EVALUATION OF FRUIT FLIES (DIPTERA: TEPHRITIDAE) ATTRACTANTS IN NORTHEASTERN ETHIOPIA

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ABSTRACT

A study was conducted in South Wollo and North Wollo administrative zones of northeastern Ethiopia in 2018; Torula yeast, protien hydrolase, methyl eugenol, trimed lure and terpinyil acetate were evaluated for adult fruit fly species complexes trapping. Four fruit fly species was trapped; *Bactrocera dorsalis, Ceratitis cosyra*, *Ceratitis capitata* and *Ceratitis fasciventris. Bactrocera dorsalis* was the most abundant species accounted for 97.9% of the total trapped adults. The number of *B. dorsalis C. cosyra* and *C. capitata* showed a significant difference among trapping locations and attractants; The highest number of *B. dorsalis* was trapped with methyl eugenol at Kalu (722.2 flies/ trap/ week); *C. capitata* was higher at Habru which was guava and coffee dominated habitat while *C. cosyra* was relatively higher at Kobo which is mango dominated; more adults were trapped in male lure traps (97.03%) than food-based attractants (2.97%); food-based attractants could be valuable alternatives for detection and monitoring of fruit flies

Key words: Attractants, *Bactrocera dorsalis*, *Ceratitis fasciventris*, *Ceratitis capitata*, *Ceratitis cosyra*, Methyl eugenol, protein hydrolase, trimed lure, torula yeast, *Wollo*

Fruit flies (Diptera: Tephritidae) are one of the most diverse groups of insects, comprising over 4000 species in 481 genera (Jaipal et al., 2012). Tephritid fruit flies are considered by far the most important group of horticultural pests worldwide. Each continent is plagued by several fruit fly pests, both indigenous as well as invasive ones, causing tremendous economic losses (De Meyer et al., 2016). Tephritidae are distributed worldwide in temperate, tropical, and subtropical regions (IPPC, 2015). The genus *Anastrepha* are restricted to the Western Hemisphere, while most of the *Bactrocera* are native to tropical south and southeast Asia (Putnam, 2006). In most African countries many indigenous fruit fly species belong to *Ceratitis*. However, *Bactrocera* spp. (mainly Asian origin) appear to dominate over *Ceratitis* (Mwatawala et al., 2009). A complex of fruit fly species commonly coexists in the fragmented fruit and vegetable production systems in Africa (Ekesi and Billah, 2007). especially alien invasive species, constitute a major threat to horticulture in Africa (Ekesi et al., 2016). An important aspect of fruit fly management is accurate information on the species and their host spectrum (Badii et al., 2015). In Ethiopia, different species of fruit flies have reported to infest the berry and stone fruits in considerable extents (Chemeda et al., 2011; Dawit et al., 2015; Fikru et al., 2018). Recently the invasive species *B. dorsalis* is being reported as the most devastating in Eastern, Southwestern and Central Ethiopia (Dawit et al., 2015; Fekadu and Zenebe, 2015; Tibebe, 2017) even causing up to 100% loss on guava in central rift valley region (Tibebe, 2017). Here, *Ceratitis capitata* and *C. fasciventris* were previously reported as dominant (Ferdu et al., 2009). Recently up to 78% fruit infestation on guava and 28% on mango have been reported (Aderajew et al., 2020). However, most of the producers have not recognized the fruit flies as a problem and did not associate the fruit rotting (Fikru et al., 2018)

The first step for the successful management of fruit flies in fruit orchards is to have an effective monitoring system. Monitoring is important to: (1) identify species present in the orchard to establish whether there is in fact a pest problem, (2) determine seasonal changes in population levels, (3) give an indication of the population present and the severity of pest, (4) determine the time for control actions to be initiated and (5) determine the efficacy of control measures. Hence in Northern Ethiopia, especially northeastern part, having wide coverage of fruit crops this information about the species complexes and their attractants have not been well studied. This information required to plan management options. Hence, this study was conducted to evaluate attractants for the monitoring of fruit fly species complexes in major fruit crop producing areas of northeastern Ethiopia.

MATERIALS AND METHODS

The study was conducted in the Eastern Amhara, Ethiopia, focusing on fruit crops like mango, guava, orange, banana, and coffee. Three orchards were selected for adult trapping, each with an area of over two ha. The Harbu nursery and semi-fruit production site in Kalu district, Anto farmer's field in Habru district, and Durlebes traping site in Kobo district were chosen. Three male lures, namely methyl eugenol (ME), trimedlure (TML) and terpinyil acetate (TA), and two food-based attractants, torula yeast and protein hydrolase are used to attract the fruit flies. Different traps can be combined to reach the possible higher number of fruit flies (IPPC, 2010). Finally the specialized male lures were evaluated with food-based attractants–ME for *B. dorsalis*; TML and TA for *Ceratitis* spp. were evaluated along with torula yeast and protein hydrolase.

Empty water bottles of 1ℓ capacity were used for making a modified trap by cutting the bottle at 2/3 level and the cutoff neck served as an entry funnel into the rest of the bottle. Then the modified trap was hanged with a binding wire by penetrating at the bottom of the bottle. Baits with polymeric plug formulation were smeared in the inner side of the bottle whereas liquid formulated attractants were placed in the bottle using a piece of cotton wick. Locking from the opened side with the binding wire by dipping in a mixture of carbaryl (Sevin 85% WP) in 1 to 4 ratio with attractants was used to kill the fly (Grahmann, 2011). The trap bottles with the male lures and food-based attractants were suspended with a binding wire on mango trees at a height of 1.5-2 m from the ground for eight consecutive weeks (1 July to 26 August 2018). Each lure was replicated three times in each trap area with a minimum spacing of 20 m among and 50 m with attractant types; there were three traps without any attractant with carbaryl (Sevin 85% WP) as control at each trap sites (totally 18 traps/ site including the control treatment). The trap sites were 60-180 km apart from each other.

New water bottle traps were used to avoid contamination of the outer surface of the bottles with the baits, which may keep the flies to settle to the outer side of the bottle instead of getting in. The trap holding wires were smeared with grease to prevent the entry of ants. Renewing of the attractants were employed in a weekly interval for food-based attractants (torula yeast and protein hydrolase) and monthly for male lures (ME, TA and TML), After each inspection, there was a clockwise rotation of traps; inspection was employed in 7 days interval (IPPC, 2010). The trapped flies were preserved in vials containing ethanol 70% for further identification. The samples were identified at the Laboratory of Entomology at Sirinka Agricultural Research Center with the help of color print guide books (Ekesi and Billah, 2007; Choudhary et al., 2014) and for confirmation voucher specimens were sent to the International Center of Insect Physiology and Ecology (ICIPE), Addis Ababa, Ethiopia. Data for all insect counts were converted to no. of flies/ trap/ week and were subjected to ANOVA using generalized linear model (PROC GLM, SAS Institute). The data were transformed using the procedure Log_{10} (x+1) for *B. dorsalis* and for *C. capitata* and *C. cosyra* and means were separated by Student-Newman-Keuls Test ($p < 0.05$).

RESULTS AND DISCUSSION

The results showed that there is a significant difference between treatments (F=265.04; DF=3; p<0.001) for *B. dorsalis* (Table 1). The highest number of *B. dorsalis*/ trap/ week were trapped at Kalu with methyl eugenol (722.2 flies) followed by the same attractant at Kobo (376.5) and Habru (90) (Table 1). For *B. dorsalis* the effects of attractants were consistent between locations, with ME attracting a significantly more adults; *B. dorsalis* catches showed significantly different values among locations (F=59.27; DF=2; p<0.001), with overall mean being significantly higher at Kalu (184.4), perhanps they use seed source for rootstock from Southern Ethiopia (Fekadu and Zenebe, 2015; Fikru et al., 2018).

There was significant difference in the number of *C. capitata* between attractants (F=53.62; DF=4; p<0.001), the highest number of *C. capitata* was trapped by TML at Habru (4.83 adult flies); this lure also trapped significantly higher number of flies at Kalu (2.79) and Kobo (1.88) while the other male lure TA recorded was at par with the food based attractants except at Habru (1.29) (Table 2). There was also a significant difference for *C. capitata* among the trap sites (F=15.04; DF=2; p<0.001). The highest number of *C. capitata* was trapped at Habru (1.45) followed by Kalu (0.66) and Kobo (0.42) (Table 2). Number of *C. fasciventris* showed non-significant deferences among trapping sites (F=0.46; DF=2; p=0.63) and attractants (F=3.69; DF=4; p=0.06); overall number of *C. fasciventris* was

Table 1. Mean *B. dorsalis* adults trapped-Eastern Amhara, Ethiopia in (2018)

Sources of variations		*Bactrocera dorsalis*
Location	Attractants	Number/ trap/ week
Habru	Methyl eugenol	90(1.91)c
	Protein hydrolase	2.7(0.39)f
	Torula yeast	1.8(0.32)f
	Control	0.0(0)g
Mean		23.6
Kalu	Methyl eugenol	722.2(2.81)a
	Protein hydrolase	9.4(0.89)d
	Torula yeast	6.0(0.67)e
	Control	0.0(0)g
Mean		184.4
Kobo	Methyl eugenol	376.5(2.56)b
	Protein hydrolase	5.7(0.61)e
	Torula yeast	2.5(0.43)f
	Control	0.0(0)g
Mean		96.2
Grand Mean		101.4
CV (%)		30.7
Location (p)		<0.001
Attractant (p)		<0.001

Value in parentheses $Log_{10}(x+1)$ transformed values.

Table 2. Mean *Ceratitis* spp. adults trapped-Eastern Amhara, Ethiopia in 2018

Source of variations		*Ceratitis capitata*	*Ceratitis fasciventris*	*Ceratitis cosyra*
Location	Attractants	number/ trap/ week	number/ trap/ week	number/ trap/ week
Habru	Trimed lure	4.83(2.16)a	0.00(0.71)	0.00(0.71)b
	Terpinyil acetate	1.29(1.30)c	0.00(0.71)	0.00(0.71)b
	Protein hydrolase	0.71(1.04)d	0.21(0.79)	0.54(0.90)b
	Torula yeast	0.42(0.92)de	0.04(0.73)	0.25(0.82)b
	Control	0.00(0.71)e	0.00(0.71)	0.00(0.71)b
Mean		1.45	0.05	0.16
Kalu	Trimed lure	2.79(1.68)b	0.00(0.71)	0.00(0.71)b
	Terpinyil acetate	0.33(0.87)de	0.00(0.71)	0.00(0.71)b
	Protein hydrolase	0.04(0.73)e	0.54(0.85)	0.29(0.82)b
	Torula yeast	0.13(0.77)e	0.08(0.74)	0.38(0.86)b
	Control	0.00(0.71)e	0.00(0.71)	0.00(0.71)b
Mean		0.66	0.13	0.13
Kobo	Trimed lure	1.88(1.50)b	0.00(0.71)	0.00(0.71)b
	Terpinyil acetate	0.17(0.79)de	0.00(0.71)	0.00(0.71)b
	Protein hydrolase	0.00(0.71)e	0.21(0.79)	7.25(2.23)a
	Torula yeast	0.04(0.73)e	0.42(0.86)	0.21(0.81)b
	Control	0.00(0.71)e	0.00(0.71)	0.00(0.71)b
Mean		0.42	0.13	1.49
Cumulative Mean		0.84	0.10	0.59
CV (%)		33.5	28.7	56.6
Location (p)		<0.001	0.63	0.004
Attractant (p)		<0.001	0.06	<0.001

Value in parentheses shows square root transformed results of the data.

negligible and limited number of *C. fasciventris* was trapped with torula yeast and protein hydrolase at all sites; *C. fasciventris* do not got traped with male lures and much lower numbers got traped with food based attractants; however this species was reported as a dominant species especially on citrus fruits (Fardu et al., 2009).

The weekly trapped *Ceratitis cosyra* showed significant difference among attractants (F=7.90; DF=4; p<0.001) and trapping sites (F=5.71; DF=2; p=0.004). The highest number of *C. cosyra* was trapped by protein hydrolase at Kobo followed by the same attractant at Habru and Torula yeast at Kalu (0.38). *Ceratitis cosyra* was more at Kobo (1.49), and this site was mango dominated *Ceratitis cosyra* has been linked more closely to mango (Ekesi et al., 2009). Both PH and TY trapped the flies in all trapping sites through male lures for *Ceratitis* spp. Overall, 27641 (27060 *B. dorsalis*, 231 *C. cosyra*, 342 *C. capitata* and 8 *C. fasciventris*) specimens were collected. The total number of specimens was higher in male lure traps (97.03%) compared to food-based attractants (2.97%) (Table 3).

Thus, study of fruit flies in Eastern Amhara revealed four species: *Ceratitis capitata, C. cosyra, C. fasciventris*, and *Bactrocera dorsalis. Bactrocera dorsalis* was the dominant species of all. *Ceratitis capitata* was more prevalent in higher altitude trap sites like Habru and Kobo, while *C. cosyra* was more prevalent in mango-dominated sites. Food-based attractants like protein hydrolase and torula yeast effectively trapped *Ceratitis* spp. making them valuable for detection and monitoring.

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AUTHORS CONTRIBUTION STATEMENT

Conceptualization, A.M. and Y.W.; methodology, A.M, M.A. and Y.W.; formal analysis, A.M.; investigation, A.M, and M.A.; writing original draft preparation, A.M.; writing review and editing, A.M, M.A, and Y.W.

CONFLICT OF INTEREST

No conflict of interest.

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Table 3. Fruit flies attracted by the male lure and food-based attractants

Species	Attractants										Total
	Male lures						Food-based				
	ME		TML		TA		Protein hydrolase		Torula yeast		
B. dorsalis	number	%	number	%	number	%	number	%	number	%	
							426	1.54	246	0.91	27060
	26386	97.5	0		2	0.05		2.45			
C. capitata			120	35.1	102	29.8	71	20.8	49	14.3	342
	0			64.9				35.1			
C. cosyra			181	78.3	29	12.5	8	3.5	13	5.6	231
	0			90.8				9.1			
C. fasciventris							3	37.5	5	62.5	8
	0			0				100			
Overall			97.03%					2.97%			27641

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