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Diversity of Fruit Flies and Mealybugs in the Upper West Region of Ghana

Kwasi Wih[1]* and Maxwell Kelvin Billah[2]

[1] Ministry of Food & Agriculture, P.O. Box 21, Wa, Upper West Region, Ghana
[2] Department of Animal Biology & Conservation Science, Faculty of Science, University of Ghana, Legon

Mango (*Mangifera indica* L.), a member of the family Anarcardiaceae, is one of the most common fruits in Ghana and could easily be cultivated in the northern part of the country. Mango production, however, has been threatened by insect and disease problems since commercial-scale production started in the Upper West Region. Asian fruit flies of the genus *Bactrocera* are destructive pests of fruits and vegetables worldwide, but little information has been obtained on their prevalence and diversity in the region since the first formal detection of *Bactrocera invadens* in 2005. Systematic trapping and host-fruit surveys conducted in 2007 confirmed the presence *B. invadens* in the region. We examined the diversity of fruit flies and mealybugs that have been observed to be major threats to mango and other crops in the Upper West Region. Nine fruit fly species (*B. invadens*, *Ceratitis ditissima*, *Ceratitis anonae*, *Ceratitis bremii*, *Ceratitis cosyra*, *Ceratitis capitata*, *Ceratitis rosa*, *Dacus bivittatus* and *Dacus vertebratus* and four mealybug species (*Pseudococcus longispinus*, *Paracoccus marginatus*, *Rastrococcus invadens* and *Icerya* sp.) were identified during the survey. While mango was dominated by *R. invadens*, the ornamental plants were mostly affected by *Icerya* sp., papaw by *P. marginatus*, and *Jatropha* species infested by *P. longispinus*. The mealybug species were fairly common in the region. In certain cases, other pest species such as aphids and whiteflies were found in close association (in complex mixtures) with the mealybugs.

Key words: Fruit fly, mealybug, mango, diversity, Upper West Region, Ghana

Introduction

Mango (*Mangifera indica* L.), a member of the family Anarcardiaceae, is one of the world's most important tropical fruits. Mango is also one of the most common fruits in Ghana and could easily be cultivated in the northern part of the country. Mango production, however, has been threatened by insect and disease problems. Fruit flies and mealybugs are the two most serious insect pests of mango in the Upper West Region. There are more than 4000 species of fruit fly worldwide, with a number of them recorded in Ghana as pests of economic importance (Billah *et al*., 2009). The situation was further exacerbated with the detection of the Invader fly, *Bactrocera invadens* in Africa in 2003 and Ghana in 2005 (Lux *et al*. 2003; Drew *et al*., 2005; Billah *et al*., 2006). It attacks a wide range of fruits and vegetables, and has been described by the African Union as a "devastating quarantine pest" (French, 2005).

Mealybugs are also known to be polyphagous insects which have been recorded to feed on numerous plant species, and there are many species (Green, 1908). In Ghana, mealybugs attack many plants including tubers and roots, vegetables, fruit and tree crops, ornamentals and weeds. They can be found on the leaves, stem, fruits and shoot of plants. The adults and nymphs suck sap from the phloem tissues of plants causing yellowing of the plant part and eventually leading to yield losses or death of the plant. The occurrences of these pests and the periods when they are destructive are still not well known to many mango farmers in the region, despite the economic losses in the mango industry.

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* Corresponding author: Ministry of Food & Agriculture, P.O. Box 21, Wa, Upper West Region, Ghana.
Tel: +233208294487, E-mail: kwasiwih@yahoo.com

In the latter part of 2009, some unidentified mealybug samples from Ghana were sent to the International Institute of Tropical Agriculture (IITA) in Benin, and were identified as the invasive Papaya mealybug, *Paracoccus marginatus* Williams and Granara de Willink (Homoptera: Pseudococcidae), adding to the list of mealybugs in the country. To develop control strategies for these pests requires that some knowledge of the range of species present in an area is acquired. This study was therefore aimed at establishing the species diversity of the two insect pests in the Upper-West Region of Ghana.

Materials and Methods

Two types of field survey were carried out — trapping survey in three mango orchards for fruit flies and open field collection of mealybugs from infested plants.

Fruit fly collection

Three mango orchards were selected from Kaleo (Nadowli District), Jang (Nadowli District) and Loho (Wa Municipality). Plots were selected based on production levels, fruiting trees and with known varieties (Kent and Keitt). Plot sizes ranged from 2−5 hectares, with 200−400 trees and were 15−45 km apart.

Traps and attractants

Three attractants were used; Methyl eugenol (ME), which mostly attracts *Bactrocera* species; Terpinyl acetate (TA) and Trimedlure (TML), both of which attract different subgenera of *Ceratitis* species. Lures were in the solid slow-releasing polymeric plug forms (Fig. 1A) which were placed in the holding chamber of Tephri-traps (SORYGAR® S.L., Madrid, Spain)(Fig. 1B). Dimethyl 2, 2-diclorovinyl phosphate (DDVP) strips (2.5 cm) were placed at the bottom of the traps to serve as killing agents. Six traps (2 of each attractant ie 2 ME＋2 TA＋2 TML) were deployed per orchard by hanging them on trees at heights 2−4 m above ground, and at distances 40−50 m apart to minimize interference with each other. Traps were laid in an alternating fashion to prevent the same attractant types being placed together or allowing one set of attractants to be restricted to a particular section of the orchard. Traps were emptied of their fly catches once a week and their positions changed (i.e. trap 1 moves to position of trap 2 and trap 2 moves to position of trap 3 etc) for each trap to have the chance of being placed in all the positions in the orchard. Collected flies were preserved in 70% ethanol and taken to the laboratory for counting and identification. After each 4-week exposure period, the traps were serviced by cleaning and replacing both the attractants and the killing agent. This was done during the 15-week fruiting season.

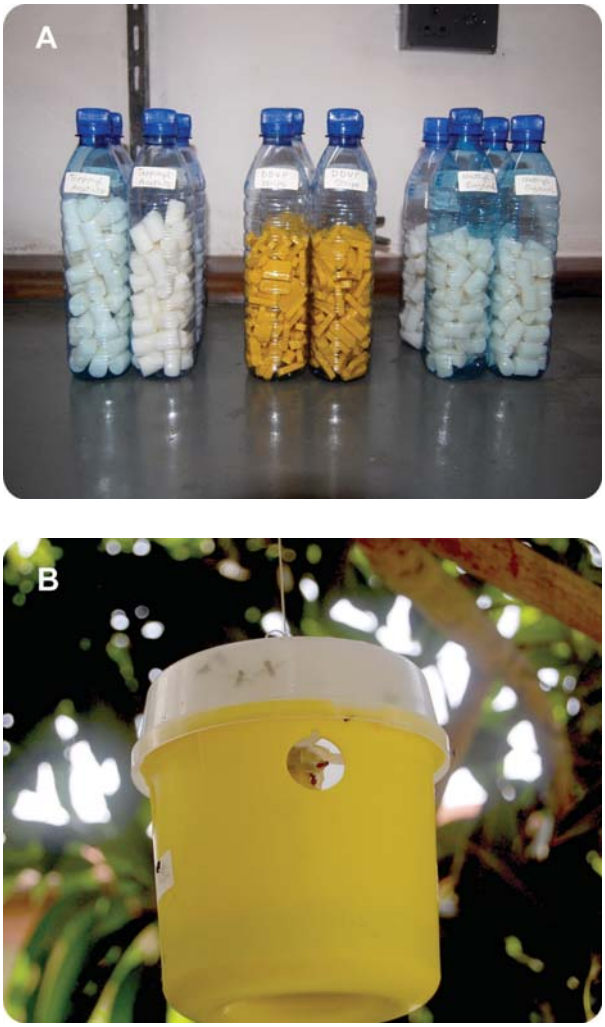

Fig. 1. Field materials used. A＝Different attractant types packaged in mineral water bottles for easy transportation and handling, i.e. one plug at a time. B＝Tephri-Trap.

Mealybug collection

Based on information provided by the Plant Protection and Regulatory services Directorate (PPRSD) of the Ministry of Food and Agriculture (MoFA) of Ghana on outbreak districts and spots in the Upper-West Region, mealybug species were collected from host plants with the aid of soft featherweight forceps and camel-hair brushes into screw-cap vials containing

70% ethanol between January and March 2011. Identifiable parts (twigs, leaves, flowers, and fruits) of host plants that could not be identified in the field were collected, labeled, and placed in improvised plant presses for identification.

For further observation of live material, plant parts with insects were collected and placed in large brown grocery bags. The bags were stapled at the top and stood in large open containers to prevent both the plant parts and the live mealybugs on them from being crushed. During very hot times of the day, water was sprinkled on the tops of the bags to cool the samples, and photographs taken for reference. Severity of infestation in the field was ranked from 1 to 4 using the following categorization: plants with less than 20% surface coverage by the insects, insect activity was classed as low (rank 1). Coverage of 20% and 40% were indicated moderate activity (rank 2). Coverage of 40% to 60% indicated high activity (rank 3). Those above 60% indicated very high or severe activity (rank 4).

Sample Identification

Identification of fruit flies was done using a Leica EZ4 D microscope and taxonomic keys by White and Elson-Harris (1992) and Billah *et al*. (2009). Mealybug species and their unidentified host plants were sent to the Entomology Museum of the Department of Animal Biology and Conservation Science and the Herbarium of the Department of Botany (both of the University of Ghana), respectively for identification. Voucher specimens of identified species are deposited at the two Departments.

Data analysis

The number of fruit flies captured was expressed in the standard relative fly density index (IAEA, 2003), which allows comparison across different localities, over different exposure periods, and irrespective of the number of traps used. Number of flies captured was log-transformed [log (x+1)], subjected to analysis of variance (Epsky *et al*., 1999), using PROC GLM and means separated by Student-Newman-Keuls (SNK) test at $P=0.05$. Non-target catches were recorded to access the effect of the attractants on beneficial organisms such as insect pollinators, parasitoids, predators and on diversity of insects in the orchards.

Results

Fruit flies

A total collection of 17,561 organisms was made from the traps. Out of which fruit flies formed 99.2% (17,416) and 0.8% (145) as non fruit flies (Table 1). Nine species of fruit flies (belonging to three genera) were identified, including *Bactrocera invadens* (Africa Invader fly), *Bactrocera cucurbitae* (Melon fly), *C. ditissima* (West African citrus fly), *Ceratitis cosyra* (Mango fruit fly), *Ceratitis anonae*, *Ceratitis capitata* (Mediterranean fruit fly) *Ceratitis rosa* (Natal fruit fly), *Dacus bivittatus* (Pumpkin fly) and *Dacus vertebratus* (Jointed pumpkin fly).

Table 1. Fruit flies collected during the trials.

Locality	Attractant	No. Flies	No. Traps	Exposure period	F/T/D	%
Jang	ME	1754	2	105	8.35	99.04
	TA	12	2	105	0.06	0.68
	TML	5	2	105	0.02	0.28
Kaleo	ME	9055*	2	105	43.12	99.43
	TA	30	2	105	0.14	0.33
	TML	22	2	105	0.1	0.24
Loho	ME	6495	2	105	30.93	99.34
	TA	32	2	105	0.15	0.45
	TML	11	2	105	0.05	0.18

Note: F, Flies collected; T, Number of traps; D, Days of trap exposure; ME, Methyl eugenol; TA, Terpinyl acetate; TML, Trimedlure.

Relative Fly Densities

To compare the relative densities of flies, trap catches were expressed as number of flies collected (F) divided by the number of traps (T) and further divided by the exposure period of traps (in Days) (IAEA, 2003).

In all three orchards, traps baited with Methyl eugenol had the highest number of flies (over 99% in each case) compared with those from the TA and TML traps (Fig. 2). The bulk of flies from the ME traps were mostly *Bactrocera invadens*, with the exception of a few species of *C. ditissima*, *Bactrocera cucurbitae*, and the 2 *Dacus* species (*D. bivittatus* and *D. vertebratus*). While *Ceratitis ditissima* is one of the few other species that are known to be attracted to ME, *B. cucurbitae*, *D. bivittatus* and *D. vertebratus* are not (White and Elson-Harris, 1992). These last three species are known to be major pests of the family Cucurbitaceae, attacking melons, squashes, cucumbers and pumpkins. Only 2 specimens of *B. cucurbitae* and single specimens of *D. bivittatus* and *D. vertebratus* were collected in the survey from Kaleo. These catches are not too surprising because there are a number of irrigation vegetable fields near the mango orchard where the trapping was done, and the flies are most likely to have found their way into the traps from those fields.

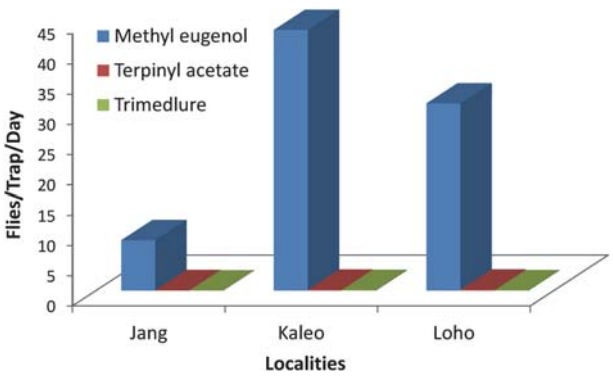

Fig. 2. Relative fly density levels at different localities.

This is even more important in the light of the recent detection of a new invasive fruit fly species, *Bactrocera invadens* in Africa (Lux *et al*., 2003; Mwatawala *et al*., 2004; Drew *et al*., 2005), which has prompted the use of methyl eugenol as the bait of choice in detection and delimitation surveys of the pest across tropical Africa. Ghana is no exception to this rapid invasion of *B. invadens* (Billah *et al*., 2006). A total of 99.2% target catches means attractants are specific and have very little negative impact on non-targets, especially beneficial ones like pollinators and parasitoids. Total number of flies collected from Jang was significantly different from those from Kaleo and Loho (but statistically not different between those from Kaleo and Loho).

Even though there were significant differences in catches of individual traps from various fields, mean trap catches from Kaleo and Loho did not differ significantly but those two differed significantly from the mean numbers from Jang ($F=4.81$; $P=0.0001$).

Non-target captures

One hundred and forty-five (145) non-target organisms in four orders (Araneae, Blattaria, Diptera, and Hymenoptera) were captured, with 75.2% (109) coming from Methyl eugenol traps (Table 2). This was followed by a 17.2% (25) contribution from Terpinyl acetate traps and the Trimedlure traps contributing 7.6 % (11). The non-targets formed only 0.8% of the total number of organisms (17, 416+145) collected and

Table 2. Non-target catches and their percentage contributions (%).

Attractant	Non-target species				
	Araneae	Blattaria	Diptera	Hymenoptera	Total
Methyl eugenol	4	5	69	31	109 (75.2)
Terpinyl acetate	3	0	13	9	25 (17.2)
Trimedlure	1	0	7	3	11 (7.6)
Total	8 (5.5)	5 (3.4)	89 (61.4)	43 (29.7)	145

Table 3. List of plants infested with mealybugs.

Plant species	English or Common name	Family
Abelmoschus esculentus	Okra	Malvaceae
Acalypha hispida	Cat's tail or Chenille plant	Euphorbiaceae
Adansonia digitata	Baobab or Dead rat tree	Malvaceae
Amaranthus dubius	Chinese spinach	Amaranthaceae
Amaranthus spinosus	Spiny or Thorny amaranth	Amaranthaceae
Anarcardium occidentale	Cashew tree	Anarcardiaceae
Azadirachta indica	Neem tree	Meliaceae
Boerhavia diffusa	Hogweed	Nyctaginaceae
Bougainvillea glabra	Paper flower	Nyctaginaceae
Canjamus canjan	Pigeon pea	Fabaceae
Capsicum annuum	Pepper	Solanaceae
Carica papaya	Pawpaw	Caricaceae
Citrus limon	Lemon	Rutaceae
Citrus sinensis	Sweet orange	Rutaceae
Cochoris olitorious	Tossa or Nalta jute	Malvaceae
Codiaeum variegatum	Variegated croton	Euphorbiaceae
Commelina erecta	Whitemouth dayflower	Commelinaceae.
Euphorbia hirta	Asthma weed	Euphorbiaceae
Euphorbia milii	Crown of Thorns	Euphorbiaceae
Gossypium hirsutum	Cotton	Malvaceae
Ipomea batatas	Sweet potato	Convolvulaceae
Jatropha curcus	Barbados nut	Euphorbiaceae
Jatropha gossypiifolia	Bellyache Bush	Euphorbiaceae
Jatropha multifida	Coral Bush	Euphorbiaceae
Jatropha integerrima	Spicy Jatropha	Euphorbiaceae
Lycopersicon esculentum	Tomatoes	Solanaceae
Mangifera indica	Mango	Anarcardiaceae
Moringa oleifera	The Miracle tree	Moringaceaea
Ocimum gratissimum	African Basil	Lamiaceae
Ocimum basilicum	Sweet Basil	Lamiaceae
Persea americana	Avocado pear	Lauraceae
Plumeria acutifolia	Forget me not or Frangipani	Apocynaceae
Psidium guajava	Guava	Myrtaceae
Sida acuta	Wire weed	Malvaceae
Solanum melongena	Brinjil	Solanaceae
Strelitzia reginae	Crane flower or Bird of paradise	Strelitziaceae
Terminalia catappa	Tropical almond	Anarcardiaceae
Terminalia mantaly	Madagascar almond	Anarcardiaceae
Vernonia amydalina	Bitter leaf	Asteraceae

targeted flies 99.2% (17,416). Diptera (flies) had the highest contribution, followed by Hymenoptera (ants, bees and wasps), Araneae (spiders) and Blataria (Cockroaches) (Table 2).

The high number of Diptera collected were mostly drosophilids, phorids, sphaerocerids and carrion-related ones (i.e. families that are known to be associated with rotting, decaying and/or fermenting organic matter). They are very tiny in size and were attracted in large numbers to the dead and decaying fruit flies in the traps. No beneficial organisms such as honey bees or fruit fly parasitoids were captured. All the Hymenoptera collected were foraging ants. A few predatory spiders, preying on arriving flies or spinning their web around the trap entrances, were knocked down by the killing agent (DDVP) in the traps (especially when traps were left for long periods (3−7 days). The Blattaria were all tree cockroaches which usually feed on trapped flies.

Mealybugs

Four (4) mealybug species (in four genera) were identified in the region. These included *Paracoccus marginatus* (Papaya mealybug), *Pseudococcus longispinus* (Long-tailed mealybug), *Rastrococcus invadens* (Mango mealybug) and *Icerya* sp. (Ground pearls or Cottony cushion scale). Over 200 plants, including forest trees, vegetables, shade trees, fruit trees, ornamental plants, weeds and shrubs were examined. Out of which 39 plants from 19 families were infested with mealybugs (Table 3). The highest number of plant species infested was from the family Euphorbiaceae (8). This was followed by Malvaceae (5), Anarcardiaceae (4), Solanaceae (3), Amaranthaceae, Lamiaceae, Nyctaginaceae and Rutaceae (2 each) and the 11 remaining families contributing a species each.

Severe infestation of mango and ornamental plants were by *R. invadens* and *P. marginatus*, respectively. Moreover, some crops were affected by several species of the suborder Homoptera other than mealybugs; at times these other species were found co-existing on the same plant parts, forming complexes of different species of mealybugs, aphids, and white flies that made the level of infestation and degree of damage severe.

Conclusion and Recommendations

The presence of 4 species of mealybug and 9 species of fruit fly in the region demonstrated the biodiversity of the insects in the Upper West Region. Control of the rapid invasion of new pests such as *B. invadens* is extremely important for obtaining early control of threats to mango.

Due to the widespread occurrence of these mealybugs, there is the need to research on their biology (especially *P. marginatus*), host interactions (semiochemicals), insecticide resistance status and extent of damage on commercially-important host plants. Since *P. marginatus* is a new invasive species in the country, it presently has no associated natural enemies in its new environment, and was therefore not surprising that it was the most common species wherever it was available. A quick move to bring the numbers down to appreciable managing levels would be the introduction of natural enemies like parasitoids into the country. A wider range of attractants are therefore needed to assess the true diversity of fruit flies in the country. There is also a need to intensify surveys to ensure early detection of any advent populations of fruit flies, which can then be eradicated before they become well established.

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