

Identification of Fruit Fly Species in and around Mango Orchards in Selected Villages of Bal'ad and Afgoye Districts, Somalia

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Abstract

This study aimed to screen and identify fruit fly species infesting mango orchards in selected villages of Bal'ad and Afgoye districts, Somalia. Fruit flies (Diptera: Tephritidae and Lonchaeidae) are among the most destructive pests affecting fruit production globally, causing estimated annual losses of US\$2 billion in Africa alone due to yield reduction and quarantine restrictions. Field studies were conducted from October 2023 to February 2024. Five types of traps (Bacterocera Block, Certitis Block, Last Call, Fruit Fly Mania, and Liquid Food Baits) were deployed across selected villages in both districts. Additionally, infested samples of fruits containing fruit flies were collected and reared under laboratory conditions at the Faculty of Agriculture and Environmental Science, Somali National University, to identify emerging adult flies. Results revealed a high density and variation in fruit fly populations between the two study sites. A total of 99.83% of captured flies were successfully identified, while 0.17% remained unidentified. Bal'ad accounted for 82% of total captures, while Afgoye contributed 18%. Among the traps used, B. block was the most effective, capturing the highest mean number of fruit flies (1,854.0 A). The most dominant species identified were *Bactrocera dorsalis*, *B. tryoni*, *B. zonata*, *Ceratitis rosa*, and *C. capitata*, with *B. dorsalis* being the most prevalent (85.15%). Rearing studies also confirmed the dominance of *B. dorsalis* and a minor presence of *C. rosa*. The study highlights the urgent need to develop and implement improved diagnostic tools and integrated pest management strategies tailored to local conditions in order to manage these significant economic pests effectively.

Keywords

Fruit Fly, Species Identification, Mango Orchards, Tephritidae, Somalia

1. Introduction

Mango (*Mangifera indica* L.) is one of the choicest fruits in the world [1]. It belongs to the family Anacardiaceae, genus *Mangifera*, and species *indica*. The origin of the mango can be traced back to the Indo-Burma region, which encompasses parts of present-day India, Bangladesh, Myanmar, and Thailand. Archaeological evidence suggests that mangoes have been cultivated in this region for over 4,000 years [2]. Mangoes are among the most popular fruits in the world, and they are grown in a wide range of tropical and subtropical regions. The global mango production is estimated to be around 44 million metric tons annually, with India, China, and Mexico being the top three producers [3]. Mango production plays a crucial role worldwide in providing nutritious food and generating significant employment opportunities along the mango value chain. Mango is a vital economic tree crop, ranking second in international trade among tropical fruits and fifth in total global production among major fruit crops. It serves as both food and an important medicinal plant. The fruit, which is commonly eaten by humans, is a rich source of vitamin A and also contains vitamins B and C [4]. Some important diseases affect mango production worldwide, differentiating among those that affect the fruit, the leaves and flowers, and soil diseases, including Anthracnose, Bacterial black spot (BBS), Stem-end Rots, and *Alternaria* Rot [5]. Additionally, mango trees are susceptible to several pests that can damage the fruit and reduce yields. These pests include stem borer, mango nut weevil, bark-eating caterpillar, flower gall midge, mango leaf webber, shoot borer, leaf caterpillar, flower webber, mango mealy bugs, and fruit flies [6].

Fruit flies are among the most important pests of fruit and vegetables worldwide. The fruit flies belong to the order Diptera with two dominant families: Tephritidae and Lonchaeidae [7]. Tephritidae is the most species-rich family of fruit flies, with around 5,000 described species in six subfamilies (Tachiniscinae, Blepharoneurinae, Phytalmyiinae, Trypetinae, Dacinae, and Tephritinae); about 500 genera, and probably many undescribed species worldwide [8]. Nearly 250 of these species are capable of achieving pest status by feeding on economically significant plants and causing severe damage. Lonchaeidae is the second family of fruit flies with economic importance [9]. The Lonchaeidae fruit flies have about 500 described species worldwide in two subfamilies and nine genera [10]. The economically important species of fruit flies in Africa belong to the genera *Bactrocera*, *Ceratitis*, *Dacus*, and *Trirhithrum* [11].

The genera *Ceratitis*, *Dacus*, and *Trirhithrum* are native to Africa, while *Bactrocera* is native to Asia. Female fruit flies that lay eggs under the skin of the fruits cause direct losses. The eggs hatch into larvae that feed on the decaying flesh of

the crop. Infested fruit rots quickly and becomes inedible or drops to the ground [12]. In Africa, annual losses of horticultural produce due to fruit flies are estimated at US\$2 billion, both directly through fruit damage and indirectly through loss of market opportunities as a result of quarantine restrictions [13]. The production of fruits and vegetables can be a significant source of income. A constantly growing population, rising incomes, and urbanisation levels increase the demand for fruits and vegetables. To meet this demand, better farming strategies are necessary. The presence of pests such as fruit flies constitutes an obstacle to their production. These fruit flies are considered a highly destructive group of insects that cause significant economic losses in agriculture, particularly affecting a wide variety of fruits, vegetables, and flowers [14].

Due to the heavy infestation and spread of invasive fruit flies, which threaten the primary commercial production and market for fruits in Somalia—especially mangoes and guavas—significantly reducing the quality and quantity of mango and guava yields, there is a lack of awareness regarding the factors contributing to the risk of fruit fly invasion in the country. These factors include the fragile nature of quarantine measures for this phytosanitary pest, the liberalization of fruit trade, and the absence of scientific research identifying fruit fly species in Somalia, alongside limited information on their seasonal abundance and level of risk. Moreover, there is a lack of effective management methods for this alien pest. Therefore, the objectives of this study are: to identify the fruit fly species in and around mango orchards in selected villages of Bal’ad and Afgoye Districts; to assess the level of fruit fly abundance in these villages; to determine the effectiveness of traps chosen to target specific species; to identify the most prevalent fruit fly species in the study areas and their pest status; and to study the biology of fruit fly species through rearing under laboratory conditions to ascertain if the species infest fruits similar to those identified.

2. Methodology

2.1. Collection Equipment

Traps

Different types of fruit fly traps were selected to capture various species. These included species-specific traps such as the B. block for *Bactrocera* spp. and the Ceratitis Block for *Ceratitidis* spp., along with general fruit fly collection traps such as Fruit Fly Mania, Last Call, and liquid Food Bait traps. The traps, including B. Block, C. Block, Last Call, and Fruit Fly Mania, were imported from Kenya, primarily by Kenyan biologists, while the Liquid Food Bait was produced locally. Twenty traps of each type were meticulously prepared and placed in each study area, ensuring consistent trap density. The traps were spaced 50 metres apart and inspected weekly to collect the captured fruit flies. Baits in the Last Call, Fruit Fly Mania, and Liquid Food Bait traps were replaced weekly, whereas those in the *Bactrocera* Block and *Ceratitidis* Block did not require replacement. Using a fine camel hairbrush, the captured flies were collected and transferred to labelled vials

containing 70% ethanol for further identification. The details of the traps are as follows.

1) **Bactrocera-Block and Ceratitis Block**

Both *Bactrocera* and *Ceratitidis* blocks comprise a 5 × 5 cm wooden block impregnated with the attractants Methyl Eugenol and Ginger Oil, respectively, alongside the contact insecticide Malathion. *Bactrocera* and *Ceratitidis* blocks were utilised to collect fruit flies for identification and comparison with other traps. The blocks were placed inside a transparent, 1000 ml cylindrical plastic bottle with two equidistant holes made opposite each other near the uppermost part. A lid and a small metal string were employed to hang the traps from trees. The traps were suspended 1.5 to 2 metres above ground level, within the tree canopy.

2) **Last Call Trap**

The Last Call trap is an innovative combination of a sex pheromone and insecticide designed to attract male fruit flies. Last Call is presented as a clear droplet containing the sex pheromone of the female fruit fly, enticing and drawing in the males. It can be paired with a dose of permethrin insecticide, which eliminates the males after they have “mated” with the enticing substance.

3) **Fruit Fly Mania**

This protein-based food bait trap has proven to be highly attractive to both male and female fruit flies, including common species such as the African invasive fruit fly, melon fly, and Mediterranean fruit fly. Specifically developed for African conditions, Fruit Fly Mania serves the dual purposes of fruit fly collection and control. The traps consist of 500 ml transparent cylindrical plastic bottles with two equidistant holes and lids, similar to the *Bactrocera* Block and *Ceratitidis* Block housings. Metal strings are utilized to attach the traps to trees, ensuring they are hung 1.5 to 2 meters above ground level within the tree canopy.

4) **Liquid Food Bait Traps**

The Liquid Food Bait trap, which consisted solely of mango juice, is a traditional and locally crafted trap. It was employed and suspended in a similar fashion among the shaded mango trees on sturdy branches to support the weight of the trap filled with mango juice.

5) **Vails**

Labeled vials were used for the collection of captured fruit flies and their transport to the laboratory.

6) **Traps as Treatments**

The treatments applied to the used traps are presented below.

N/A	Treatments	Treatments Symbol
1	Bactrocera Block	T1
2	Ceratitidis Block	T2
3	Last Call Trap	T3
4	Fruit Fly Mania	T4
5	Liquid Food Bait	T5

2.2. Study Area and Duration

The study was conducted from October 2023 to February 2024 in the Afgoye and Bal'ad districts, situated in the Lower and Middle Shabelle regions of Somalia, respectively. Located approximately 30 kilometres southwest and northeast of Mogadishu in the Shabelle Valley, these two principal irrigated agricultural districts featured a variety of fruit and vegetable crops, predominantly cultivated along the Shabelle River.

2.3. Experimental Design

A randomized complete block design was employed as the mapping method in this experiment, with four replications for each treatment at each location.

2.4. Sampling Techniques

The field experiment was designed using a Randomized Complete Block Design (RCBD). In each village, five (5) traps were used and distributed equally within selected farms. The selection of mango trees was guided by prior fruit fly surveillance mapping. A W-shaped sampling pattern was applied in the field, where the researcher systematically walked through each farm to detect the presence of fruit flies. Based on this approach, five (5) mango trees were selected per farm, and one trap was assigned to each tree. Each village within the district represented one replicate of the experiment. Scouting was conducted in four villages in both the Afgoye and Bal'ad Districts to screen for various species of fruit flies. The areas chosen for the survey in Afgoye District included Tarasmatalaha, Bulofolyo, Tarafiko, and Balbaley. In Bal'ad District, the following areas were mapped: Iriridoley, Yaxasow, Buurobisharo, and Biyoxireenka. Five mango plants were randomly selected on one farm in each village. A variety of horticultural crops, including guava, mango, citrus, and vegetables, could be found on the selected farms. Two methods were employed to collect fruit flies in this study. The primary method involved using species-specific traps, such as the *Bactrocera* Block for *Bactrocera* spp. and the *Ceratitis* Block and Last Call for *Ceratitis* spp. Additionally, general fruit fly collection traps like Fruit Fly Mania and Liquid Food Bait traps were used to capture a wider range of species. These different traps were hung from trees at a height of 1.5 meters above the ground.

2.5. Fruit Fly Rearing Procedure

Five infested mangoes were randomly collected from each village in the two districts, totaling 40 sampled fruits. The fruits were collected at various stages of ripeness, including ripe and semi-ripe, to capture a wider range of life stages. The collected mangoes were washed, individually weighed, and placed in clean 13 × 12.5 cm cylindrical plastic containers within the Plant Protection Laboratory. Lids were removed and replaced with 22 × 34 cm Hessian mesh bags, secured at the ends to prevent adult flies from escaping. A layer of well-sieved sand (particles smaller than 1.60 mm) was added to each container to provide a suitable pupation

medium for the fruit flies. The infested fruits were kept in containers for 6 - 8 weeks, with daily monitoring for the emergence of adults. Water-soaked cotton wool and sugar were provided on the cage roofs for the emerged adult flies to feed on. Adults were allowed sufficient time in the cages for the complete development of their morphological features. Using a camel hairbrush, emerged flies were carefully transferred to vials containing 70% ethanol for identification and long-term preservation.

2.6. Identification of the Fruit Fly

Fruit flies were identified using stereo microscopes with a magnification range of 7× to 35×. A light source, 90 mm diameter Petri dishes, and forceps were used to prepare the specimens for identification in the laboratory, focusing on the distinctive morphological features of each collected species. Key features included wing morphology; the presence or absence of various setae and their relative size; overall colour and colour patterning; and the presence, shape, and colour of thoracic vittae. The diagnostic manuals used for species identification are the Australian handbook for the identification of fruit flies written by a group of authors, mainly: Professor Dick Drew, International Centre for Management of Pest Fruit Flies, Griffith University, 2011. No special method was independently verified or used for *Bactrocera tryoni*, except using a stereo microscope for identification, similarly with other species, and referring to the literature as confirmation for the identification.

2.7. Data Analysis

The data were analyzed using the Statistic 8 program due to its strength in handling agricultural field experiment data. It offers a wide range of statistical tools suitable for analyzing capture rates between different trap types (e.g., ANOVA). Then, Duncan's multiple range test (DMRT) was used for treatment means comparison.

3. Results and Discussion

The findings of this study, conducted in the Bal'ad and Afgoye Districts, focused on screening and collecting fruit flies using various selected traps for both generic and specific species. The study summarized the total number of fruit flies captured by the five selected traps across four villages in each district, as well as the effectiveness of each trap based on the number of fruit flies captured during a five-week operation in Bal'ad District's four villages. Additionally, the study identified species among the captured fruit flies, alongside some unidentified species. Furthermore, findings from fruit flies reared under laboratory conditions were presented, emphasizing the number of emerged fruit flies and their identification.

3.1. The Total Number of Fruit Flies Captured by Five Traps from Four Villages in the Bal'ad District

The results of **Table 1** indicate the overall number of fruit flies captured from

four selected villages in Bal'ad District using various locally made and imported traps. It was shown that there are variations in the presence and density of fruit flies among the four villages, which may be related to several factors, including the abundance of fruit orchards, the availability of suitable breeding sites, seasonal changes, and climatic conditions (**Table 1**). Iridoley village hosted the highest density of fruit flies, accounting for 29.1%, followed by Bihireyn village with 25%. Bulo Bisharo village followed Bihireyn with a percentage of 24.4%, while Yahasow recorded the lowest percentage of fruit flies at 21.5% (**Figure 1**).

Table 1. Fruit fly capture data obtained from five traps across four villages of Bal'ad district.

No	Location	Total Species	Percentage
1	Bulo Bisharo	2567	24.4
2	Yahasow	2260	21.5
3	Iridoley	3064	29.1
4	Bihireyn	2631	25
Total		10,522	100

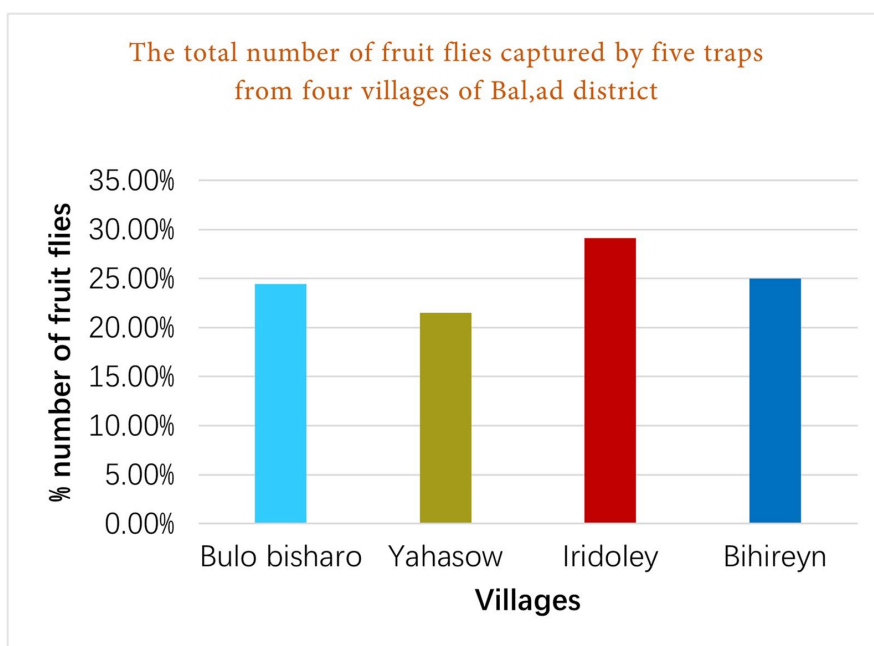


Figure 1. Spatial distribution of fruit fly captures in four villages of Bal'ad district.

3.2. The Total Number of Fruit Flies Captured by Five Traps from Four Villages in the Afgoye District

The results in **Table 2** indicate the total number of fruit flies captured in four selected villages of Afgoye District using various locally made and imported traps. The results indicate variations in the presence and density of fruit flies among the four villages, likely due to factors such as the abundance of fruit orchards, availability of suitable breeding sites, seasonal changes, and climatic conditions. Taraf-

iko village recorded the highest density of fruit flies, accounting for 40.90%, followed by Bulofolio village with 35.45% (**Table 2**). Tarasmatale village followed Bulofolio with a density of 18.38%, while Balbaley reported the lowest density of fruit flies at 5.27% (**Figure 2**).

Table 2. Summary of fruit fly captures recorded by five traps across four villages of Afgoye district.

No	Location	Total Fruit Flies	Percentage
1	Tarasmatale	422	18.38%
2	Tarafiko	939	40.90%
3	Bulofolio	814	35.45%
4	Balbaley	121	5.27%
Total		2296	100%

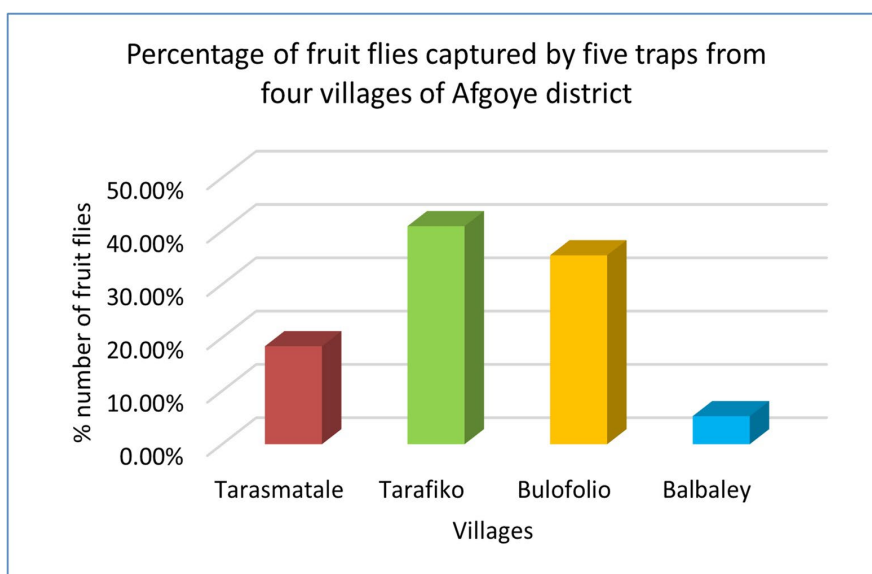


Figure 2. Distribution of total fruit fly captures across four villages of Afgoye district.

3.3. Trap Effectiveness Related to the Number of Captured Fruit Flies, Which Operated in Four Villages of Bal'ad District over Five Weeks

The data in **Table 3** addressed the significant performance of selected traps, *i.e.*, (B. Block, C. Block, Last Call, F. Fly Mania, and Liquid Food Bait) for the collection of different fruit flies in four villages of Bal'ad District. The trap in B. Block showed the highest performance. It was significantly different in capturing the most fruit fly species, with a mean number of 1854.0, mainly targeting the genus *Bacterocera* spp., compared to other traps. The traps of C. Block, Last Call, F. Fly Mania, and Liquid Food Bait appeared to have no significant difference between them for capturing fruit flies in the study areas of Bal'ad villages, with mean numbers of (174.4 B, 54.6 B, 14.6 B, 14.0 B), respectively. Although each trap can target

a specific genus of fruit fly (**Figure 3**).

Table 3. Mean fruit fly captures recorded by five traps over five weeks in four villages of Bal'ad district.

Treatments	Treatment Means
Bacterocera Block	1854.0 A
Ceratitis Block	174.4 B
Last Call	54.6 B
Fruit Fly Mania	14.6 B
Liquid Food Bait	14.0 B
CV%	79.22
SE+	149.61
P	0.000
G. Mean	422.32

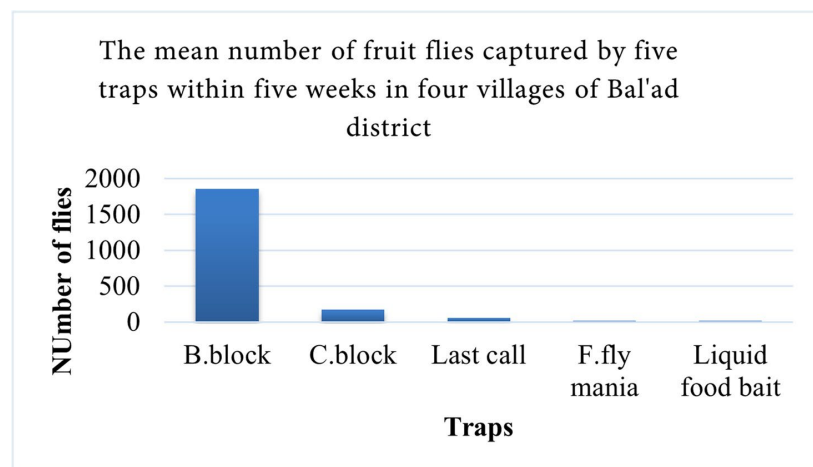


Figure 3. Temporal variation in mean fruit fly captures by five traps over five weeks across four villages of Bal'ad district.

3.4. Trap Effectiveness Was Related to the Number of Captured Fruit Flies, Which Were Operated in Four Villages of the Afgoye District over Five Weeks

Table 4 addresses the significant performance of selected traps, namely (B. Block, C. Block, Last Call, F. Fly Mania, and Liquid Food Bait), for the collection of different fruit flies in four villages of Afgoye District. The B. Block trap exhibited the highest performance and was significantly better at capturing the most fruit fly species, with a mean number of 368.20A, primarily targeting the genus *Bactrocera* spp. compared to the other traps. The traps C. Block, Last Call, F. Fly Mania, and Liquid Food Bait showed no significant difference among them in capturing fruit flies in the study areas of Afgoye villages, with mean counts of (28.20 B, 1.40 B, 0.60 B, and 0.40 B), respectively (**Table 4**). However, each trap can target a specific

genus of fruit fly, as mentioned above. This research, supported by findings from Dhillon *et al.* (2005), emphasizes the essential need for ongoing monitoring of fruit fly populations and their species composition to guide timely and specific interventions. Further studies could investigate local biocontrol alternatives or pheromone traps tailored to the dominant species in the area to enhance control effectiveness (**Figure 4**).

Table 4. Average fruit fly captures recorded by five traps in four villages of Afgoye district during a five-week sampling period.

Treatments	Treatment Means
Bacterocera Block	368.20 A
Ceratitis Block	28.20 B
Fruit Fly Mania	1.40 B
Last Call	0.60 B
Liquid Food Bait	0.40 B
CV%	64.68
SE+	23.072
G. Mean	79.76
P	0.0000

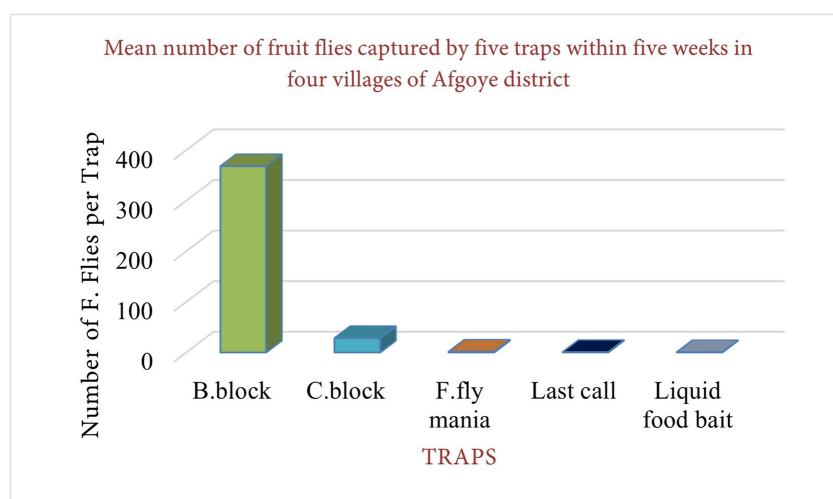


Figure 4. Temporal variation in mean fruit fly captures by five traps over a five-week period across four villages of Afgoye district.

The results of this study aligned with the findings of [15], who reported that the capture rate of fruit flies per attractant (sex attractants and food attractants) varied from one bait to another. This rate ranged from 1.57% to 86.82%, depending on the attractants used. The highest capture rate was observed with methyl eugenol, achieving 86.82% of captures. The capture rates of the other attractants were estimated at 5.00%, 3.40%, 3.13%, and 1.57%, respectively.

3.5. Identified Species of Fruit Fly Captured by Five Traps from the Four Villages of Bal'ad District

The results of this part demonstrate the performance of different types of traps for fruit fly identification, as previous research indicates that each type of trap targets specific genera and species. The traps were treated as interventions, with one of each trap placed in each village to assess the variations between them. The identified species from the traps used as treatments—namely (B. Block, C. Block, Last Call, F. Fly Mania, and Liquid Food Bait)—included *B. dorsalis*, *B. tryoni*, *B. zonata*, *C. rosa*, and *C. capitata*. For *B. dorsalis*, it was recorded from all traps (B. Block, C. Block, Last Call, F. Fly Mania, and Liquid Food Bait). However, the B. Block recorded the highest number of *B. dorsalis* and was significantly different ($p < 0.05$) from the other traps, with a mean of 2,087.5 A flies compared to the C. Block, Last Call, F. Fly Mania, and Liquid Food Bait, which had mean numbers of (88.8 B, 13.3 B, 5.0 B, 0.3 B) respectively. There was no significant difference between the treatments of C. Block, Last Call, F. Fly Mania, and Liquid Food Bait regarding the capture of *B. dorsalis*. *B. tryoni* was the second most frequently captured species in the trial traps (B. Block, C. Block, Last Call, F. Fly Mania, and Liquid Food Bait). The B. Block trap also recorded the highest number for *B. tryoni*, with a mean of 190.75A flies, which was significantly different ($p < 0.05$) from the records of the other treatments: C. Block, Last Call, F. Fly Mania, and Liquid Food Bait had mean numbers of (17.250 B, 0.0000 B, 2.7500 B, and 1.7500 B) respectively.

Bacterocera zonata was the least recorded species across all trap treatments. However, no significant variation was observed among the traps (C. Block, Last Call, F. Fly Mania, and Liquid Food Bait) with mean numbers of (0.5000 A, 0.0000 A, 0.0000 A, 0.2500 A, and 0.0000 A), respectively. Nonetheless, B. Block captives recorded the highest mean number of 0.5000 A for *B. zonata*. For *Ceratitis rosa*, it was observed in all treatment captives in small numbers, with no significant differences between them. However, the treatments using C. Block and Last Call traps revealed the highest mean numbers of 104.75 A and 47.25 A flies, respectively, followed by Fruit Fly Mania, Liquid Food, and B. Block, which had average numbers of (2.25 A, 0.50 A, and 0.50 A) flies, respectively. The capture rates of *Ceratitis capitata* varied among trap treatments. The traps labelled Last Call and C. Block recorded the highest figures for *Ceratitis capitata*, with mean numbers of 18.000 A and 11.500 AB, respectively. These were significantly different from B. Block, Fruit Fly Mania, and Liquid Food Bait, which had mean numbers of (0.2500 C, 2.2500 BC, and 0.0000 C), respectively (Table 5 and Figure 5).

Table 5. Abundance of identified fruit fly species recorded by five traps across four villages of Bal'ad district.

Treatments	Treatment Means				
	<i>B. dorsalis</i>	<i>B. Tryoni</i>	<i>B. zonata</i>	<i>C. rosa</i>	<i>C. capitata</i>
Bacterocera Block	2087.5 A	190.75 A	0.5000 A	0.50 A	0.2500 C
Ceratitis Block	88.8 B	17.250 B	0.0000 A	104.75 A	11.500 AB

Continued

Last Call	13.3 B	0.0000 B	0.0000 A	7.25 A	18.000 A
Fruit Fly Mania	5.0 B	2.7500 B	0.2500 A	2.25 A	2.2500 BC
Liquid Food Bait	0.3 B	1.7500 B	0.0000 A	0.50 A	0.0000 C
CV%	29.88	66.69	298.14	246.24	104.94
SE+	65.581	14.171	0.2236	38.413	3.3581
G. Mean	438.95	42.5	0.15	31.2	6.4
p =	0.0000	0	0.4449	0.2881	0.0084

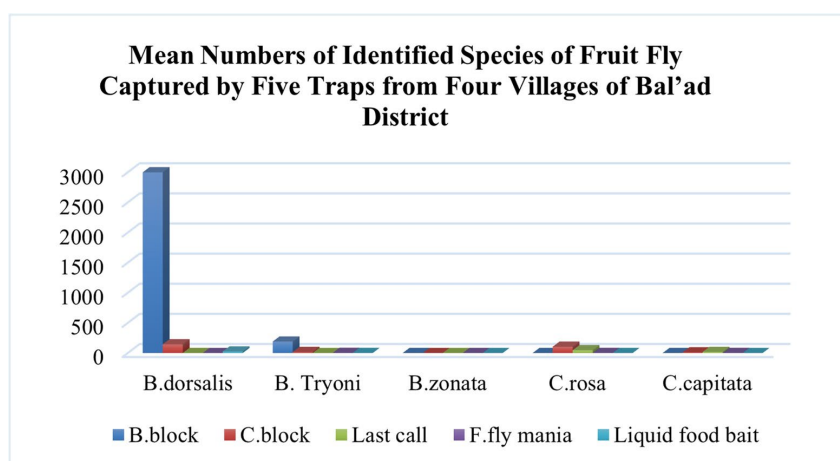


Figure 5. Variation in captures of identified fruit fly species across four villages of Bal'ad district.

3.6. Identified Species of Fruit Fly Captured by Five Traps from the Four Villages of Afgoye District

The results of this section illustrate the performance of different types of traps for fruit fly species, as previous research indicated that each block of traps targets specific genera and species. The traps were assigned as treatments, with one of each trap placed in each village to assess the variation among them. The identified species from the traps used as treatments, namely (B. Block, C. Block, Last Call, F. Fly Mania, and Liquid Food Bait), included *B. dorsalis*, *B. tryoni*, *B. zonata*, *C. rosa*, and *C. capitata*. For *B. dorsalis*, it was recorded from all treatment traps (B. Block, C. Block, Last Call, Fruit Fly Mania, and Liquid Food Bait). However, B. Block was the most frequently recorded trap for *B. dorsalis*. It was significantly ($p < 0.05$) different, with a mean number of 518.50 A flies, compared to the treatments of C. Block, Last Call, F. Fly Mania, and Liquid Food Baits (30.250 B, 0.0000 B, 0.7500 B, 0.5000 B) respectively, with no significant difference between the treatments C. Block, Last Call, F. Fly Mania, and Liquid Food Baits according to the capturing of *B. dorsalis*.

Bactrocera tryoni was the second most common species caught by all traps, which included B. Block, C. Block, Last Call, F. Fly Mania, and Liquid Food Bait. However, B. Block was the most frequently recorded trap for this species, with an average of 31,000 A flies. This was significantly ($p < 0.05$) different from the rec-

ords of other treatments, which had mean numbers of 3.5000 B, 0.0000 B, 0.0000 B, and 0.0000 B, respectively, for C. Block, Last Call, F. Fly Mania, and Liquid food bait, and no significant differences were found between these treatments based on *B. dorsalis* captures. The records of *B. zonata*, *C. rosa*, and *C. capitata* from the traps (B. Block, C. Block, Last Call, F. Fly Mania, and Liquid Food Bait) concluded that there is no significant difference between trap captures for each species of *Bactrocera zonata*, *C. rosa*, and *C. capitata* with the mean numbers of (0.2500 A, 0.2500 A, 0.0000 A, 0.0000 A, 0.0000 A), (0.0000 A, 0.2500 A, 0.0000 A, 0.2500 A, 0.0000 A), and (0.0000 A, 0.5000 A, 0.2500 A, 0.2500 A, 0.0000 A), respectively (Table 6 and Figure 6).

Table 6. Average captures of identified fruit fly species recorded by five traps across four villages of Afgoye district.

Treatments	Treatment Means				
	<i>B. dorsalis</i>	<i>B. tryoni</i>	<i>B. zonata</i>	<i>C. rosa</i>	<i>C. capitata</i>
Bactrocera Block	518.50 A	31.000 A	0.2500 A	0.0000 A	0.0000 A
Ceratitis Block	30.250 B	3.5000 B	0.2500 A	0.2500 A	0.5000 A
Last Call	0.0000 B	0.0000 B	0.0000 A	0.0000 A	0.2500 A
Fruit Fly Mania	0.7500 B	0.0000 B	0.0000 A	0.2500 A	0.2500 A
Liquid Food Bait	0.5000 B	0.0000 B	0.0000 A	0.0000 A	0.0000 A
CV%	142.36	157.79	329.14	329.14	209.17
SE+	78.299	5.4437	0.1646	0.1646	0.2092
G. Mean	110	6.9	0.1	0.1	0.2
p =	0.0017	0.0061	0.6114	0.6114	0.4449

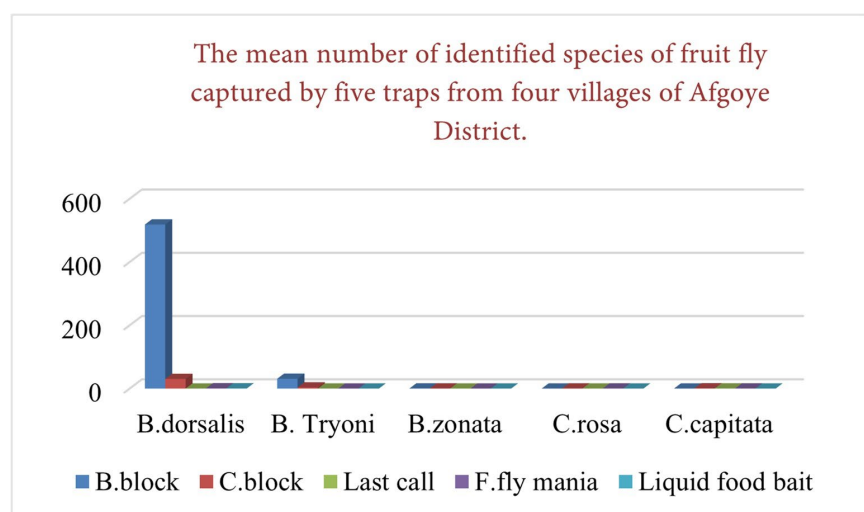


Figure 6. Comparative abundance of identified fruit fly species captured by five traps across four villages of Afgoye district.

3.7. Morphological Features for Identified Species of Collected Fruit Fly from Four Villages of Each of Bal'ad and Afgoye Districts

The collected fruit flies from each location in both districts were brought to the Laboratory of the Faculty of Agriculture and Environmental Science at Somali National University. Fruit flies were identified by using Stereo Microscopes with a magnification range of 7× to 35×, focusing on morphological identification keys, such as features of wings, presence or absence of various setae, overall colour, and colour patterning. The shape, size, and colour of thoracic vittae regarding the identity of each species were mentioned by previous research. Thus, several fruit fly species were identified among the captured flies by the traps. These include: *B. dorsalis*, *B. tryoni*, *B. zonata*, *C. rosa*, and *C. capitata*.

3.7.1. Oriental Fruit Fly (*Bactrocera dorsalis*)

The Oriental fruit fly *Bactrocera dorsalis* is distinguished from other species of fruit fly by its distinct physical appearance, namely: round or oval facial spots on the head. This dark scutum is entirely black except for two lateral yellow stripes, and the wings have a narrow costal band extending to the apex and overlapping a vein segment (R4 + 5). Additionally, the abdomen is yellow to yellowish-brown with a distinct “T” marking. This marking consists of a black band across the front of the third abdominal segment and a longitudinal black stripe extending over segments three to five (Figure 7).

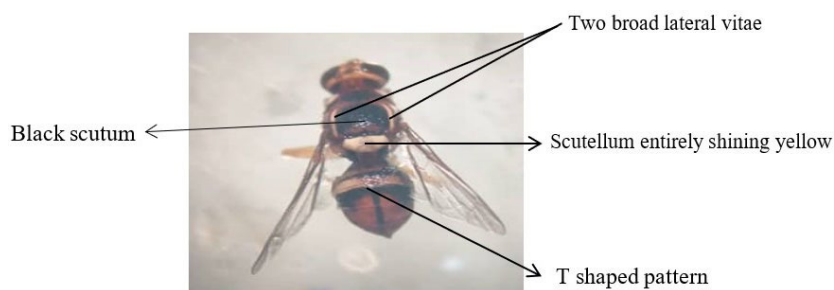


Figure 7. Illustrates the oriental fruit fly (*Bactrocera dorsalis*) species that were recognized from the specimens that have been collected from the selected research locations.

3.7.2. *Bactrocera tryoni*



Figure 8. Demonstrates the identification of the *B. tryoni* species among specimens collected.

Bactrocera tryoni specimens exhibited several distinct features. The head was consistently round or oval, with prominent facial spots. The predominant colour of the scutum was red-brown, featuring yellow/orange lateral post-sutural vittae. These stripes did not extend anterior to the suture, were tapered, and reached the posterior supra-alar seta. The wing displayed a complete costal band, potentially extending below R2 + 3 but not reaching R4 + 5. The costal band was not observed to expand into a spot at the apex (Figure 8).

3.7.3. Peach Fruit Fly (*Bactrocera zonata*)

Medium-sized flies and adults are pale orange-brown to red in colour. The head has two pairs of frontal bristles and one pair of orbital bristles. The face features a small oval-shaped black spot. The scutum is red-brown with two medium-sized lateral yellow vittae. Anterior supra-alar setae, prescutellar setae, and two scutellar setae are present. The scutellum is yellow with a narrow dark red-brown basal band. The legs are fulvous, with the apices of the femora being red-brown in colour. The wings have a costal band, with only cell Sc and the apex of vein R4 + 5 being coloured. The abdominal tergites exhibit a medial dark stripe, usually on T3 - T5 or with a medial dark stripe on T5 only (Figure 9).

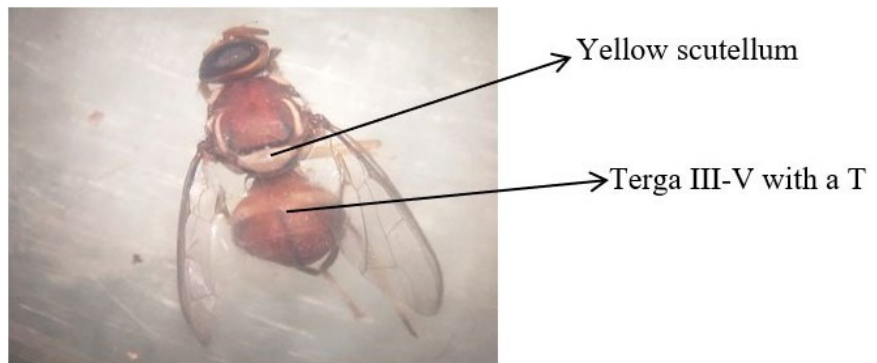


Figure 9. Illustrates the Peach Fruit Fly (*B. zonata*) species that were identified from the samples collected from the selected research locations.

3.7.4. Mediterranean Fruit Fly (*Ceratitis capitata*)

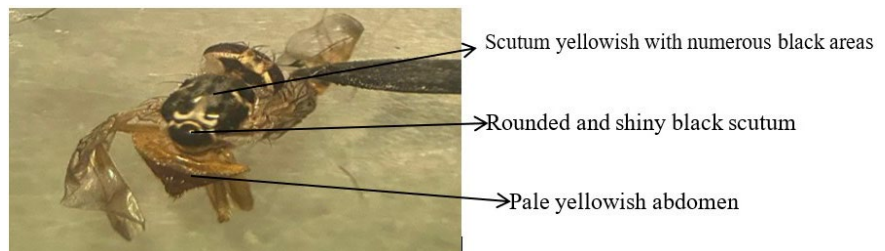


Figure 10. Shows the mediterranean fruit fly (*C. capitata*) that was identified from the specimens collected.

The Mediterranean fruit fly is a small to medium-sized insect with striking coloration. These flies possess a swollen, rounded, and shiny black scutellum marked

by a thin, sinuous yellow streak near the base on its dorsal surface. The scutum, the upper portion of the thorax, is yellowish and adorned with a distinctive pattern of numerous black areas. The abdomen is yellowish as well, but it is further distinguished by two narrow, light-colored bands running across its width. Finally, the wings of these flies are relatively broad in comparison to their length, exhibiting a cloudy yellow appearance. Three brown bands adorn the apical two-thirds of the wing, separated from one another, while smaller, irregularly shaped dark streaks reside within the cells of the proximal half (Figure 10).

3.7.5. Natal Fruit Fly (*Ceratitis rosa*)

The pale yellowish abdomen of *Ceratitis rosa* displays a distinctive morphology. Its thorax has a scutellum adorned with black and yellow markings, with the yellow lines or areas meeting the margin. Each apical scutellar seta is situated in or adjacent to a yellow stripe. The male mid-femora lack stout ventral setae, while the mid-tibiae exhibit rows of stout setae along the distal half of both the anterior and posterior edges, resulting in a feathered appearance. These characteristics distinguish *Ceratitis rosa* from most other members of its subgenus, as the feathering is confined to the distal half of the tibia and there are no stout setae on the underside of the mid-femur. Furthermore, males do not possess the spatulate head appendages typical of the subgenus *Ceratitis* (Figure 11).

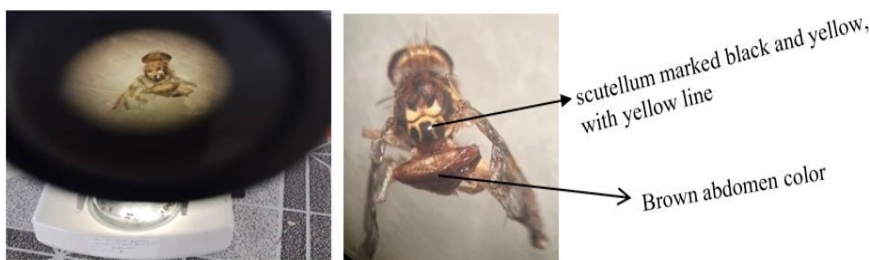


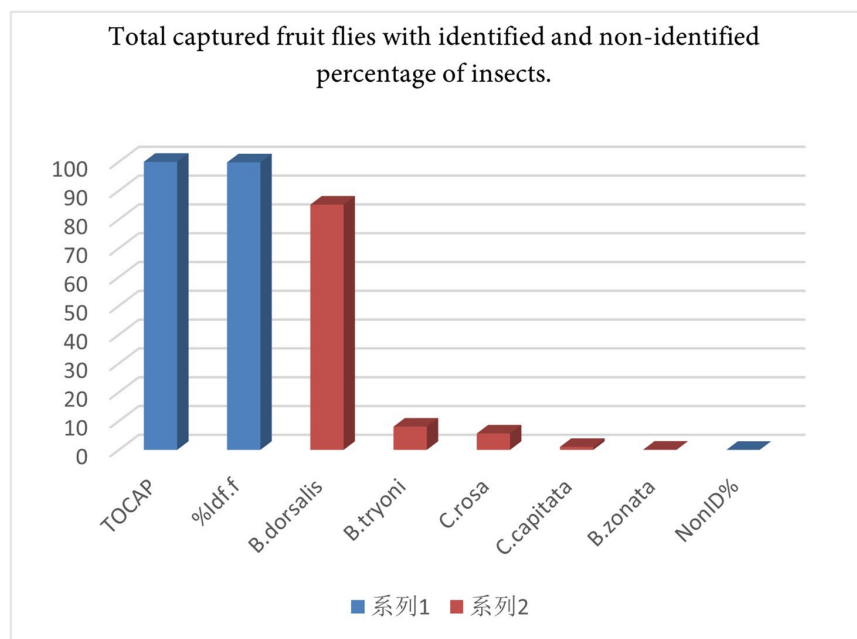
Figure 11. Shows the mediterranean fruit fly (*Ceratitis capitata*) that was identified from the specimens collected.

3.8. The Total Captured Fruit Flies with Identified and Non-Identified Percentages of Insects

A total of 12,780 fruit flies were collected, with a remarkable 99.83% identified to their species, while 0.17% remained unidentified due to some morphological similarities with other species that led to confusion, limited equipment, and the unavailability of further methods for insect identification; *i.e.*, molecular biology for insect identification and additional literature studies related to this small percentage. The identified fruit flies, comprising 99.83% of the insects, included five of the most dominant species with varying percentages. *Bactrocera dorsalis* accounted for the highest percentage at 85.15%, followed by *Bactrocera tryoni* (8.08%), *C. rosa* (5.68%), *C. capitata* (1.03%), and *B. zonata* (0.06%), which recorded the lowest percentage. Finally, the most abundant species with the highest percentage was *B. dorsalis* in both regions (Table 7 & Figure 12).

Table 7. Summary of identified and unidentified fruit flies among the total captures.

The Total Number of Fruit Flies Was 12,818.	Number of Identified Fruit Flies Was 12,758	% of Identified Fruit Flies Was 99.83	Total Number of Non-Identified F Flies Was	% of Non-Identified Fruit Flies Were
<i>B. dorsalis</i>	10,882	85.149		
<i>B. tryoni</i>	1032	8.075		
<i>C. rosa</i>	726	5.681	22	0.17%
<i>C. capitata</i>	132	1.033		
<i>B. zonata</i>	8	0.063		

**Figure 12.** Percentage distribution of identified and unidentified fruit flies in the total captures.

The results are similar to those of Field [16], who reported collecting a total of 14,480 individual fruit flies from three study sites. The *B. dorsalis* was the most common species found in all study sites, accounting for 85% of the total abundance. These were significantly different from B. Block, Fruit Fly Mania, and Liquid Food Bait, which had mean numbers of (0.2500 C, 2.2500 BC, and 0.0000 C), respectively.

3.9. Rearing of Fruit Flies in the Laboratory by Collection of Infested Mangos from Balcad Locations

Table 8 presents the results of a study on the rearing of fruit flies collected from mango fruits in four villages of the Afgoie district. The infested fruit was gathered from mangoes affected by fruit flies and reared in the laboratory of the Faculty of Agriculture at Somalia National University. Overall, 126 adult fruit flies emerged

from the mangoes. Of these, 89.68% were identified as *B. dorsalis* and 10.32% as *C. rosa*. The highest percentage of *B. dorsalis* was found in mangoes collected in Yaxasow (39.68%). In contrast, the highest rate of *C. rosa* was found in mangoes collected in Irridoley and Biyoxiren, with percentages of 3.97% and 2.38%, respectively. The study follows that of [15], who emphasised the importance of species identification for developing targeted integrated pest management strategies, as the biology and behaviour of *B. dorsalis* and *C. rosa* differ significantly, affecting control measures and timing (Figure 13).

Table 8. Rearing of fruit flies in the laboratory by collecting infested mangos from Bal'ad locations.

Locations	Number of Adults Emerged	Emerged Species			
		total no <i>B. dorsalis</i>	% of <i>B. dorsalis</i>	Total of <i>C. rosa</i>	% of <i>C. rosa</i>
Yxsow	50	50	39.68	0	0
B. bisharo	14	9	7.14	5	3.97
Irridoley	41	36	28.57	5	3.97
Biyoxiren	21	18	14.29	3	2.38
Total	126	113	89.68	13	10.32

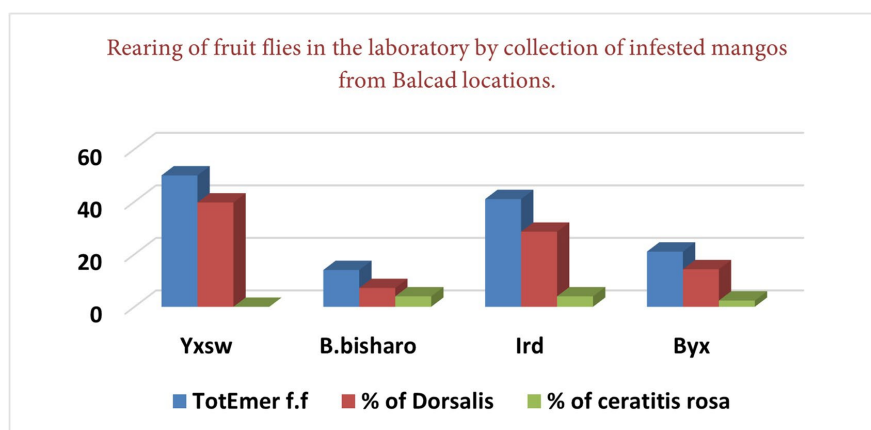


Figure 13. Laboratory rearing of fruit flies from infested mangoes collected in Bal'ad district.

3.10. Rearing Fruit Flies in the Laboratory by Collecting Infested Mangos from Afgoye Locations

Table 9 presents the results of a study on raising fruit flies collected from mango trees in four villages of the Afgoye district. The infested fruit was gathered from mangoes affected by fruit flies and reared in a laboratory at the Faculty of Agriculture of the Somali National University. Overall, 92 adult fruit flies emerged from the mangoes, with 73.56% identified as *B. dorsalis* and 26.44% as *C. rosa*. The highest percentage of *B. dorsalis* emerged from mangoes collected in Taras-matale (34.48%), while the highest percentage of *C. rosa* emerged from mangoes

collected in Balbley (13.79%) (**Figure 14**).

Table 9. Rearing of fruit flies in the laboratory by collecting infested mangos from Afgoye locations.

Locations	Number of Adults Emerged	Emerged Species			
		Total <i>B. dorsalis</i>	% <i>dorsalis</i>	Total of <i>C. rosa</i>	% <i>C. rosa</i>
Tarasmatale	41	30	34.48	6	6.9
Tarafiko	4	2	2.3	2	2.3
Bolofolio	7	4	4.6	3	3.45
Balbley	40	28	32.18	12	13.79
Total	92	64	73.56	23	26.44

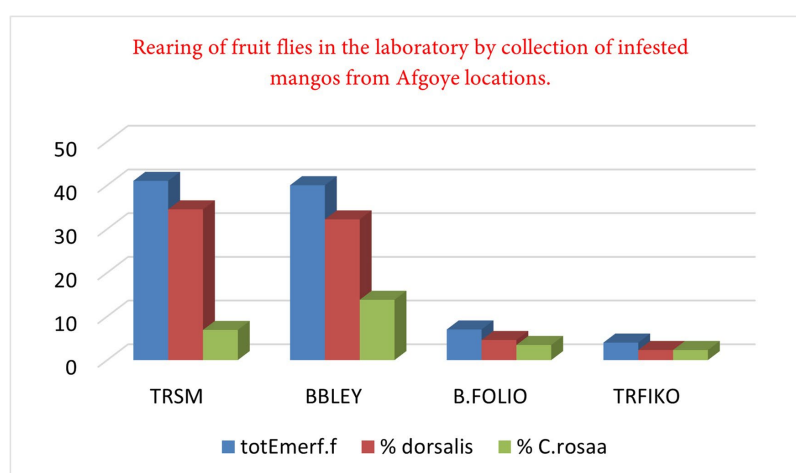


Figure 14. Laboratory rearing of fruit flies from infested mangoes collected in Afgoye district.

This result is supported by the findings of Field [16], who reported that a total of 7,064 adult fruit flies emerged from the collected fruits. *Bactrocera dorsalis* was the most abundant species, accounting for 78.89% of the total emerged adults.

The clear dominance of *Bactrocera dorsalis* in this study is consistent with its well-documented status as a highly invasive and competitively superior fruit fly species across the selected villages of Afgoye and Bal'ad District. Its broad host range, high reproductive capacity, and strong attraction to methyl eugenol-based lures enhance its detection and apparent abundance in surveillance traps. The dominance of *Bactrocera dorsalis* observed in this study is consistent with findings across East Africa, where the species was first reported in Kenya in 2003 and rapidly spread throughout the region [17]. Studies in Tanzania have demonstrated its high abundance and competitive displacement of indigenous fruit fly species, while its broad host range and adaptability in Kenya further explain its ecological dominance [18]. The main study limitations include inaccessibility of feasibility studies, limited research and identification equipment, some morphological sim-

ilarities with other species that led to confusion, and the unavailability of further methods for insect identification, *i.e.*, molecular biology for insect identification, and unavailability of additional literature studies related to this small percentage.

4. Conclusion

The abundance of fruit flies in the selected villages of Bal'ad and Afgoye was high, and all tested trap types (B. Block, C. Block, F. Fly Mania, Last Call, and Liquid Food Bait) demonstrated satisfactory attraction performance. Among these, the B. Block trap proved to be the most effective for capturing fruit flies. The study identified five fruit fly species belonging to the genera *Bactrocera* and *Ceratitis*. *Bactrocera* spp. was the most dominant genus in both Bal'ad and Afgoye orchards, particularly *Bactrocera dorsalis* and *Bactrocera tryoni*, while *Ceratitis* ranked as the second most abundant genus, especially *Ceratitis rosa* and *Ceratitis capitata*. The presence of these two dominant genera was further confirmed through laboratory rearing of fruit flies from infested mango fruits. Consequently, *Bactrocera dorsalis* and *Ceratitis rosa* emerged as the primary observed species.

Recommendations

Based on the results of this study, *Bactrocera* and *Ceratitis* traps were the most suitable tools to integrate into farmers' pest management practices. It is recommended that various tools and identification methods for fruit fly species be introduced in the country to help recognize the most harmful species. To reduce the threat of these pests, it is crucial to implement phytosanitary measures, including the Phytosanitary Strategy and Pest Risk Analysis (PRA) developed by the Ministry of Agriculture and Irrigation and Somali Agriculture Regulatory and Inspection Services (SARIS). Biological control and sanitation methods are safer and more effective than chemical control, and both government and private sectors should support and invest in these approaches. Additionally, the economic losses caused by fruit fly infestations—especially for smallholder farmers—must be quantified to raise awareness of the problem's severity.

Authors' Contributions

Abdihamid Salad Hassan: Conceptualization, formal analysis, investigation, Methodology, Resources, Software, supervision, writing - original draft, writing - review & editing.

Abdirisaq Abdulahi Farah: Conceptualization, formal analysis, investigation, methodology, resources.

Hussien Osman Hassan: Investigation, experiments, methodology, resources, Writing - original draft.

Faysal Nur Mohamed: Conceptualization, formal analysis, investigation, experimental methodology, resources.

Mohamud Ali Abdi: Conceptualization, formal analysis, investigation, methodology, writing - original draft, and resources.

Abdirahman Barre: Formal analysis, draft preparation for publication.

Anisa Hussien Hersi: Conceptualization, formal analysis, investigation, methodology, resources, software, writing - original draft.

Abdifitah Ali Abdirahman: Formal Analysis, writing - review, editing, and draft preparation for publication.

Abdi Mohamed Hussein: Review and validation.

Said Hassan Abdirahman: Investigation, data curation, writing - review & editing.

Ethical Approval and Consent to Participate

This study was approved by the Ethics Committee of the institutional review board of Somali National University and Somali Agricultural Regulatory and Inspection Services, and informed consent was obtained from all individual participants included in the study. This research was conducted ethically in accordance with the Declaration of Helsinki.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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