol and dried in an oven (Model Wagtech GP/100/CLAD/F/250/HYD) at 40^{o}C for 1 hour. The dried insects from the various petri dishes were next poured separately on white polyester cloth spread on a laboratory bench.

The following data on the insect species were taken after sorting and grouping the insects where possible into orders, families, genus and species.

1. Names of insect species on male inflorescence in anthesis
2. Names of insect species on receptive female inflorescence
3. Number of various insect species per male inflorescence
4. Number of various insect species per female inflorescence
5. Number of unidentified insect species per male and female inflorescences

In order to aid easy field identification, some individual insects from the various species were photographed. In addition, oil palm yield using the weight per fresh fruit bunch from field K30 where the study on pollinator insect species on receptive female inflorescence was carried out was obtained from the breeding yield record book at the Institute.

The data were analysed using graphs, and the relationship between the major pollinator insect species (*E. kamerunicus*) numbers and oil palm yield assessed using regression analysis. As a point of interest for further investigation, *E. kamerunicus* was examined under the microscope to check whether it carries other organisms on its body.

RESULTS AND DISCUSSION

Pollinator insect species encountered were mainly coleopterans and included the following insect species: *Elaeidobious plagiatus, E. singularis, E. kamerunicus, E. bilineatus, E. subvittatus, Microporum congolenses, M. dispar, Atheta sp, Prosoestus sculptilis,* and *P. minor* (Plates 1-10). There were some other unidentified insect species including dermapterans (earwigs), lepidopterans (carterpillars) and in very rare cases hymenopterans (ants).

Plate 1. *Elaeidobious plagiatus*

Plate 2. *E. singularis*

Plate 3. *E. kamerunicus*

Plate 4. *E. bilineatus*

Plate 5. *E. subvittatus*

Plate 6. *Microporum congolenses*

Plate 7. *Microporum dispar*

Plate 8. *Atheta* sp.

Plate 9. *Prosoestus sculptilis*

Plate 10. *Prosoestus minor*

Figures 1a-4b show the result of the pollinator insect species which visited the male inflorescences on plot K29 and receptive female inflorescences on plot K30. All the insect species mentioned above except *P. sculptilis* and *P. minor* occurred monthly throughout the years (2006-2009) on male inflorescences (Figures 1a, 2a, 3a and 4a). *E. subvittatus* was the predominant insect species on the male inflorescences monthly throughout the years 2007, 2008 and 2009. It was most abundant on the male inflorescence (>1000 per male inflorescence) in February (Figures 2a, 3a and 4a) except in 2006 when it was most abundant in May (Fig. 1a). In 2006, no one insect species pre-dominated the insect species visiting the male oil palm inflorescences in all the month. The predominant pollinator insect species varied in a particular month and included *E. plagiatus*,

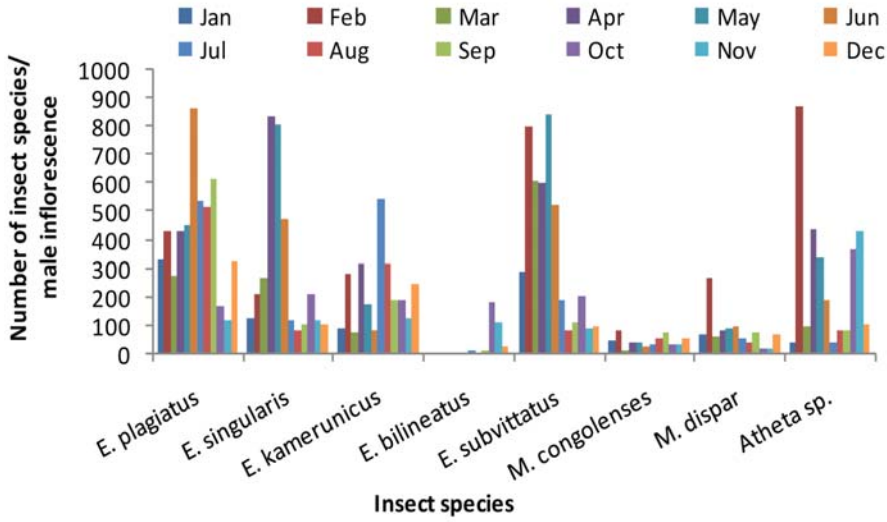

Fig. 1a. Monthly occurrence of pollinator insect species on male oil palm inflorescence in 2006.

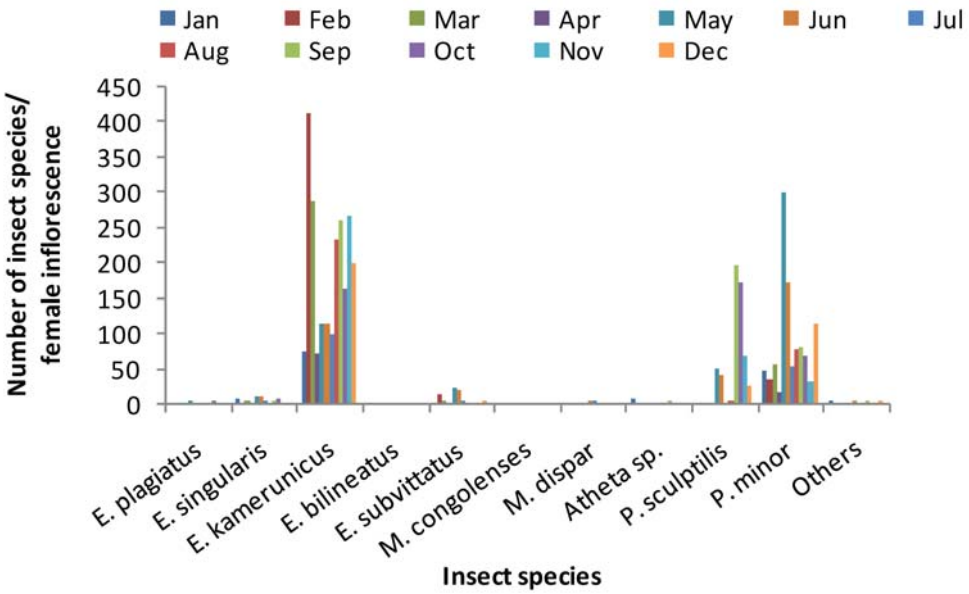

Fig. 1b. Monthly occurrence of pollinator insect species on female oil palm inflorescences in 2006.

E. singularis, *E. subvittatus*, *Atheta* sp. and *E. kamerunicus* and were thus important in carrying pollen grains. A study by [13] showed that *E. kamerunicus*, *E. subvittatus* and *E. plagiatus* move high quantities of pollen grains of which 68.5% was viable.

Figures 1b, 2b, 3b and 4b show the visits of pollinator insect species on receptive female oil palm inflorescences at K30. *E. kamerunicus* was the predominant pollinator insect species on the female inflorescence. The species generally occurred in all the months throughout the years of

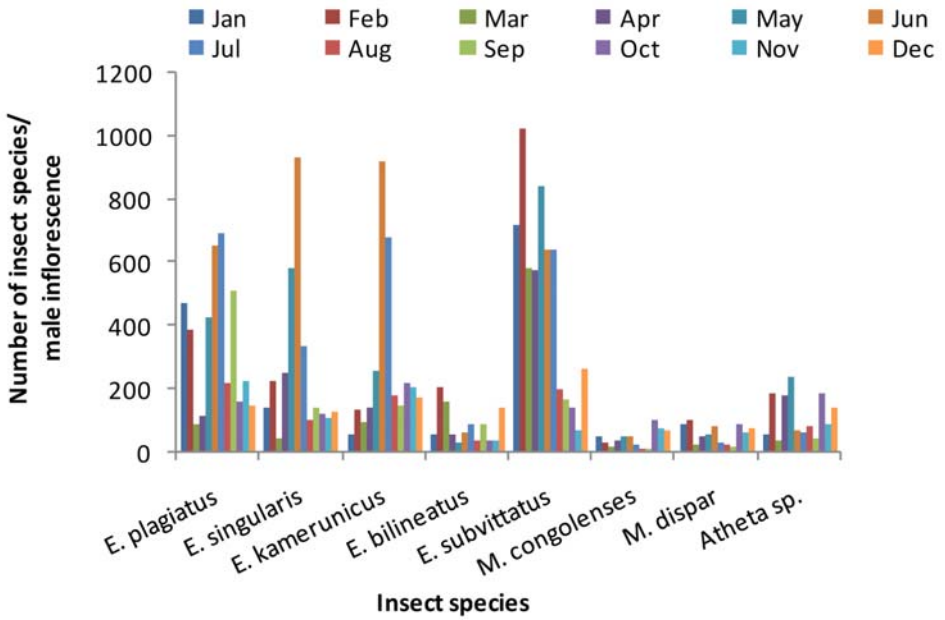

Fig. 2a. Monthly occurrence of pollinator insect species on male oil palm inflorescence in 2007.

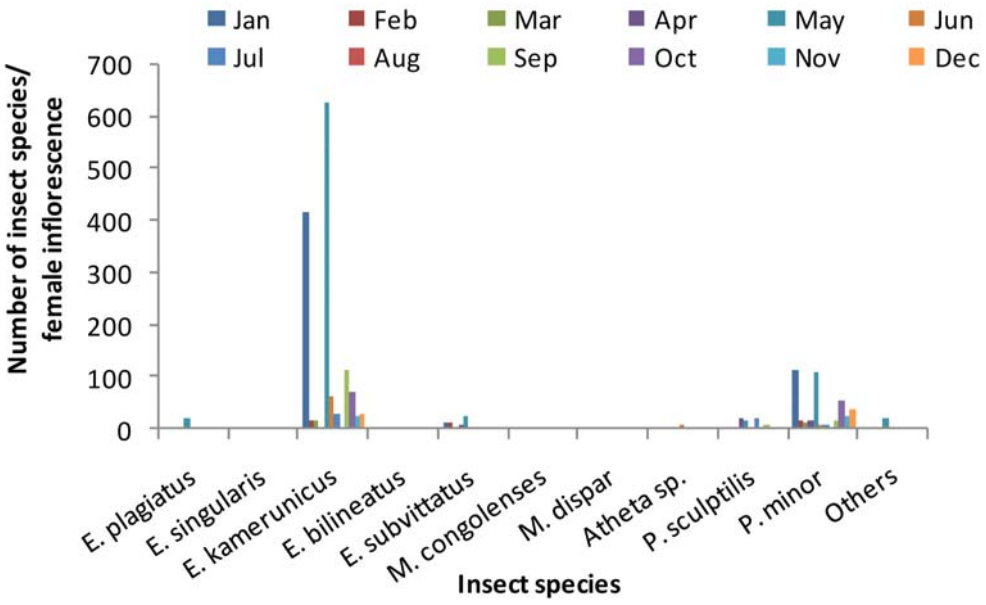

Fig. 2b. Monthly occurrence of pollinator insect species on female oil palm inflorescence in 2007.

study. The species was most abundant in February, May, August and June in the years 2006, 2007, 2008 and 2009 respectively. *E. kamerunicus* number reached a maximum (>600 insects per inflorescence) in May, 2007 (Fig. 1b). *Prosoestus* sp. also occurred on the female inflorescences in most months of the years after *E. kamerunicus*, with *P. minor* being the next common pollinator insect species on receptive female inflorescence but the species number was generally low. *P. minor* for instance had a maximum number of <300 insects per female inflorescence (Fig. 1b, 2006) which was less than half that of *E. kamerunicus* maximum number of >600 insects per female inflorescence. The species was most abundant in January (Figs. 3b, 4b) and in May (Figs. 1b and 2b). Some pollinator insect species which occurred on the male inflorescences including *E. bilineatus* and *M. congolenses*, were in most cases absent on the receptive female inflorescence in all or most months of the years under study. This shows that these insects do not play any significant role in oil palm pollination. Other pollinator insect species including

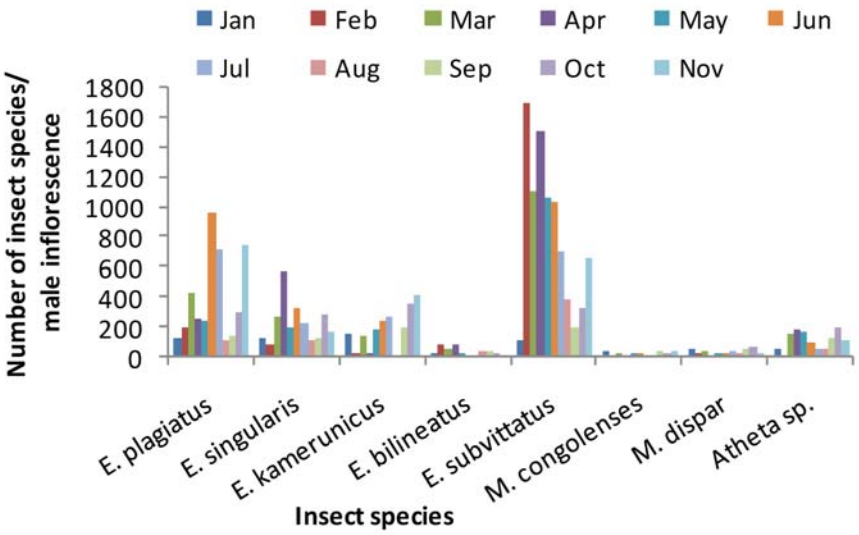

Fig. 3a. Monthly occurrence of pollinator insect species on male oil palm inflorescence in 2008.

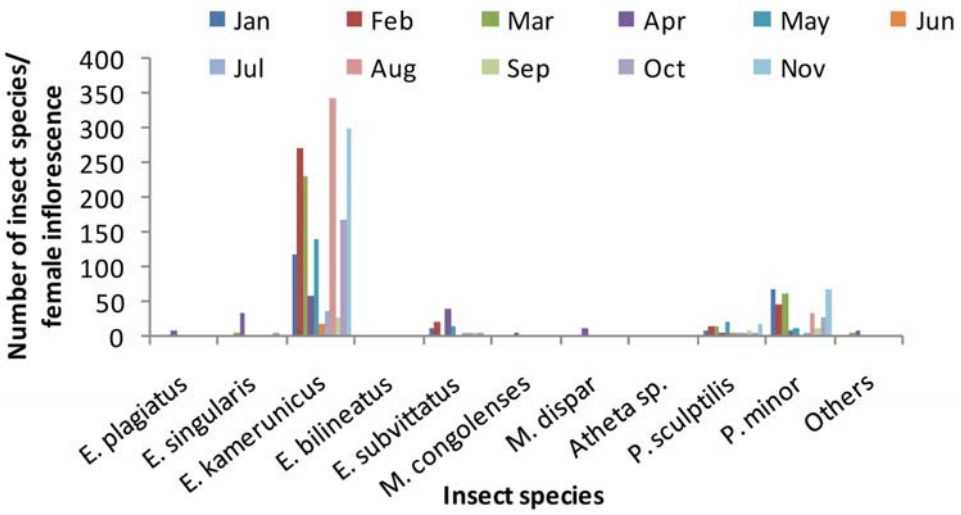

Fig. 3b. Monthly occurrence of pollinator insect species on female oil palm inflorescence in 2008.

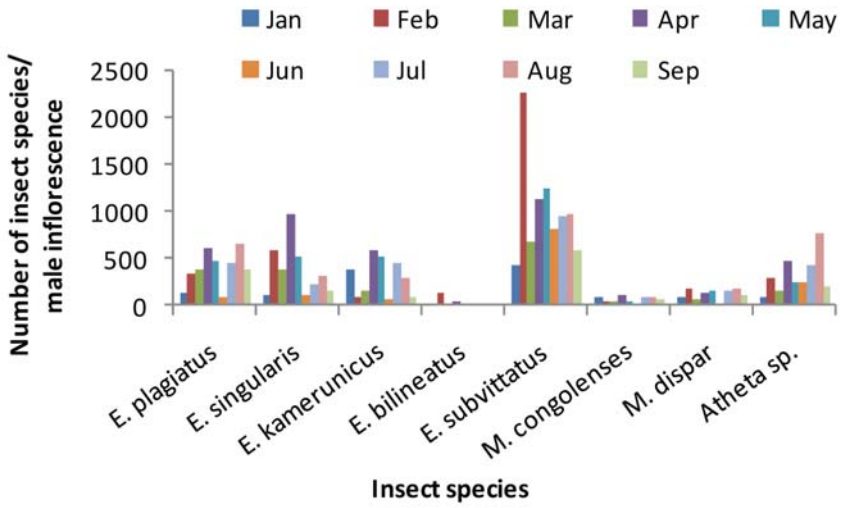

Fig. 4a. Occurrence of pollinator insect species on male oil palm inflorescence in 2009.

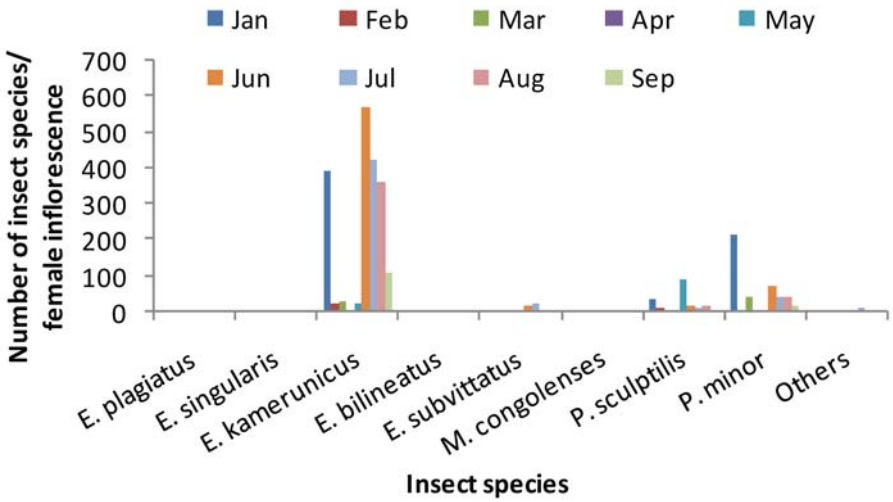

Fig. 4b. Occurrence of pollinator insect species on female oil palm inflorescence in 2009.

E. plagiatus, E. singularis, E. subvittatus, M. dispar, Atheta species and *P. sculptilis* occurred in very low numbers (<35 insects per female inflorescence) on the female inflorescence.

Figure 5 shows changes in numbers of pollinator insect species on male inflorescence over the years 2006-2009. The number of *E. subvittatus* showed significant increase yearly from 2006 to 2009 on male inflorescence in anthesis. *E. subvittatus* was also the most abundant pollinator insect species from 2007 to 2009. *Atheta* sp. showed a drop in numbers in 2007 and 2008. The numbers in 2007 and 2008 were not significantly different from each other but differ significantly from numbers in 2006 and 2009. The number in 2009 was the highest but was not significantly different from the 2006 numbers. The rest of the pollinator insect species including *E. plagiatus, E. singularis, E. kamerunicus, E. bilineatus, M. congolenses* and *M. dispar* did not show any significant change in numbers on the male inflorescence over the years.

Figure 6 shows the change in numbers of pollinator insect species that visited the female inflorescence during the study period. *E. kamerunicus* was the predominant insect species

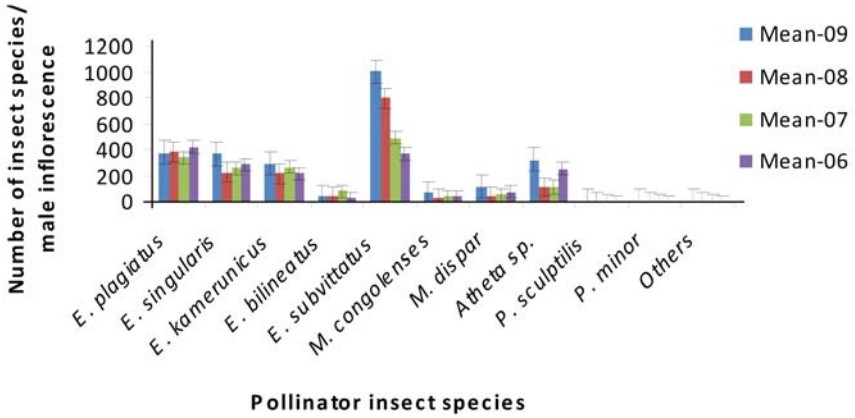

Fig. 5. Yearly trend of pollinator insect species occurrence on male oil palm inflorescence from 2006-2009.

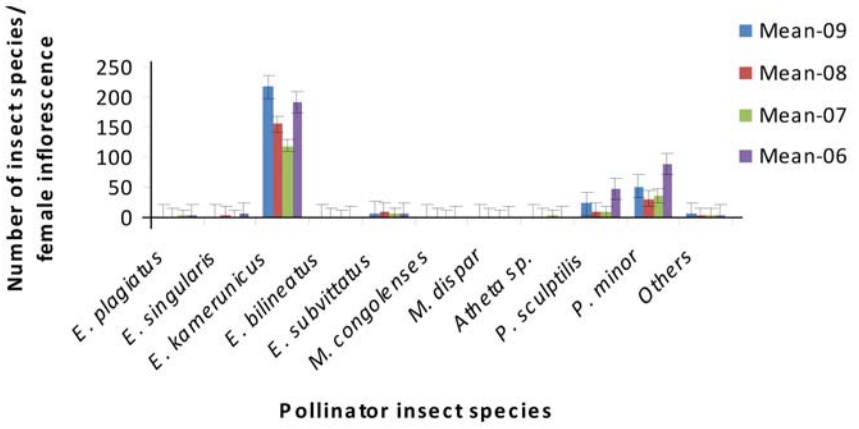

Fig. 6. Yearly trend of pollinator insect species occurrence on female oil palm inflorescence from 2006-2009.

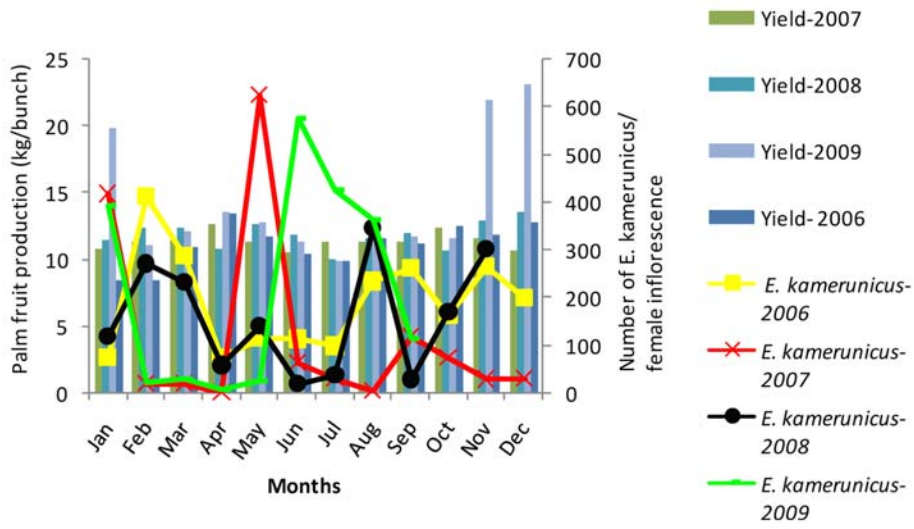

Fig. 7. Monthly oil palm yield in relation to *E. kamerunicus* occurrence from 2006-2009.

on the inflorescence over the 4 year period. The number of *E. kamerunicus* declined to the lowest value (118 insects per inflorescence) in 2007 and then increased significantly in both 2008 and 2009. The number of *E. kamerunicus* was highest (216 insect per inflorescence) in 2009 although the number was not significantly different from that of 2006. The next pollinator insect species which showed some variation in numbers on the female inflorescence were *P. minor* and *P. sculptilis*. *P. minor* numbers reached the highest value in 2006 which then declined significantly in 2007 and then continued to decline further to a low value in 2008. The numbers then rose in 2009 but fell short of the 2006 value. The values in 2007, 2008 and 2009 were not significantly different from each other indicating no change in *P. minor* numbers on receptive female oil palm inflorescence from 2007 to 2009. *P. sculptilis* numbers similarly was highest in 2006 but declined in 2007. It increased slightly in 2008 and 2009. The insect numbers in 2007, 2008 and 2009 were not significantly different from each other indicating no change in *P. sculptilis* numbers on receptive female inflorescence. The rest of the pollinator insect species did not show any significant change in numbers of visiting insect species on the female inflorescence over the years. It is evident from Figures 1b, 2b, 3b, 4b and 6 that the individual contribution of the insect species *E. singularis*, *E. subvittatus*, *M. dispar*, and *Atheta* sp. to successful high oil palm pollination was very low although they might be significant collectively. Contribution to pollination by *E. plagiatus, E. bilineatus and M. congolenses* to pollination are very insignificant or zero as they rarely occur on the female inflorescences to bring in pollen collected from male inflorescences. *P. sculptilis and P. minor* were also poor pollinators as they rarely occurred on the male inflorescence in anthesis where they could collect pollen for pollination on receptive female inflorescence. *E. kamerunicus* showed good pollination activities by occurring on both male and female inflorescences in anthesis and receptivity throughout the months in the years and also in relatively high numbers. *E. kamerunicus* thus showed significant contribution to pollination of oil palm among all the pollinator insect species encountered and this goes to confirm work done by [6, 3] that *E. kamerunicus* plays a significant role in oil palm pollination, hence selection for introduction into various countries to enhance oil palm pollination and increase yield. [3] also indicated that *E. kamerunicus* was selected for introduction into Asia because of its possession of the following characteristics: high numbers, moves large quantity of pollen grains than other insect species, its high reproductive rate, good searching ability and host specificity. In general, Figures 1-6 show that more pollination insect species occur on male inflorescence in anthesis than female in receptivity. A study by [14] showed that variation in male inflorescence in anthesis quantity is the main factor that causes the fluctuation observed in the population of pollinators, especially *E. kamerunicus*.

Figure 7 shows monthly oil palm fresh fruit bunch weight (kg) and *E. kamerunicus* occurrence over the years. The highest fresh fruit bunch weight was obtained in December, 2009 and lowest in January, 2006. Oil palm pollination, development and maturation spans a period of 5-6 months. The high numbers of *E. kamerunicus* which occurred in June, 2009 on receptive oil palm inflorescences may have contributed in part to the high and successful pollination observed. This translated into high fresh fruit bunch weight in November and December, 2009. Figures 8-11 show the relationship of *E. kamerunicus* to oil palm fresh fruit bunch weight. Figures 8 and 9 showed negative relationship in 2006 and 2007 respectively. Figures 10 and 11 however showed positive relationship in 2008 and 2009 respectively. The low coefficient of correlation values in Figures 8-11 show the important contribution of other pollinating insect species and perhaps the wind to oil palm yield. Fresh fruit bunch weight in 2009 was high in January (Fig. 7). This may be due to an earlier high pollination by *E. kamerunicus* in August, 2008. [15] studying the seasonal variation in the extraction rate in oil palm made a similar observation. They noted a seasonal pattern in the average fresh fruit bunch weight with the activity or population of pollinating insects in Costa Rica. Fruit per bunch and bunch weight showed a positive correlation with the population of pollinator insects occurring five to six months before harvesting, i.e. during inflorescence pollination. [16] had earlier observed periods of low pollinator insect populations to be

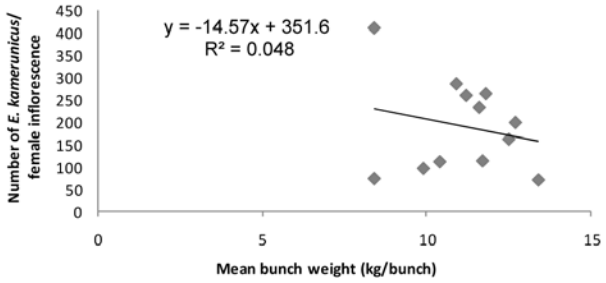

Fig. 8. Relation between number of *E.kamerunicus* and oil palm bunch weight in 2006.

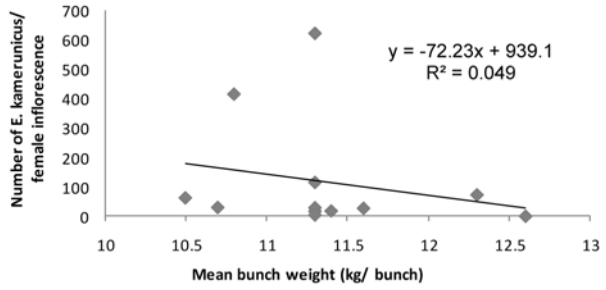

Fig. 9. Relation between number of *E.kamerunicus* and oil palm bunch weight in 2007.

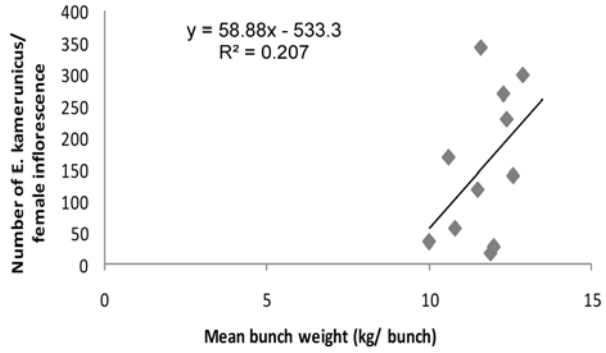

Fig. 10. Relation between number of *E.kamerunicus* and oil palm bunch weight in 2008.

associated with low fruit set rates and low bunch weights.

Observation of the body of *E. kamerunicus* under the microscope showed the presence of unidentified mites on the body. The underside of the eletra also showed the presence of nematodes. The role of such phoretic mites and nematodes are yet to be investigated.

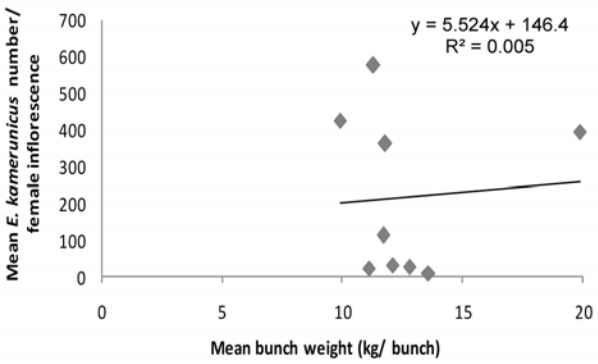

Fig. 11. Relation between number of *E.kamerunicus* and oil palm bunch weight in 2009.

CONCLUSION

The study showed that pollinator insect species that occurred on oil palm inflorescences were mainly coleopterans. The common insect species encountered were: *Elaeidobious plagiatus, E. singularis, E. kamerunicus, E. bilineatus, E. subvittatus, Microporum congolense, M. dispar, Atheta sp, Prosoestus sculptilis,* and *P. minor.* More pollinator insect species occur on the male inflorescence than the female inflorescence. Not all the insect species found occurred on both the male and female inflorescences. The pollinator insect species found on both the male and female inflorescence were: *E. singularis, E. kamerunicus, E. subvittatus, M. dispar, and Atheta species* and are therefore important for oil palm pollination in Ghana. *Elaeidobious subvittatus* occurrence was the most common insect species monthly, on the male inflorescence throughout the years 2007, 2008 and 2009. *E. kamerunicus* occurrence was also the most frequent among the pollinator insect species found on the female inflorescence. *E. kamerunicus* was the leading pollinator insect species as its occurrence on the male inflorescence and female inflorescence was quiet high and very high respectively over the study period. *E. singularis* and *E. subvittatus* occurrence on female oil palm inflorescence was low whilst *M. dispar* and *Atheta* sp. was even very low or infrequent. Their individual contribution to successful female oil palm pollination was therefore very low although collectively, they might be significant. There was a positive correlation between occurrence of *E. kamerunicus* and mean fresh fruit bunch weight in 2008 and

2009. The highest fresh fruit bunch weight was obtained in December, 2009 and lowest in January, 2006. Further study would be carried out to quantify the contribution of the wind to pollination and the relationship between the pollinator insect species numbers and fruit numbers per fresh fruit bunch. Also, further investigation would have to be carried out to identify the mites and nematodes which occur on *E. kamerunicus* body and determine the role they played on the insect.

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REFERENCES

1. Hardon, J. J. and Corley, R. H. V. 1976, Pollination. In Developments in Crop Science 1. Corley, R. H. V., Hardon, J. J. and Wood, B. J. (Eds). Elsevier, Amsterdam. pp 532.
2. Turner, P. D. and Gilbanks, R. A. 1974, Incorporated Society of Planters. Kuala Lumpur, pp. 672.
3. Syed, R. A. 1979, Bulletin of Entomological Research, 69, 213-224.
4. Yawson, G. K., Appiah, S. O., Kim, C. S. and Owusu, E. O. 2006, Journal of the Ghana Science Association, 8(1), 118-126.
5. Mariau, D. and Genty, P. 1988, Oleagineux, 43(6), 233-240.
6. Basri, M. W. 1984, Developments of the oil palm pollinator *Elaeidobious kamerunicus* in Malaysia. Palm Oil Developments 2, 1-3.
7. Kang, S. M. and Zama A. Karim. 1982, In Proceedings of International Plant Protection in the Tropics. Malaysian Plant Protection Society. Kuala Lumpur.
8. Chinchilla, C. and Richardson, D. L. 1989, Boletin Tecnico OPO-United Brands, 3(2), 29-48
9. Ming, K. S. 1999, The Planter, 75(876), 143-150.
10. Rao, V. and Law, I. H. 199, The Planter (Malaysia), 74(870), 463-483.
11. Yawson, G. K., Appiah, S.O., Tegoe, S. M. and Owusu, E. O. 2009, CSIR-Oil Palm Research Institute, 2009, Annual Report, 23-35.
12. Van der Vossen, H. A. M. 1969, Ghana Journal of Agricultural Science, 2, 113.
13. Caudwell, R., Hunt, D., Reid, A., Mensah, A. and Chinchilla, C. 2005, Palmas, 26(1), 29-46.
14. Bulgarelli, J., Chinchilla, C. y Rodríguez, R. 2002, Inflorescencias musculinas, poblacion de *E. kamerunicu* (Curculionidae) y calidad de la poinizacion en una plantacion commercial joven de palmas aceitara en Costa Rica. ASD Oil Palm Papers, No. 2, 1-8.
15. Alvarado, A. and Sterling, F. 1998, Seasonal variation in the oil extraction rate in oil palm, ASD Oil Palm Papers No. 17, 20-30.
16. Chinchilla, C. and Richardson, D. L. 1991, Pollinating insects and the pollination of oil palm in Central America, ASD Oil Palm Papers (Costa Rica) 2 (Special number).