International Journal of Agricultural Sciences ISSN: 2167-0447 Vol. 3 (3), pp. 450-454, March, 2013.
Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Population dynamics of fruit fly (Diptera: Tephritidae) species associated with mango in the Guinea Savanna Agro-Ecological zone of Ghana

Nboyine J. A.[1*], Abudulai M.[1], Nutsugah S.K.[1], Badii B.[2] and Acheampong A.[2]

[1]Entomology Section, CSIR-Savanna Agricultural Research Institute, P. O. Box 52, Tamale, Ghana.
[2]Department of Agronomy, Faculty of Agriculture, University for Development Studies, P. O. Box 1882, Tamale, Ghana.

Accepted 04 January, 2013.

Fruit flies are a major threat to the mango industry in Ghana. Effective control of these flies requires understanding the dynamics in the population of the species present. Therefore, the objective of this study was to determine the population dynamics of fruit fly species associated with mango in the Guinea Savanna Agro-ecological zone of Ghana. Traps baited with methyl eugenol, terpinyl acetate, and trimedlure and the killing agent Dimethyl 2, 2-DichloroVinyl Phosphate were used to trap the flies. A total of 6,889 fruit flies belonging to the genera *Bactrocera* and *Ceratitis* were captured during the study. *Ceratitis cosyra* was the dominant species recorded in traps and from incubated fruits during the dry and main fruiting periods of January to April, while *Bactrocera invadens* was the dominant species recorded during the wet and towards the end of the mango season of May to November. Populations of *C. cosyra* were positively correlated with temperature but negatively correlated with relative humidity, while populations of *B. invadens* were positively correlated with relative humidity but negatively correlated with temperature. These findings demonstrate that fruit fly management in the study area should be targeted at *C. cosyra* during the dry periods and *B. invadens* during the wet season.

Key words: Mango, fruit flies*, Ceratitis cosyra, Bactrocera invadens,* Guinea Savanna zone, weather, Ghana.

INTRODUCTION

Fruit flies (Diptera: Tephritidae) are a major constraint to mango production in West Africa (Ekesi and Billah, 2009; Lux et al., 2003a). The female fly oviposits in the mesocarp of developing mango fruits causing them to rot and/or drop resulting in loss of marketable yield (Lux et al., 2003a). Worldwide, an average of 20 to 30% of the mango crops is lost due to fruit fly alone (White and Elson-Harris, 1992). The yield loss recorded for seven mango cultivars in the West African country of Benin in 2006 ranged from an average of 17% at the beginning of April to 80% at the end of the mango season in June (Vayssieres et al., 2009). In Ghana, fruit loss due to fruit flies has been estimated nationally to be 65% (Billah, 2007).

Fruit flies of the genera *Ceratitis* and *Bactrocera* have been widely reported as being economically important and infesting tropical fruits in Africa (Billah et al., 2006; Mwatawala et al., 2009). For instance, the key pest of mango across Africa prior to 2003 was reported to be the Marula fly, *Ceratitis cosyra* (Walker) (Ekesi et al., 2006). Lux et al. (1999) reported that the mango fruit was less frequently attacked by the Medfly, *C. capitata* (Wiedemann). In 2003, a new fruit fly species was reported to be spreading rapidly on fruits across Africa (Lux et al., 2003b). The species was later described as *Bactrocera invadens* Drew, Tsuruta and White (Drew et al*.,* 2005). This new pest is polyphagous, attacking mangoes, citrus and other tropical fruits and vegetables.

Effective management of these flies on mango requires a better understanding of the seasonal dynamics of the species present in a locality. This will ensure that control measures are targeted at periods of maximum population build up and/or at the most vulnerable stage of the crop to achieve effective control (Ekesi and Billah, 2009). The present study was conducted to determine the population

*Corresponding author. E-mail: nboyinejerry@yahoo.co uk. Tel: +233249583471/+233206667278.

dynamics of fruit fly species of economic importance associated with mango in the Guinea Savanna Agro-ecological zone of Ghana.

MATERIALS AND METHODS

Study area and climate

The study was carried out from March 2011 to February 2012 at the mango orchard of the CSIR- Savanna Agricultural Research Institute (CSIR-SARI) located at Nyankpala (latitude 9°25'141N, longitude 0°58'142W and an altitude of 183 m above sea level) in the Tolon-Kumbungu District of the Northern Region of Ghana. The study area lies within the Northern Guinea Savanna Agro-ecological zone of Ghana, with a warm climate of mean minimum temperature of 25°C and a maximum temperature of 35°C. It is characterized by an annual rainfall of about 1,022 mm, which falls between April and early November each year, followed by a pronounced dry season from the latter part of November to March (SARI, 2001). The total land area of the orchard surveyed was 3.5 ha. All the trees in the orchard were at the economic fruit bearing age of seven years and above at the time of the survey.

Monitoring of fruit flies

Improvised lynfield traps were used to monitor populations of fruit flies (Billah et al. 2006) in the mango orchard. The traps were locally made from a clear cylindrical recyclable plastic container (5 cm diameter and 10 cm high), with two square holes (2 cm^2 each) on opposite sides of the container. The bottoms of the traps were perforated for easy drainage of water after a rainfall. The traps were hung on the mango trees using nylon thread. Grease was applied to the first one-third proximal part of the thread near the branch to prevent ants from preying on the fruit fly catches.

The attractants used for the monitoring were methyl eugenol (ME) for attracting *Bactrocera* species, and trimedlure (TML) and terpinyl acetate (TA) (AgriScience®, UK) for attracting *Ceratitis* species. The attractants were in the slow-releasing polymeric plug form. Strips of Dimethyl 2, 2-DichloroVinyl Phosphate (DDVP) were used as killing agents in the containers. The lures and the killing agent were changed after every four weeks.

Six traps (2 ME, 2 TA, and 2 TML) were randomly deployed in the field at a distance of 60 m apart to prevent trap interference. The traps were hung at a height of 1.5-4 m above ground depending on the architecture of the tree (Ekesi and Billah 2009). The different traps were placed in an alternating fashion in the semi-shaded area and upwind part of the canopy. The traps were rotated monthly to prevent the location of a trap from interfering with its performance.

Collection and identification of trap catches

The traps were emptied weekly into insect collection vials containing 70% ethanol. The insects collected were sent to the laboratory for identification and counting. Identification was made based on the morphological characteristics of the collected specimen using taxonomic keys developed by the African Fruit Fly Initiative (AFFI) (Ekesi and Billah, 2009). Samples of the identified insects have been deposited at the Entomology Section of CSIR-SARI, Nyankpala-Tamale, Ghana.

Host fruit incubation

Mango fruits were collected and placed on pre-sterilized sand in plastic vessels and covered with muslin cloth to keep-off small flies. The mean room temperature during the incubation period was 25°C, while the relative humidity for the same period was between 75 and 86%. The sand was inspected every three (3) days to remove fruit fly pupae until no pupae were present in the sand. The pupae were placed in plastic bottles (diameter, 8 cm and height 17 cm) lined at the bottom with moist tissue paper for emergence. Emerged flies were released into cages containing fruit fly diet composed of yeast and sugar in the ratio 1:3. Water was also provided in the cages (Ekesi and Billah, 2009). The flies were kept alive for seven days by which time all the morphological characters used for identification were fully developed for easy identification.

Climatic data

Data on rainfall, temperature and relative humidity of the study area were obtained from the local weather station at the CSIR-SARI, Nyankpala.

Data analysis

Data on fly catches were converted into fly abundance (that is, Number of flies per trap per day) (IAEA, 2003) before analysis. One way analysis of variance was performed on the fly abundance using the GENSTAT® Discovery Edition 4 statistical package, and differences between means were separated at the 5% significance level. Multiple linear regression and correlation analyses were used to determine the effect of the three climatic variables of rainfall, temperature and humidity on fly catches.

Table 1. Fruit fly species recovered from incubated fruits.

Month	Weight (g) of mango	Number of fruit fly species Emerged		
		B. invadens	***C. cosyra***	***C. capitata***
March	789	0	70	0
April	688	5	24	0
May	707	27	2	0
June	699	50	0	0
LSD (*P<0.05*)		17.00	12.72	

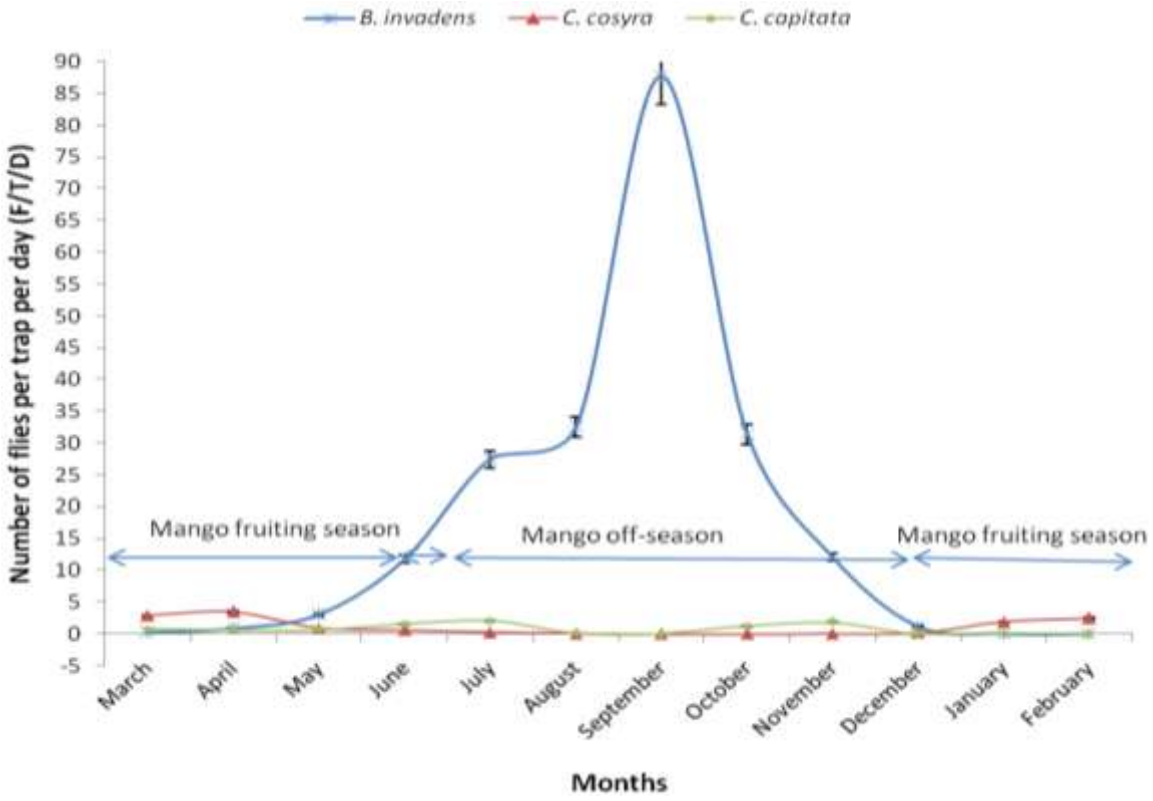

Figure 1. Mean number of fruit flies per trap per day (F/T/D) of three fruit fly species from March 2011 to February 2012.

RESULTS

A total of 6,889 fruit flies were captured in the traps during the study. Of these 90.6% (6,242) were *B. invadens*, 5.5% (381) was *C. cosyra* and 3.9% (267) was *C. capitata.* In addition, 178 fruit flies emerged from incubated mango fruits of which 53.9% were *C. cosyra* and 46.1% were *B. invadens* (Table 1).

Figure 1 shows population dynamics of the different fruit fly species during the study period. The number of flies per trap per day for *C. cosyra* was significantly higher ($P<0.05$) in the main mango fruiting months of January to April than those for *B. invadens* and *C. capitata.* Population of *B. invadens* was significantly higher ($P<0.05$) from the latter part to the off mango fruiting months of May to November than those for *C. cosyra and C. capitata*. The highest number of flies per trap per day for *B. invadens* was recorded in September, while the highest catch for *C. cosyra* was recorded in February and March. The highest trap catch for *C. capitata* was recorded in June, July, and November.

Figure 2 shows the mean number of flies per trap captured for each species during the study period. The trap catches for the three fruit fly species were significantly different ($P<0.05$). The mean number of *B. invadens* captured during the study was significantly higher than those of *C. cosyra* and *C. capitata.* The mean number of *C. cosyra* was significantly higher than that of *C. capitata*.

C. cosyra was the most dominant ($P<0.05$) fruit fly

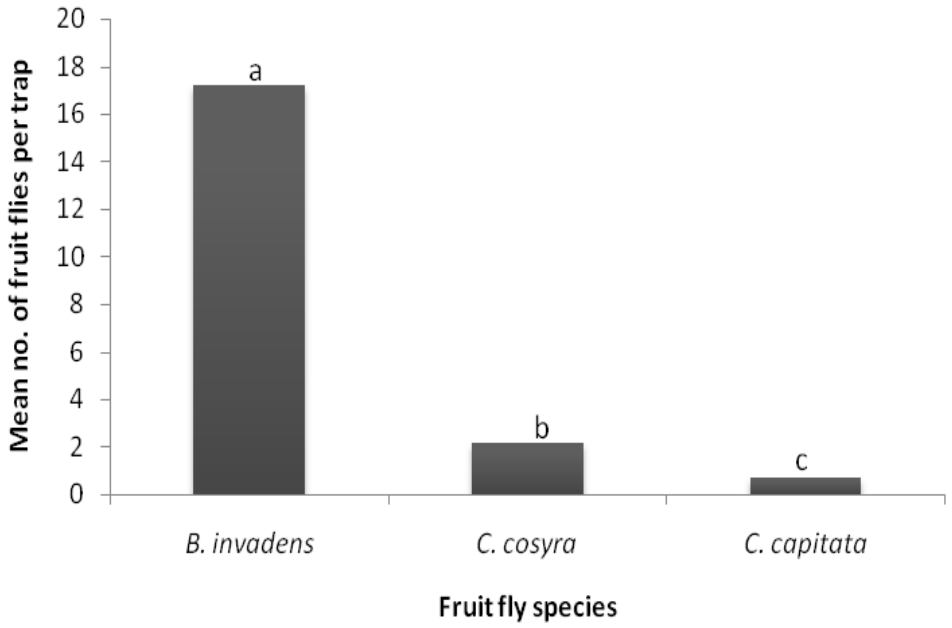

Figure 2. Mean number of each fruit fly species per trap captured from March 2011 to February 2012. Means with different letters are significantly different at P<0.05.

Table 2. Correlations (*r)* between the occurrence of fruit flies and weather parameters

	A	B	C	D	E	F
B. invadens (A)	1					
C. cosyra (B)	-0.552*	1				
C. capitata (C)	-0.475	-0.224	1			
Rainfall (D)	0.384	-0.448	0.149	1		
Relative Humidity (E)	0.768*	-0.635*	0.009	0.821*	1	
Temperature (F)	-0.508*	0.188*	0.227	-0.698	0.770*	1

Figures with asterisks are significant (P< 0.05)

species that emerged from incubated fruits in the peak mango season months of March and April, while *B. invadens* was dominant towards the end of the mango season months of May and June (Table 1). *C. capitata* was not recorded from incubated fruits.

Table 2 shows the partial correlations matrix for the three fruit fly species. The occurrence of *B. invadens* was negatively correlated with that of *C. cosyra.* The occurrence of *B. invadens* was also negatively correlated with temperature but positively correlated with relative humidity. However, populations of *C. cosyra* were positively correlated with temperature but negatively correlated with both relative humidity and rainfall. Populations of *C. capitata* did not show significant correlation with temperature, relative humidity and rainfall.

DISCUSSION

The production of mango in Africa is threatened by three major insect pests, namely, termites (Isoptera: Termitidae), mealybugs (Homoptera: Pseudococcidae), and fruit flies (Diptera: Tephritidae). However, only the latter cause large scale economic damage to the mango fruits (White and Elson-Harris, 1992). For example, fruit losses due to fruit flies of up to 40% have been reported in East Africa (Lux et al. 1999) and between 12 to 65% in West Africa (Billah, 2007; Vayssieres et al., 2005).

Studies on the species range of fruit flies associated with mango in the Guinea Savanna agro-ecology of Ghana showed that *B. invadens, C. cosyra,* and *C. capitata* were the most important fruit fly species (Nboyine et al., 2012). The results from the present study showed that *C. cosyra* was the dominant species during

the first four months of the year, that is, from January to April. It was also the dominant fruit fly species that emerged from incubated mango fruits. The dominance of this fruit fly species coincided with the fruiting of both early and late maturing mango varieties. This could be due to the absence of fruits on the alternative host plants (shea fruits, egg plant, pepper etc) during the period (Mwatawala et al., 2009). In addition, the months of January to April are the dry periods in the Guinea Savanna Agro-ecology, which is conducive for the population growth of *C. cosyra* (Veyssierres et al., 2005). *C. cosyra* therefore causes enormous damage to mango fruits and can result in complete fruit loss if appropriate control measures are not taken (Billah, 2007; Lux et al., 2003b).

B. invadens recorded low fly numbers during the dry periods of December to April. However, its numbers increased during the wet periods of May to November, with a population peak in September. It was also the major fruit fly species that emerged from incubated fruits for the months of May and June. The high trap catches of *B. invadens* during the wet season is corroborated by Vayssierres et al. (2005, 2009). They observed an increase in trap catches for this pest shortly after the on-set of the rain season. The period (May to June) during which this pest begins recording higher abundance in the Guinea Savanna zone coincided with the maturity and harvesting of late maturing mango varieties. During this period, farmers complete harvesting of early maturing mango varieties hence, this pest is important for late maturing mango cultivars such as Keitt and Kent but of less importance to early maturing varieties, such as Haden, Amelie Jaffna, and Irwin.

Lux et al. (1999) stated that mangoes are attacked less by *C. capitata.* This was demonstrated in the present study by the low periodic catches of this fruit fly species in traps and its absence in incubated fruits. The fly probably uses the mango fruit less as a resource for its development and was attracted to the mango orchard by the lures. Its presence during both dry and wet season corroborates report by White and Elson-Harris (1992) that it is indigenous to the African continent.

Populations of *B. invadens* and *C. cosyra* were negatively correlated, which corroborates the findings of Ekesi et al. (2009) that *B. invadens* was competitively superior to *C. cosyra*. The presence of *B. invadens* in the orchard resulted in the lowering of the population of *C. cosyra* over time. However, the two fruit fly species had their peak abundance at different times of the year. Thus, protection measures against fruit flies in orchards must be specific to the dominant species present.

In summary the results from this study showed that *C. cosyra* was the dominant fruit fly species in the mango ecosystems in the Guinea Savanna agro-ecology during the dry season. This period coincides with the main mango fruiting season. Hence, control measures must be targeted at this pest during this period to forestall damage to the fruits. *B. invadens* was dominant during the wet season by which time all early maturing mangoes were harvested. Hence, this pest only inflicts damage on the late maturing mango cultivars. Farmers who cultivate late maturing cultivars must therefore adopt management strategies that are targeted at both *C. cosyra* and *B. invadens.*

ACKNOWLEDGEMENTS

We are grateful to the field staff of CSIR-SARI especially Mr. Issifu Ramat, Kwabena Yaw James and Fredrick Anaman for their assistance in data collection.

REFERENCES

Billah MK (2007). ECOWAS fruit fly scoping study and regional action programme. Evaluation of the fruit fly problem in Ghana. A report on Ghana. 47pp.

Billah MK, Wilson DD, Cobblah MA, Lux SA, Tumfo JA (2006). Detection and preliminary survey of the invasive fruit fly, *Bactrocera invadens* (Diptera: Tephritidae) in Ghana. J. Gh. Sci. Assoc. 2(8): 38-144.

Drew RAI, Tsuruta K, White IM (2005). A new species of pest fruit fly (Diptera: Tephritidae: Dacinae) from Sri Lanka and Africa. Afr. Entomol. 13(1): 149-154.

Ekesi S, Billah MK (Eds.) (2009). A Field Guide to the Management of Economically Important Tephritid Fruit Flies in Africa. 2nd Edition. ISBN: 92-9064-179-7.Pp. 3 - 45

Ekesi S, Billah MK, Nderitu PW, Lux SA, Rwomushana I (2009). Evidence for competitive displacement of *Ceratitis cosyra* by the invasive fruit fly *Bactrocera invadens* (Diptera: Tephritidae) on mango and mechanisms contributing to the displacement. J. Econ. Entomol. 102(3): 981-991.

Ekesi S, Nderitu PW, Rwomushana I (2006). Field infestation, life history and demographic parameters of *Bactrocera invadens* Drew, Tsuruta & White, a new invasive fruit species in Africa. Bull. Entomol. Res 96: 379-386.

International Atomic Energy Agency, IAEA (2003). Thermatic plan for fruit fly control using the sterile insect technique. IAEA Publication, Vienna, Austria, TP-NA-D4-02.

Lux SA, Copeland RS, White IM, Manrakhan A, Billah MK (2003b). A new invasive fruit fly species from the *Bactrocera dorsalis* (Hendel) group detected in East Africa. Insect Sci. Applic. 23(4): 355-361.

Lux SA, Ekesi S, Dimbi S, Mohamed S, Billah MK (2003a). Mango infesting fruit flies in Africa-perspectives and limitation of biological approaches to their management, pp 277-293.

Lux SA, Zenz N, Kimani S (1999). The African fruitfly Initiative: Development, testing and disseminations of

technologies for control of fruit flies. ICIPE Ann. Sci. Rep. 1998-1999, 7: 78-80.
Mwatawala MW, De Meyer M, Makundi RH, Maerere AP (2009). Host range and distribution of fruit infesting pestiferous fruit flies (Diptera: Tephritidae) in selected areas of Central Tanzania. Bull. Entomol. Res., 10: 1-13.
Nboyine JA, Billah MK, Afreh-Nuamah K (2012). Species range of fruit flies associated with mango from three agro-ecological zones in Ghana. J. Applic. Biosci., 52: 3696-3703.
Savanna Agricultural Research Institute, SARI (2001). Agro-meteorological survey. Savanna Agricultural Research Institute, Nyankpala, Tamale, Ghana, SARI Report. 34-36pp.
Vayssieres JF, Goergen G, Lokossou O, Dossa P, Akponon C (2005). A new *Bactrocera* species in Benin among mango fruit fly (Diptera: Tephritidae) species. Fruits 60: 1-9.
Vayssieres JF, Sinzogan A, Korie S, Ouagoussoun I, Odjo A (2009). Effectiveness of spinosad bait sprays (GF-120) in controlling mango infesting fruit flies (Diptera: Tephritidae) in Benin. J. Econ. Entomol. 102(2): 515-521
White IM, Elson-Harris M (1992). Fruit flies of economic significance: Their identification and bionomics. International Institute of Entomology, London. p. 601.