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Species Composition of Fruit Flies (Tephritidae: Diptera) and Extent of Infestations on Mango (Mangifera indica L.) in Western Ethiopia

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Abstract
The family Tephritidae is comprised of different genera and species of fruit flies, with a varied composition causing yield losses in different parts of the world. This study was conducted with the objective of determine the species composition of fruit flies and extent of infestation on mangoes by fruit fly in western Ethiopia. Fruit flies were collected using two methods; parapheromones and rearing of the adult flies from infested mango fruits in western Ethiopia at different sites of the mango farm. A total of 1348 with nine fruit fly species were trapped by the paraphermones, namely Bactrocera invadens, Bactrocera cucurbitae, Dacus telfaireae, Dacus masaicus, Ceratitis fasciventris, Ceratitis (Ceratalaspis) sp, Ceratitis cosyra, Ceratitis fasciventris, and Dacus bivittatus. The relative abundance of flies /trap/day ranged from 0.1-24.91flies per trap per day However, only three fruit fly species, Bactrocera invadens, Ceratitis fasciventris and Ceratitis cosyra, were reared from infested mango fruits in descending order of dominance, respectively. There were variations among the area in terms of mango fruit infestation levels 16.667%-55.556% in western Ethiopia in 2010. Farmers have not recognized the fruit flies as a problem and did not associate the fruit rotting to this pest. As a result they do not practice any management practice against fruit flies. It is recommended that the farmers should get training so that they recognize and understand fruit flies, and introduce to basic management of fruit flies and integration of sanitation and prompt harvesting, use of baits in order to produce and supply quality fruits for both local and export markets. The need for further investigation on species composition of fruit flies (Diptera: Tephritidae) attacking mangoes and other fruits, population studies of fruit fly species, evaluations of different monitoring and management techniques, and detailed studies yield loss are recommended.
Keywords: fruit fly species, bait, Tephritidae, parapheromones

INTRODUCTION

Fruit flies are insects belonging to a family with a broad-based distribution limited by host availability and divided into two groups (univoltine and multivoltine) defined by the physiological and ecological characteristics (Steck and McPheron, 1996). The family Tephritidae includes more than 5000 species worldwide, approximately 1400 species of which develop in fleshy fruits (Norrbom *et al*., 1999). Nearly 250 of these species are capable of achieving pest status by feeding on plants of economic importance and causing severe damage (White and Elson-Harris, 1992; Thompson, 1999).

Fruit flies can be controlled by main strategic options: eradication-eliminates from an area an established pest or an outbreak of an introduced pest, suppression-reduces pest populations, and prevention-applies phytosanitary and regulatory measures to prevent the introduction or reintroduction of a pest into a pest free area (FAO, 2002). If the information of population dynamics and the related ecological factors are not jointly gathered, impossible to control at the right time and place (Jiang *et al*., 2008).

Many fruit fly species (Diptera: Tephritidae) are commonly found in Africa, where they attack 50 to 300 species of the cultivated and wild fruit species of mango (White and Elson-Harris, 1992). Among the major insect pests of mango, the family Tephritidae has economic importance. A total of 48 species of fruit flies attacking mango and a related species of fruit flies have been reported although they are found in almost all mango growing areas of the world (Singh, 1991). They attack ripe mangoes and inflict damage to the fruit either directly (larvae feeding on pulp) or by causing blemished fruit, which limits marketing possibilities especially export of fruit (Aluja 1994). Of the 1.9 million tone of mangoes produced in Africa annually, about 40% is lost due to fruit flies where infestation rates vary among countries and seasons, ranging from 5% to 100% (Lux,

1999).

Bactrocera invadens was first found in Kenya in 2003 (Lux *et al*., 2003) and believed to have invaded Africa from the Indian sub continent and was discovered in Sri lanka after it was first reported from Africa, where it has become the significant pest of quarantine and economic importance (Mwatawala *et al*., 2004). Although, initially thought to be a variant form of *Bactrocera dorsalis*, was recognized as a distinct species (Drew *et al*., 2005). The insect has spread along tropical Africa and in addition to Kenya, it is now reported from Benin, Democratic Republic of Congo, Ghana, Uganda , Mali, Nigeria, Sudan, Tunisia, Togo, Guinea, and Equatorial guinea and Comoros Island (Drew et al., 2005). Also Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann), is currently the most important pests from an invasive species perspective and host range includes 350 species of fruits and vegetables (Liquido, 1991b).

The production of mango is mainly by small-holder producers produce up to 80% in Africa and a large part of the production is for local consumption (Lux, 1999). Increased production and marketing of undamaged mangoes are important in reducing poverty, however, because of fruit fly as a quarantine pest, phytosanitary bans on exports resulting in a huge loss of economic opportunity in terms of income for the populations involved(Vayssieres et al., 2008). The percent ripening of mango fruit can influence the extent of damage by post harvest diseases and insect pests (Litz, 1997). Therefore this study was conducted with the objectives: determine the species composition of fruit flies and extent of infestation on mangoes in western Ethiopia.

MATERIALS AND METHODS

Study area

The study was conducted in four mango growing areas of western Ethiopia (Bako, Arjo Gudattu, Dedessa and Asossa districts). Bako is located at latitude $9^0$07'N and longitude $37^0$05'E and 260km from Addis Ababa and with average altitude 1714 m. It gets about 1239mm annual rain fall with unimodial distribution. It has a warm humid climate with mean minimum, mean maximum and average air temperature of 13.20^0c, 28^0c and 21^0c, respectively (metrological data weather condition of Bako woreda in 2008). Assosa is located in western Ethiopia of Benishangul-Gumuz Region. This town is located at latitude 10°04′ 34°31′E to 10.067°N and longitude 34.517°E with an elevation of 1570 m. The climate is characterized by a long rainy season (June-September, 75% total rainfall), a short rainy season (February/March to April/May) and a dry season (October-January). The district was received an average rainfall of 950-1000 mm annually. The average annual temperature was reached from 20-25^0C. During the hottest months (January - May) it reaches a 28 - 34^0C (metrological data of Assosa woreda in 2008).

Collection of mango fruits and fruit fly rearing

In each four area mango fruits were collected from three farmers association and 5kg ripe mango fruits were randomly sampled from each farm. The fruits from each farm were separately kept in plastic buckets, which have a bottom sand layer for pupation of the flies. The fruits were left in the bucket for 30 days. The sand layer was kept moist by adding small amount of water periodically. The buckets were covered by cloth to allow air circulation but keep the emerging flies inside the bucket. The sample containers were checked every 3-4 days for Puparia and adult flies' emergence. Puparia was sieved from sand and kept in transparent Petri dish for adult emergence. The flies were removed from the bucket and preserved in vials containing ethanol 97% for further identification.

Traps setting (attractants/lures)

Baited Traps with five different attractants (methyl eugenol, trimedlure, cue lure, 3-ways lures, and Terpinyl Acetate) were used to attract the fruit flies. The lures in a modified plastic water bottle trap were hanged in farmer's orchards within a minimum distance of 50m far apart depending on the size of mango orchards. The water bottle traps of one-liter capacity with four round entry holes having a diameter of 2.5cm punched at equidistant places at 2/3level of the bottle were used to collect the flies. Dimethyl 2, 2-DichloroVinyl Phosphate (DDVP) was placed at the bottom of the trap as a killing agent to kill attracted insects that enter the trap. The collected fruit flies were sorted and sent for further identification to the United State Department of Agriculture-Animal and Plant Health Inspection Service (USDA-APHIS) in Pretoria, South Africa.

Assessment of mango fruit infestation

In each area, three farms were selected and from each farm 10kg of ripe mango fruits were sampled and sorted in to "Infested" and "Non Infested" categories by examining the ovipunctures of fruit flies. The clean looking mango fruits were kept in fruit containers for a week and then dissected to check for the presence of fruit fly larvae. The proportions of damaged fruits were added in to "Infested" category to calculate the level of infestations as follows:

$$\text{Percent infestation} = \frac{Number\ of\ infested\ fruits}{Total\ number\ of\ fruit\ sampled} * 100$$

Data analysis

Mainly descriptive statistics (mean, percentage, range, standard error) were used to summarize and analyze the

data. Mean and proportions of fruit fly species composition trapped were calculated for each area, and data on infestation levels of mango fruits by fruit flies in different area were subjected to analysis of variance as a Completely Randomized Design using SAS software. Means were separated using Least significance Difference (LSD) at P<0.05. For relative fly abundance, counts were expressed as number of flies per trap per day (F/T/D)

$A = (\sum W \div N)$

Where, A=Abundance, ∑w = Sum of individual of a particular fruit flies species across all samples, N= total number of samples.

The dominance: - of fruit flies species was determined using the formula

$$D = A * 100/\left(\sum W\right)$$

Where,

D= Dominance of particular species

A= Abundance of the same species

∑w= total abundance of an individual fly species in relation to total flies abundance

RESULTS

Fruit fly Species Assessment

A total of 1348 number of adult fruit flies and nine different species were trapped by different attractants. In terms of abundance (flies per trap per day), *Bactrocera* invadens was the dominant species, followed by *Dacus bivittatus* but also low number of Ceratitis (*Ceratalaspis* sp). The relative abundance of flies ranged from 0.1-24.91flies per trap per day (Table 2).

By default, non target insects from different families were also collected including in Bako district (Platystomatidae and Calliphoridae were collected with 3-Components of lure, Dolichopodidae by Trimedlure, and Nariidae by Methyl eugenol), in Arjo Gudattu district (miscellanous Diptera, Nariidae and Calliphoridae were trapped by 3-Components of lure, Calliphoridae and Nariidae by Cue lure, Nariidae by Methyl eugenol), in Asossa district (Calliphoridae and Nariidae by 3-Components of lure, and Nariidae) and in Didessa district (Diopsidae and miscellanous Diptera by 3-Components of lure, and one Calliphoridae by Cuelure) were collected.

Table 2. Proportion (%) of fruit fly (Diptera: Tephritidae) species trapped by Para pheromones (with standard error) on mango orchard in western Ethiopia, 2010

Fruit fly species	Mean number of Tephritidae fruit flies/trap/day by different Parapheromones						Proportion and Abundance of Fruit flies	
	ME	CUE	TML	3C	TA	Total	%	Abundance
Bactrocera invadens	298.0	0	0.6	0	0.3	299.0	66.5	24.91
Dacus bivittatus	7.3	78.7	5.0	1.7	0.7	93.3	20.8	7.8
Ceratitis fasciventris	0	0	8.0	4.7	19.3	32.0	7.1	2.7
Dacus telfaireae	0	16.0	0	1.3	0.3	17.7	3.9	1.5
Bactrocera cucurbitae	0	3.0	0	0	0	3.0	0.7	0.3
Dacus masaicus	0	1.3	0	0	0	1.3	0.3	0.1
Ceratitis cosyra	0	0	0	0	1.3	1.3	0.3	0.1
Ceratitis(Ceratalaspis) sp.	1	0	0	0	0	1.0	0.2	0.1
Dacus vertebratus	0	0	0.3	0	0.3	0.7	0.2	0.1

CUE=Cuelure, ME = Methyl eugenol , TA = Terpinyl Acetate, TML = Trimedlure , 3C = 3-components lure

In Asossa area six fruit fly species and 81.68 total flies were identified. Bactrocera invadens was collected in higher number followed by Dacus telfaireae, Dacus bivittatus and Bactrocera curcubitae. Dacus bivittatus and Dacus telfaireae were collected in low numbers with 3C. Similarly, TA attracted few Bactrocera invadens Dacus vertebrates and Ceratitis cosyra. Methyl eugenol was more effective in attracting Bactrocera species than other attractants**.** Bactrocera cucurbitae, Dacus telfaireae, Dacus vertebratus and Ceratitis cosyra are new recorded species for the area and the country (Table 3).

Seven species and 51.19flies/trap/day of fruit flies were caught in Didessa area. Bactrocera invadens was the most frequent fruit fly collected followed by Dacus bivittatus while Ceratitis cosyra, Dacus telfaireae, Dacus masaicus, Ceratitis cosyra, Ceratitis fasciventris and Ceratalaspis sp. were low in number (Table 3). A total of 186 flies/trap/day of flies and six species were caught in Arjo Gudattu area followed by Bako. From thus, Bactrocera invadens was highly trapped and highly dominated in the area followed by Dacus bivittatus and Dacus telfaireae, respectively. Very low number of Ceratitis fasciventris, Dacus masaicus and Dacus vertebrates were recorded in the area, respectively (Table 3).

In Bako area four fruit fly species 130.76 total flies were collected with five different attractants and next to Arjo Gudattu Bako is the second area that effected. From thus, Bactrocera invadens was the most numerous fruit

fly species followed by Ceratitis fasciventris, Dacus bivittatus and Ceratitis cosyra (Table 3). Out of the four fruit fly species collected in the area Ceratitis cosyra is a new recorded species.

Table 3: Fruit fly catches (mean values) from traps and their relative abundance levels

Area and fruit fly species	Relative fly abundance (flies/trap/day)					Total mean fly with standard error of abundance
	Me	Cue	TML	3C	TA	
1. Assosa Area						
Bactrocera invadens	65.30	0	0	0	0.30	65.7±13.05
Bactrocera cucurbitae	0	3	0	0	0	3±0.6
Dacus bivittatus	0	3.7	0	0.3	0	4.03±0.7
Dacus telfairea	0	7	0	1.3	0.3	8.3±1.36
Dacus vertebrate	0	0	0	0	0.3	0.3±0.07
Ceratitis cosyra		0	0	0		0.3±0.07
						81.68
2. Didessa Area						
Bactrocera invadens	29.33	0	0.33	0	0	29.7±5.8
Dacus bivittatus	1.7	13.33	1.7	1.0	0	17.7±2.46
Dacus telfaireae	0	0.7	0	0	0	0.7±0.14
Dacus masaicus	0	0.7	0	0	0	0.7±0.14
Ceratitus cosyra	0	0	0	0	0.7	0.7±0.14
Ceratitis fasciventris	0	0	0	0	0.7	0.7±0.14
Ceratitis Sp.	1	0	0	0	0	1±0.19
						51.19
3. Arjo Gudattu Area						
Bactrocera invadens	105.7	0	0	0	0	105.7±21.14
Dacus bivittatus	5	60.7	3.3	0.3	0.7	70.1±11.7
Dacus telfaireae	0	8.3	0	0	0.3	8.7±1.7
Dacus masaicus	0	0.7	0	0	0	0.7±0.14
Dacus vertebratus	0	0	0.3	0	0	0.3±0.07
Ceratitis fasciventris	0	0	0	0	0.7	0.7±0.14
						186
4. Bako Area						
Bactrocera invadens	97.7	0	0.33	0	0	98.03±19.5
Dacus bivittatus	0.7	1	0	0	0	1.7±0.21
Ceratitis cosyra	0	0	0	0	0.33	0.3±0.07
Ceratitis fasciventris	0	0	8	4.7	18	30.7±3.46
						130.76

CUE=Cuelure, ME = Methyl eugenol , TA = Terpinyl Acetate, TML = Trimedlure , 3C = 3-components lure.

Rearing of fruit flies from mango fruits

Only three species of fruit fly was reared from mango fruits and *Bactrocera invadens* was the dominant species followed by *Ceratitis fasciventris* and *Ceratitis cosyra* in the four areas (Table 4). *Ceratitis fasciventris* was reared from Arjo Gudatu and *Ceratitis cosyra* from Assosa only.

Table 4: Proportion of fruit fly (Diptera: Tephritidae) species composition reared from mango fruit in Western Ethiopia, 2010

Fruit fly Species	Proportion and mean number of fruit flies/ kg of mango fruits					
	Asossa	Didesa	Arjo Gudattu	Bako	Total	%
Bactrocera invadens	25	15	51	11	102	84.34
Ceratitis fasciventris	0	0	15	0	15	12.31
Ceratitis cosyra	4	0	0	0	4	3.35
Total mean	29	15	66	11	121	100

Extent of mango fruit infestation

The extent of fruit fly infestation on mango fruit varied among the different areas of Western Ethiopia. Mango fruits were attacked by fruit flies; especially *Bactrocera invadens*, *Ceratitis fasciventeris* and *Ceratitis cosyra* and infestation ranged from 16.7% to 55.6% in the study areas. Significantly higher mango fruit infestation was

recorded in Arjo Gudattu (55.6%) followed by Asossa (33.3%). and Didessa (27.7%) at P<0.05. The lowest level of infestation was observed in Bako area (Figure 1).

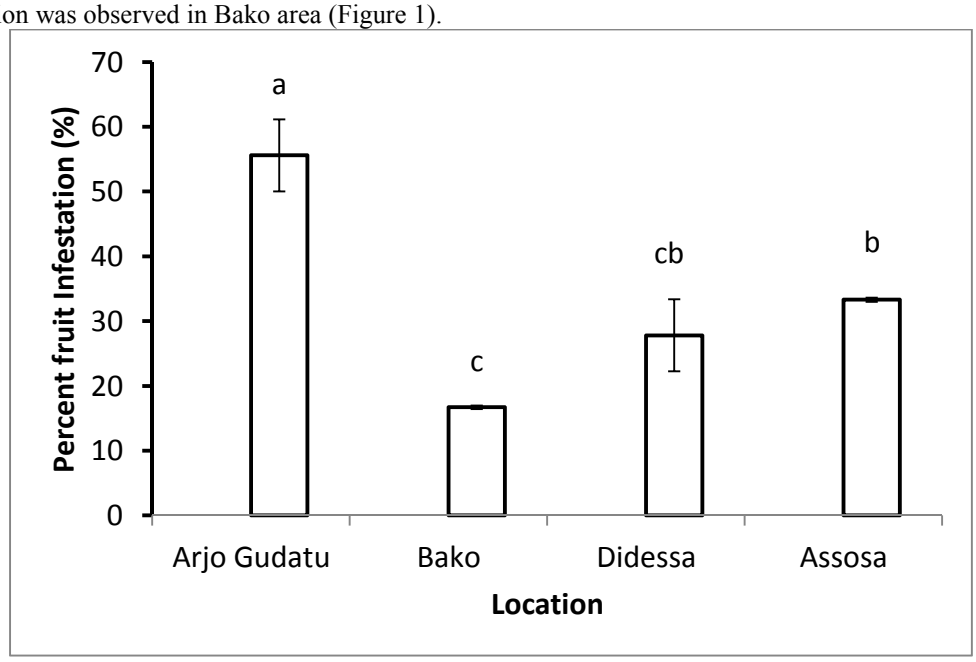

Figure 1. Levels of mango fruits infestation by fruit flies in Western Ethiopia, 2010
Bars with the same letter are not significantly different according to LSD at P ≤ 0.05.
+ = standard error of the mean

Impacts of altitude on number of fruit fly species

In this study fruit flies were collected at altitude ranges of 1230-1876masl. No relationship could be demonstrated between the population of the fruit flies and altitude except for Ceratitis fasciventris (Table 9). The distributions of the fruit fly species recorded overlaps and except Bactrocera cucurbitae the other seven fruit flies had wider distribution and found as low as 1200masl (Table 9).

Table 9: The relationship between altitude and population density of fruit fly species in Western Ethiopia, 2010

Tephritidae fruit fly Species	Altitude range(masl)	Total number of fruit flies/ trap/day	Regression coefficient	P-value
Bactrocera invadens	1230-1805	299	Y = 0.018x -12.57, R^2 = 0.02	0.447
Bactrocera cucurbitae	1489-1599	3	Y = 0.0001x + 0.019, R^2 = 0.026	0.87
Dacus bivittatus	1230-1743	93.34	Y = -0.0101x + 20.09, R^2 = 0.016	0.338
Dacus telfaireae	1265-1670	17.66	Y = -0.000x + 1.69, R^2 = 0.028	0.78
Dacus masaicus	1255-1383	1.33	Y = -0.0003x +0.549, R^2 = 0.135	0.126
Dacus vertebratus	1298-1521	0.5	Y = -0.0001x +0.154 , R^2 = 0.007	0.51
Ceratitis cosyra	1299-1876	1.33	Y = 0.0000x + 0.039, R^2 = 0.0001	0.93
Ceratitis fasciventris	1250-1876	32	Y = 0.010x -14.32, R^2 = 0.201	0.0003**
*Ceratitis (Ceratalaspis)*sp.	1230-1271	1	Y = -0.000x +0.543, R^2 = 0.049	0.09

R^2= Coeffient of determination
* Significance

DISCUSSION

In western Ethiopia *Bactrocera invadens* was found to be the most abundant fruit fly species (67%) in the all area followed by *Dacus bivittatus* (21%) and *Ceratitis fasciventris* (7%). This new invasive fruit fly pest is believed to have invaded Africa from the Asian subcontinent and was discovered in Sri Lanka soon after it was reported from Africa (Drew *et al*., 2005). Since first detection in March 2003 in Kenya, the insect has rapidly spread across tropical Africa and is now known from 28 countries and the Comoros Islands (Drew *et al*., 2005; French, 2005). Thus, fruit flies constitute a serious threat because they are a plague due to their fast proliferation and the presence of important populations in all the main fruit growing areas.

Bactrocera invadens appears to be a low land pest as reported earlier (Ekesi *et al*., 2006). It has been observed in Ethiopia from Gambella, Assosa, and Arbaminchi areas (Azerefegne *et al*., 2009) and seriously threatening the fruit production, particularly mangoes in Western Ethiopia. In this study *Bactrocera invadens* was recorded as high as 1805masl. *Bactrocera invadens* dominated the fruit flies reared from mango fruits followed by *Ceratitis fasciventris* and *Ceratitis cosyra*. *Ceratitis cosyra* had very low number except in Assosa. *Bactrocera invadens* is a recent introduction to Africa and was well established in the all area. Where polyphagous Tephritid species have been introduced in areas already occupied by a polyphagous Tephritid, interspecific competition has resulted in a decrease in number and niche shift of the pre-established species (Duyck *et al*., 2006a).

Dacus vertebrates, Dacus telfaireae, Dacus masaicus, Bactrocera curcubitae and *Ceratitis cosyra* are new recordes for Ethiopia, but two *Ceratitine* species: *Ceratitis capitata* and *Ceratitis fasciventris* were reported attacking mango fruits before at Upper Awash Agro Industry Enterprise farms, in Ethiopia (Birtukan, 2006). However, *Ceratitis capitata* was not found in western Ethiopia in all area. In the presence of many species exploiting the same resource, there will severe competition and there could be displacement of species especially if they exotics. Displacement can lead to shifts to hosts that were considered of minor importance before, or to climatic niche partitioning between the different pest species (Duyck *et al*., 2006a, b).

Ceratitis cosyra is one of the new species observed in Western Ethiopia, especially in Asossa, Didessa and Bako area and the major species attacking mango in Africa, commonly known as the mango fruit fly or marula fruit (De Meyer, 1998). The proportion of the species was recorded in little number: reared from mango fruits (3%) and trapped by parapheromones 1.33flies/trap/day (0.29%) in the area. However, the fly is a serious pest in smallholder and commercial mango across sub-Saharan Africa, where it is more destructive than either the *Ceratitis capitata* (Medfly); (Wiedemann) or the *Ceratitis rosa* (Karsch) (Javaid, 1979; Malio, 1979; Labuschagne *et al*., 1995; Rendell *et al*., 1995; Lux *et al*., 1998). It is widely spread in sub-Saharan Africa, occurring in at least 22 countries, and Madagascar (CABI/EPPO, 1999).

The melon fruit fly, *Bactrocera cucurbitae* (Coquillet) is another species that has been newly recorded in Western Ethiopia, 2010 distributed widely in temperate, tropical, and sub-tropical regions of the world and in Africa**,** but India is considered as its native home (White, 2006). Although *Bactrocera cucurbitae* was restricted to eastern Africa for several decades, it has recently been reported from Western Africa and the Seychelles (White, 2006). It is the first recording in Mali and it has a formidable pest of the Cucurbitaceae in Asia, in the Pacific, and on Réunion (Vayssieres, 2007), and present in East Africa (White and Elson-Harris, 1992). This is one of the new species recorded in Asossa, western Ethiopia because of the area found in a tropical region and has a contribution for the distribution of the flies.

Bactrocera cucurbitae has been causing damage on over 81 plant species (Dhillon *et al*., 2005). Infestations are particularly high in cucurbit crops, in which fruit losses can range from 30-100% (Dhillon *et al*., 2005). Based on the extensive surveys carried out in Asia and Hawaii, plants belonging to the family Cucurbitaceae are preferred most (Allwood *et al*., 1999). Doharey (1983) reported that it infests over 70 host plants, amongst which, fruits of bitter gourd (*Momordica charantia*), muskmelon (*Cucumis melo*), snap melon (*Cucumis melo* var. *momordica*) and snake gourd (*Trichosanthes anguina* and *Trichosanthes cucumeria*) are the most preferred hosts. Sometimes it attacks plants belonging to other families, e.g. tomato (*Lycopersicon esculentum*). Observations on non-cucurbit hosts in Tanzania, however, indicate that infestations in these hosts are very minor (Mwatawala et al., 2010).

Para pheromone lures attract only males and are more specific to species they attract. The amount of lure necessary is determined by the purpose of the trapping (i.e., monitoring versus mass trapping). The current study showed that Methyl eugenol is the most effective *Bactrocera invadens* attractant lure as compared with the other parapheromones lures at Western Ethiopia.

During the study there was 17–56% mango fruit infestation level by the most three species: *Bactrocera invadens, Ceratitis fasciventris* and *Ceratitis cosyra* in Western part of Ethiopia. Especially Arjo Gudattu area was more infested by this three species of flies and *Bactrocera invadens* has the most contribution for the infestation(84%) followed by *Ceratitis fasciventris* (12%) and *Ceratitis cosyra*(3%), respectively. Many species of fruit flies cause serious damage on fruit and limit their export to other countries. The extent of damage recorded in Benin in 2006 ranged from an average of 17% at the beginning of April, to 80% at the end of June at

the end of the mango season (Vayssieres et al., 2006). Fruit flies from different genera attack in each country. Damage levels on mangoes in Kenya due to this pest have been reported to be as high as 70 % (Ekesi *et al*., 2006). Another study conducted on Tephritids attacking mangoes in South Africa, *Ceratitis cosyra* was found to be the dominant fruit fly species attacking mango fruit than *Ceratitis capitata* (Labuschagne *et al*., 1995).

Monitoring helps identify fruit fly pests, keeps track of changes in their population levels, and indicates when or whether to use controls. The situation is further complicated by the fact that the fruit flies are regarded as quarantine pest in many countries of the world. The detection of a single larva in destination country prompts the destruction of the whole consignment. The best way to detect the presence of fruit flies and evaluate the effectiveness of control measures is to monitor fruit infestation. The methyl eugenol is highly attractive to males of several *Bactrocera* species, including the African invasive fruit fly (CTAHR, 1999). An IPM program that used field sanitation, protein bait applications, male annihilation, and release of sterile flies and parasites reduced fruit fly infestation from 30 to 40% to less than 5%, and cut organophosphate pesticide use by 75 to 90% (Vargas, 2004).

The study was conducted in selected areas of western Ethiopia. This might be one of the reasons for the weak relationships between the population density of fruit fly species and altitude. Altitude only may not determine the distribution of fruit flies, but also factors which vary with altitude like temperature, evapotranspiration and humidity and others including host availability can greatly affect the population and distribution of the flies.

CONCLUSIONS

The study showed that eight species of fruit flies namely, *Bactrocera invadens*, *Bactrocera curcubitae*, *Dacus telfaireae*, *Dacus masaicus*, *Ceratitis fasciventris, Ceratitis cosyra*, *Ceratitis fasciventris,* and *Dacus bivittatus,* are found in western Ethiopia. The newly introduced *Bactrocera invadens* was mainly trapped with Methyl eugenol (ME) and also reared from infested fruits. From the eight species of fruit fly collected five species: *Dacus masaicus, Bactrocera curcubitae, Dacus telfaireae, Dacus vertebratus, Ceratitis cosyra* and are newly recorded in the area. *Bactrocera invadens* is the dominant and the most frequently trapped fruit fly species in all the study areas followed by *Dacus bivittatus* and *Ceratitis fasciventris*.

Bactrocera invadens is the dominant species again reared from mango fruits followed by *Ceratitis fasciventris* and *Ceratitis cosyra* in the area. The flies are distributed at altitude ranges of 1238-1766m.a.s.l. but not significantly correlated with the altitude except *Ceratitis fasciventris* that has significant positive relationship ($R^2 = 0.201$). The study also revealed that there is variation in the extent of infestation on mango production area. The highest number of fruit flies as well as highest infestation was observed in Arjo Gudattu district, while low level of infestation was recorded in Bako area.

Mango production in western Ethiopia is mainly by small household producers who lack knowledge on the management of fruit flies. Due to market availability, transportation, irregular ripening of fruits and tree height they are not able to practice prompt harvesting before fruits are damaged by fruit flies. Complementary studies are necessary to gain complete inventory of the fruit fly species, the extent of damage, distribution, and the various host plants they feed on so that to develop future management programs in the country.

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