BIBLIOGRAPHY

MANUEL, ARNEL T. April 2011. Fermented Guava Fruit Extract as Natural Fruit Fly (Diptera: Tephtitidae) Attractant. Benguet State University La Trinidad, Benguet.

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ABSTRACT

The study was conducted to determine the effectiveness of guava fruit extract as adult fruit fly attractant, to determine the guava variety that attracts adult fruit fly, to determine the guava parts that attract adult fruit fly, to determine the ratio of the traps that attract adult fruit fly, to determine the duration of natural trap in attracting adult fruit fly and to identify other arthropods that were attracted to the guava fruit extract.

The natural guava trap was proven to be effective since it was able to trap adult fruit flies. Majority of the trapped fruit fly were female. Seven fruit fly species were trapped including *Strauzia longipennis*, *Tephritis formosa*, *Bactrocera tryoni* (Froggatt), *Bactrocera invadens* and three other *Bactrocera* species that was not identified.

Both the guava variety and the parts were able to attract male and female adult fruit fly. In the treatments, the pure fermented plant juice shows the highest number of adult fruit fly trapped.

The natural trap lasted for eight days and observed to trap the highest number of insects and other arthropods at day two and three but decreases at the following days.

A total of 60 families of insects and three other arthropods were attracted to the natural trap. The natural trap is capable of attracting any insect that has the ability to fly.

TABLE OF CONTENTS

INTRODUCTION

Fruit flies belong to the family Tephritidae in the order Diptera. The flies are widespread from sea level to mountainous areas over 7,000 feet and are one of the major pests of fruit crops all throughout the world. The fruit fly larva is the most damaging. The damage usually consists of breakdown of tissues and internal rotting due to the larval infestation. Infested young fruit becomes distorted, callused and usually drop while mature attacked fruits develop water soaked appearance. The larval tunnels provide entry points for bacteria and fungi that cause the fruit to rot. When only a few larvae develop, damage consists of an unsightly appearance and reduced marketability because of the egg laying punctures or tissue break down due to the decay (Russel, n.d).

Some techniques employed today require high cost of input such as fertilizers and pesticides. In addition, it causes environment degradation due to the excessive use of these inputs. For this, natural farming can be of major impact in helping reduce environment damage.

Insect traps baited with fruit extracts are essential for the natural control of fruit fly infestation without major loss of profit. It is safe environment friendly control method that follows a simple method of control.

The information that was gathered in the study will serve as a future reference for natural farming and as a potential substitute for the excessive use of chemicals.

The objectives of the study were to determine the effectiveness of guava fruit extract as adult fruit fly attractant, to determine the guava variety that attracts adult fruit fly, to determine the guava parts that attract adult fruit fly, to determine the ratio of the traps that attract adult fruit fly, to identify other arthropods that were attracted to the guava fruit extract and to determine the duration of natural trap in attracting adult fruit fly

The study was conducted at Balili Experimental Station, La Trinidad, Benguet from October 2010 to April 2011.

REVIEW OF LITERATURE

Biology and Behavior of Fruit Fly
(*Bactrocera dorsalis* Hendel)

The Oriental fruit fly's development is temperature dependent, developing faster in warm weather and slower in cooler weather. The Oriental fruit fly goes through a four-stage life cycle: egg, larva, pupa and adult. Breeding is continuous, with several annual generations. Adults live 90 days on average (Hungry Pests, 2010).

Egg. Female flies insert eggs under the skin of fruit in clusters of 10 to 50 about 1/25 to 1/8 inch below the fruit surface. The eggs measure about 1/25 by 1/250 inch and are white, elongate (Mau and Matin, 2007 and Dagdag, 2008) and elliptical (Mau and Matin, 2007). They hatch in 1-1/2 days. Development from egg to adult under summer conditions requires about 16 days (Mau and Matin, 2007). Likewise, Dagdag (2008) mentioned that eggs could sometimes easily be seen at the oviposition site of the female. The eggs measure from 0.9 to 1.1 mm in length with a mean of 1.06 and a width that measure about 1.0 mm and takes about two to four days to hatch.

Larvae. The white larva is legless, and resembles an elongated cone. The mouth is at the pointed end of the body (Mau and Matin, 2007). There are 3 larval stages, or instars. Mau and Matin (2007) stated that the entire larval stage lasts for 11-15 days but Dagdag (2008) mentioned that larvae will take about three to four days before turning into pupa. Just before pupating, the larvae often pop and flip to leave the fruit. The mature larva emerges from the fruit, drops to the ground, and forms a tan to dark brown puparium (Mau and Matin, 2007).

Dagdag (2008) found out that the newly hatched larva is transparent white in color and become yellowish when older. *B. dorsalis* larva is elongated and cylindrical with white anterior mouth hooks. Dagdag (2008) observed that during the third instar larva, a typical maggot like appearance that is yellowish in color is capable and keeps on jumping whenever outside of its host. In addition, upon hatching, the newly hatched larvae bores a tunnel inside its host, the tunneling process was done by waving its mouthparts towards the tissue of their host plants. The 2nd and the 3rd instar larvae were seen to be the most active feeders (Dagdag, 2008).

Pupa. The puparium is yellowish-brown (Mau and Matin, 2007 and Dagdag, 2008) and seed-like (Mau and Matin, 2007). Pupation normally occurs 1-2 inches under the soil (Dekker and Messing, n.d) and about nine days are required for attainment of sexual maturity after the adult fly emerges.

The pupa of *B. dorsalis* had its delicate integument covered with in a globular to oblong puparium. This is usually formed from the hardened skin of the last instar larvae. The newly pupated larvae measures about 4.4 to 5.2 mm in length and with a mean that ranges from 1.9 to 2.2 mm in width. The color of the pupa is dependent on the color of the soil where it pupated. The adult will emerge from the pupa within 15 to 17 days (Dagdag, 2008).

Adult. In the research of Dagdag in 2008, newly emerged adults had its abdomen flattened with a light color and a balance mixture of dark brown to black and yellow that becomes darker after a few hours. The adult *B. dorsalis* has a clavate antennae with a dorsal ocelli present on its head. It has a yellow colorings on its head and back, the back abdomen has stripes of black and yellow with a vertical black lining from the mid to the tip. The female has its ovipositor very slender and pointed. The female measures from about 7.4 to 8.9 mm in length and 2.2 to 2.8 mm in width. The male measures about 6.0 to 7.1 mm in length and a width that ranges from 1.8 to 2.4 mm. The wings of *B. dorsalis* are transparent that had a wingspan of about 12.8 to 15.2 mm for female and 12.0 to 15.1 mm for the male. For the female, it takes 39 to 61 days to live and the male has a shorter lifespan as an adult with 37 to 54 days.

The adults usually rest in shady locations feeding, mating or laying eggs. Most feed at dawn and mate at dusk. They are easily recognized with their inconsistent wing pattern (Mau and Matin, 2007).

Feeding behavior of adult. The female will insert its sharply pointed ovipositor on the fruit for the juice to come out where in they feed on it (Dagdag, 2008). According to Mau and Matin in 2007, most flies emerge between 7:00 and 10:00 in the morning and emerging adults crawl up through the soil, usually at an angle. Adult flies primarily feed during the morning hours. The fruit flies search for food in all types of vegetation, including low cover plants and shrubs, and may travel to areas where host plants do not occur. Without food, flies die within three days at an average temperature of 80 degrees Fahrenheit.

Mating behavior. According to Dagdag (2008), mating took place 7 to 15 days after the adult emergence. Males usually move closer to the female, it spreads its wings laterally and vibrates and waves it backwards and forward or courtship. Mating was usually done between 10:00 in the morning and 3:00 in the afternoon but sometimes done earlier in the morning or later in the afternoon when temperature is high. Mating period was from 10 to 60 seconds.

Oviposition behavior. Oviposition occurs one day after copulation. The female searches a site on the surface of the fruit and inserts its sharply pointed ovipositor and lays its egg within the tissue but sometimes, the eggs were laid freely inside. The site of oviposition can be easily recognized by a small pin hole that becomes brown to black within the skin of the fruit (Dagdag, 2008).

Like other fruit fly species, the oriental fruit fly prefers to deposits its eggs in old egg deposition lesions and in ripened fruit (Mau and Matin, 2007).

Reproduction and Percent Damage
of Fruit Fly (*Bactrocera dorsalis* Hendel)

The Oriental fruit fly can multiply and spread rapidly (Hungry Pests, 2010). Under optimum conditions, a female can lay more than 3,000 eggs during her lifetime, but under field conditions approximately 1,200 to 1,500 eggs per female is considered to be the usual production. Ripe fruit are preferred for egg laying but immature ones may be also attacked (Mau and Matin, 2007). The adult is a strong flier, recorded to travel 30 miles in search of food and sites to lay eggs. Females lay eggs in groups of three to 30 under the skin of host fruits; the female can lay more than 1,000 eggs in her lifetime (Hungry Pests, 2010). Due to the phytophagous habits of their larvae, many species of Tephritidae inflict heavy losses on fruit and vegetable crops. Economic effects of pest species include not only direct loss of yield and increased control costs, but also the loss of export markets and the cost of constructing and maintaining fruit treatment and eradication facilities (Norrbom, 2004).

In Hawaii, larvae have been found in more than 125 kinds of hosts. Infestations of 50 to 80% have been recorded in pear, peach, apricot, fig, and other fruits in West

Pakistan. It is the principal pest of mangoes in the Philippines. It was a serious pest of citrus and other subtropical fruits in Japan, Okinawa, and the Japanese islands of Amami, Miyako, and Bonin (Weems *et al*., 2010).

Distribution and Population Build up
of Fruitflies (*Bactrocera dorsalis* Hendel)

According to Weems *et al.* (2010), the oriental fruit fly is widespread throughout much of Pakistan, India, Sri Lanka, Sikkim, Myanmar, Indonesia (Celebes, Borneo, Sumatra, Java), Malaya, Thailand, Cambodia, Laos, Vietnam, southern China, Taiwan, Philippine Islands, Micronesia, and Mariana Islands (Guam, Rota, Saipan, Tinian).

In the Philippines, *Bactrocera dorsalis* Hendel is distributed throughout Luzon, Panay, Negros, Cebu, and Mindanao (Drew and Hancock, 2009).

Kudan (2007) monitored the population of fruit fly (*Bactrocera dorsalis* Hendel) within La Trinidad and observed highest population in January with a mean of 115.53. In February, it decreased to 90.40 and 40.20 in March. The population increased to 67.85 in April, 78.15 in May and 82.65 in June. The population rapidly decreased 2.25 in July and 2.10 in August. There was a slight increase to 4.65 in September. In October, the population further increased to 14.35, 50.25 in November and 78.05 in December.

According to Kudan (2007), the correlation of fruit fly population with the host crops that the decrease from January to March was affected by the harvesting and marketing of crops every December. The increase in April to June was due to the favorable temperature and the abrupt reduction in July to September was caused by rainfall. In the correlation of fruit fly population with weather, it was discussed that increase of fruit fly population in October to December was caused by the rise of total bright sunshine and constant low amount of rainfall. Kudan (2007) also concluded that when the temperature is high the fruit fly population increases but when relative humidity, total bright sunshine, rainfall or low temperature is high, the fruit fly population decreases.

The study of Kudan (2007) proved that fruit fly (*Bactrocera doralis* Hendel) is available throughout the year. Within La Trinidad, fruit fly population increases during the month of October and has a peak on January however it decreases in the months of July to September.

Natural Trap Against Fruit Fly

In 1999, Swicegood found that fragrant fruit attract fruit flies and other Dipterans. Swicegood added that 1 part molasses mixed with 2 parts vinegar placed in a yellow container attracts moths. The corporation Eartheasy in 2001 experimented on mixing ¼ cup syrup; 1 tbsp. granulated sugar and 1 tbsp. brown sugar in a small bowl and found attractive against Dipterans.

In 2003, Bashir et al. made a study to evaluate the fruits of guava (*Psidium guajava* L.), sidir/nabag (*Zizyphus spina-christi* L.) and mango (*Mangifera indica* L.) as food-base attractants for fruit flies capture in mango orchards. A protein hydrolyzate attractant, named ICIPE Yeast was used as standard and the control was treated with water. The results showed that all fruits proved effective for *Ceratitis cosyra* trapping. Guava and sidir showed superiority (7.4 and 3.8 adults /trap/week, respectively) over the ICIPE Yeast attractant (1.0 adult /trap/week). It was then concluded that the use of guava, sidir and mango as fruit fly base attractants could provide a cheap, safe and a low-tech alternative for the emerging problems of fruit flies.

Sumingwa (2004) mentioned that formulated attractant with a ratio of 1000 ml Fermented Plant Juice (FPJ) added with 4000 ml decocted vinegar is most effective in attracting insects. Nigg *et al.* (2005) mentioned that extracts of cattle guava was equal in attractiveness to males and females especially with Carribean fruit fly, *Anastrepha suspense* Loew. It was also suggested that host chemicals serve as attractants and the female and male specific attractant and traps could be developed from host kairomone data.

Pedigo and Rice stated in 2006 that traditional baits or food lures are considered under attract- and- kill programs. They added that wheat bran mixed with additives like molasses, chopped fruits, amyl acetate, sugar, and honey were effective for attraction of insects belonging to the order Hymenoptera: Formicidae.

In 2007, Prasad stated that traps baited with some attractive material namely fermented sugar, molasses etc. and poisoned with chemicals have also been found effective in capturing fruit fly adults. In Hawaii, Dekker and Messing (n.d) reported that homemade mixes of vinegar and water and yeast have attracted both males and females of Dipteran species.

Components of Guava Fruit

Hwang *et al.* (2002) identified the volatile organic components of ripe guava fruit through solid phase microextraction (SPME) and subsequently analyzed and identified by GC and GC-MS to develop attractant formulations for female adults of Oriental fruit fly, *Bactorcera dorsalis* (Hendel). There were 24 volatile components from guava fruits and according to bioassay results in the net house, the single component of either ethyl acetate or £]-caryophyllene more effectively attracted female and male adults of the Oriental fruit fly than any other single component.

Effect of Different Guava Cultivars
in Attracting Fruit Fly (*Bactrocera dorsalis* Hendel)

According to Prasad in 2007, the role played by shape of the guava fruit in the ovipositional behavior of *B. correcta* revealed that round big cultivars was the most resistant cultivar. Smooth skinned cultivar was found the most susceptible and fruits bell shaped and oblong were intermediate in reaction.

Prasad (2007) categorized guava cultivars on the basis of their fruit characters and percentage attack of fruit fly, *B. dorsalis*. Fruits of red flesh and seedless guava with rough and wrinkled skin had very low fruiting infestation whereas pink flesh and strawberry cultivars with rough and gritty skin respectively, exhibit low infestation. Mellow skin varieties had moderate infestation while smooth skinned and apple colored were severely infested. Significant variations were recorded among 32 different accessions for their reaction to *B. dorsalis*. Fruit morphological characters like skin surface and flesh and rough skin had less damage compared to those with white flesh and smooth skin. However, fruit shape did not show any effect on the incidence.

High levels of Vitamin C, total soluble solids and total phenols in the fruits of different guava cultivars were found to contribute the resistance to *B. correcta.* The percentage infestation of *B. dorsalis* was positively correlated to total sugars, TSS and total proteins but was negatively correlated to total phenols orthodohydroxy phenols and flavonols (Prasad, 2007).

METHODOLOGY

Materials

The materials that was used were six kilograms of unpeeled apple guava, six kilograms of peeled apple guava, two kilograms of apple guava peelings, six kilograms of unpeeled native guava, six kilograms of peeled native guava and two kilograms of native guava peelings, six trunks of banana (cardaba variety) about three meters in height, 20 kilograms of muscovado sugar, eight earthen jars, 240 pieces of 1.5 capacity softdrink plastic containers, clean sheet of manila paper, rubber band, cheese cloth, fifteen gallons of crude vinegar, wire mesh, wire, digital camera, microscope, reference books, pen and notebook.

Methods

Natural Trap. The fermented plant juice (FPJ) was prepared by cutting a trunk of banana (cardaba variety) early in the morning to ensure high quantity of water from the trunk. Likewise, the guava fruit that were used were the following and was arranged in factorial completely randomized design (CRD) with two guava varieties namely apple guava and native guava as factor A and six kilograms of each different guava fruit parts except the peelings (two kilograms was used) as factor B.

Factor A = Guava Variety

V_1 – Apple guava

V_2 – Native guava

Factor B = Parts of the Guava Fruit

P_1 – Peelings of the Guava Fruit

P_2 – Peeled Guava Fruit

P_3 – Unpeeled Guava Fruit

The banana trunk and the two varieties of guava fruit (peelings, peeled and unpeeled) was finely chopped into 1 cm^2 in size (Figure 1a). For every one kilogram of chopped banana trunk (Figure 1b), one kilogram of chopped guava fruit was added (Figure 1c). Also, for every two kilograms of mixed chopped banana trunk and chopped guava fruit, one kilogram of fine grinded muscovado sugar was mixed (Figure 1d); separate for each of the factors stated. The ingredients were then mixed (Figure 1e). It was covered with clean manila paper and was tied with a rubber band (Figure 2a). The earthen was placed in a dry shaded place away from direct sunlight (Figure 2b).

Figure 1. Preparation of FPJ. a. Chopping the banana trunk and guava into appropriate sizes, b. Chopped banana trunk poured into the earthen jar, c. Chopped guava poured into the earthen jar, d. Adding the muscovado sugar, e. Mixing of the chopped banana trunk, guava and muscovado sugar, f. native guava after mixing, g. apple guava after mixing.

After two weeks (Figures 2c and 2d), it was extracted. The liquid was sieved in a clean cheese cloth (Figure 2e).

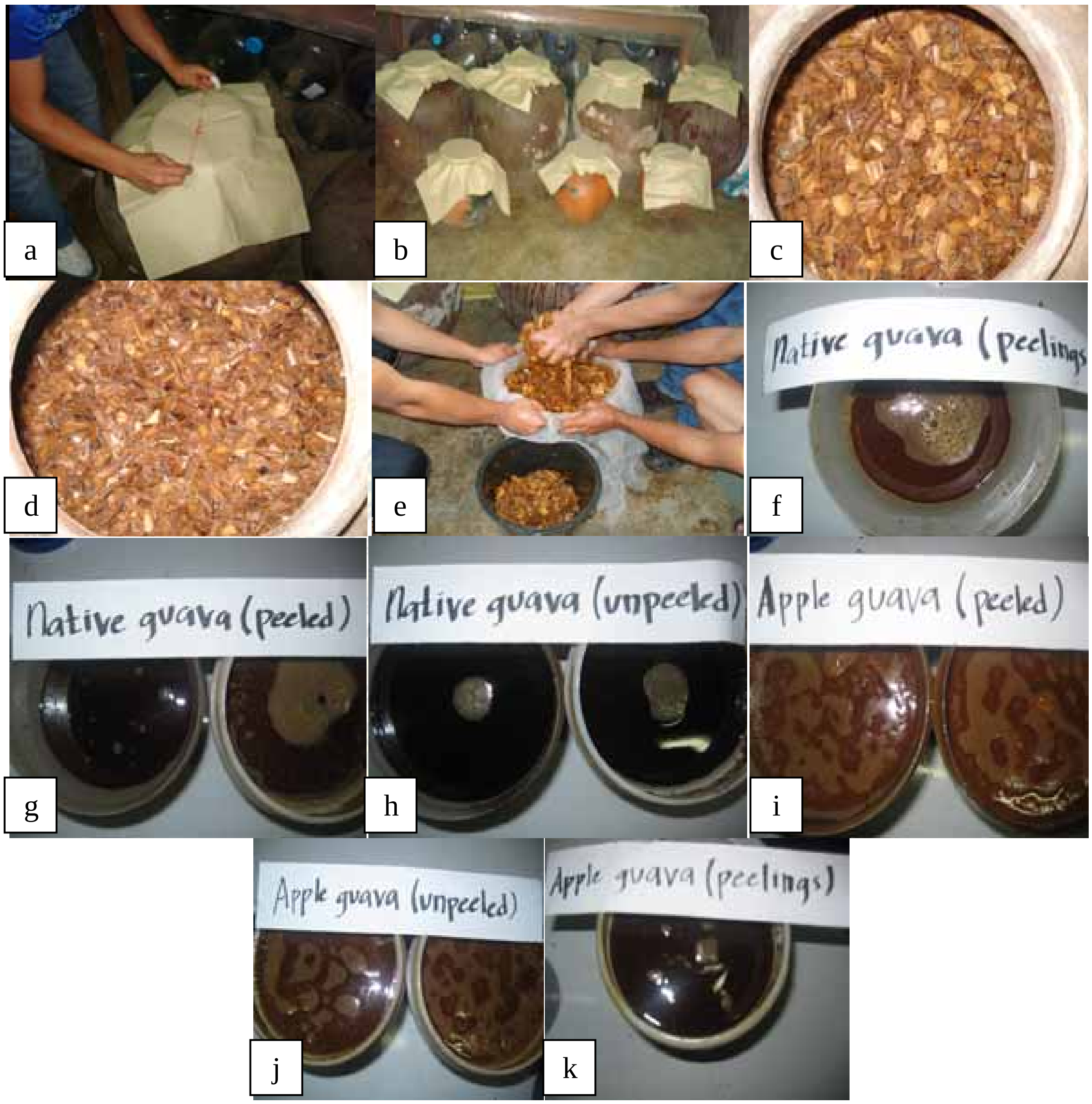


Figure 2. Fermentation and extraction of FPJ. a. Covering the earthen jar containing the mixture with manila paper fixed with rubber band, b. The mixture stored in an area away from direct sunlight, c. Native guava mixture after 14 days, d. Apple guava mixture after 14 days, e. Extracting the FPJ, f-h. The native guava extract, i-k. The apple guava extract

The vinegar juice (VJ) was prepared by mixing a total of 500 grams of muscovado sugar for every gallon of sugarcane crude vinegar (Figures 3a and 3b). It was heated for about 30 minutes and was set aside to cool (Figure 3c).

The vinegar juice was used to increase the potency of the fermented plant juice in attracting insects. In addition, it is believed to prevent beneficial Hymenopterans from being attracted and trapped.

The fermented FPJ was mixed with the prepared VJ (Figure 4a and 4b) following the proportion:

T_0 – 200 ml water (control)

T_1 – 200 ml VJ

T_2 – 200 ml FPJ

T_3 – 20 ml FPJ + 200 ml VJ

T_4 – 40 ml FPJ + 200 ml VJ

T_5 – 60 ml FPJ + 200 ml VJ

T_6 – 80 ml FPJ + 200 ml VJ

T_7 – 100 ml FPJ + 200 ml VJ

Figure 3. Preparation of vinegar juice (VJ). a. Boiling of crude vinegar, b. Addition of muscovado sugar, c. The vinegar juice

In making the trapping material, the softdrink plastic container with 1.5 liter capacity was used for all the different treatments as trapping container. Two window structures were cut from each side leaving atleast 10 cm from the bottom and atleast one inch gap from the two windows. The upper part was left uncut. The windows were lifted at an angle to make an opening. A circular Styrofoam plate was placed on top of the plastic container to avoid rain from contaminating the trap formulation. A wire was attached to the cap of the container for hanging purposes (4c). The different treatments were poured into the trapping container and hanged atleast two feet high from the ground in the five different locations (4d).

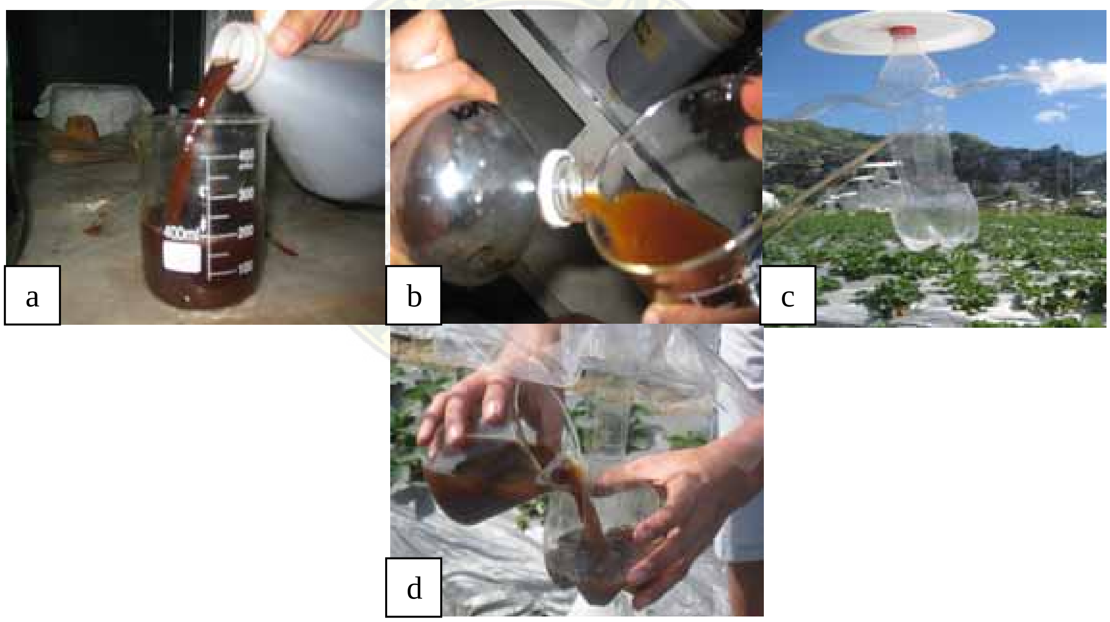


Figure 4. Preparation of the natural trap. a. Mixing the VJ with the FPJ, b. The trapping material, c. Pouring the natural trap into the trapping material.

The treatments were done separately with the native guava and the apple guava to have a total of 16 treatments. The peelings, peeled and unpeeled native guava and the apple guava was separated to have a total of 48. Each of the treatment was replicated five times to come up with 240 traps. The replication one was placed in guava trees located at the BSU pomology (Figure 5a), replication two was placed in the chayote plantation (Figure 5b), replication three was placed in a strawberry plantation (Figure 5c), replication four was at cape gooseberry (Figure 5d) plants and replication five was at the guava tree located at BSU Mites Predatory Rearing House (MPRH) (Figure 5e).

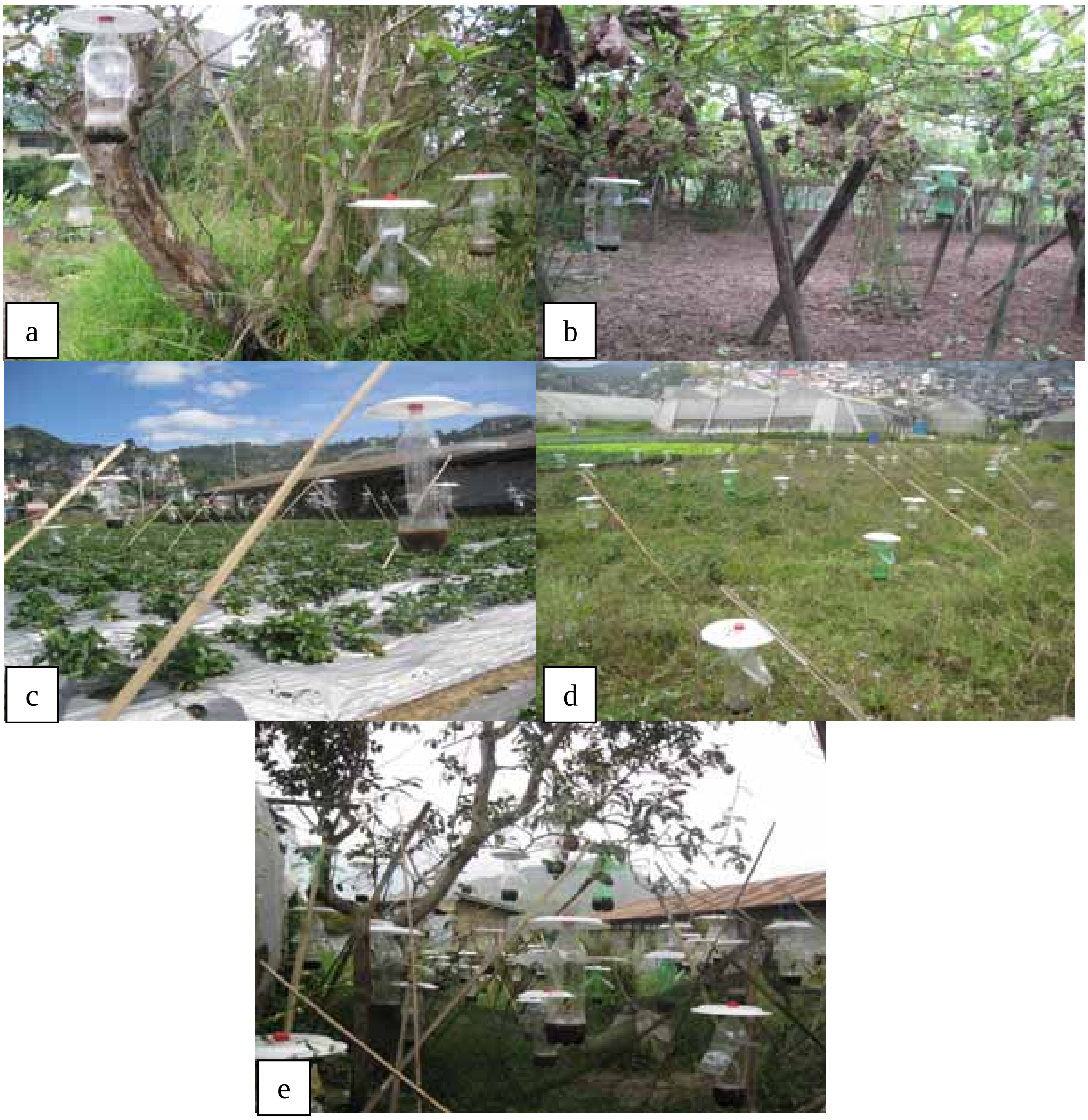


Figure 5. The trapping sites. a. Trapping site at guava (Pomology), b.Trapping site at chayote, c. Trapping site at strawberry, d. Trapping site at cape

gooseberry, e. Trapping site at guava (MPRH)

<u>Collection and Identification</u>
<u>of Trapped Fruit Fly</u>

The trapped fruit fly was scooped with a wire mesh, transferred in a plastic container (Figure 6) and was counted visually for every treatment. One representative for each fruit fly trapped was collected and was identified with the use of microscope (Figure 7). The identification of male and female was based on its ovipositor. For the species, the wing venation and the thorax banding was the primary basis. It was compared to reference books and was documented with the use of a digital camera. The number of fruit fly trapped for each species was the basis for its efficiency.

Figure 6. Collecting the trapped insects and other arthropods with the use of a scoop

Figure 7. Identification of the trapped insects and

other arthropods

Comparing the Two Guava Varieties
(Apple Guava and Native Guava)
in Trapping Fruit Fly and Other
Arthropods

The trapped insects for the different varieties of guava were counted separately. The effectiveness was compared in terms of the number of arthropods and fruit fly trapped and its longevity.

Comparing the Effectiveness of the Unpeeled, Peeled
and Peelings of Guava in Trapping Fruit Fly
and Other Arthropods

The trapped insects for the unpeeled, peeled and peeling of native guava and apple guava was determined based on the number of counted insects trapped.

Comparing the Different Proportion
of the Natural Trap (VJ and FPJ)
in Trapping Fruit Fly and Other Arthropods

For each treatment, the trapped fruit fly and other arthropods were counted. The effectiveness was compared in terms of the number of fruit fly species trapped and the family of arthropods trapped.

Collection and Identification
of Other Trapped Arthropods

Other insects or arthropods trapped was collected and brought to the laboratory for identification up to family using microscope.

Determining the Duration of Consumption
of the Natural Trap

The natural trap was observed daily from the time it attracts fruit fly and other arthropods until it was totally consumed. The date of observations was noted.

Data Gathered

1. Total number of fruit fly trapped. The population count of fruit fly and other arthropods trapped on the different treatments everyday.

2. Total number of trapped male and female fruit fly. The ratio of male and female fruit fly.

3. Species of fruit fly trapped. The identification of fruit fly trapped is up to the species.

4. Number of family of other arthropods attracted. Identification of trapped arthropods up to family.

5. Duration of consumption. The time until the trap is totally consumed.

RESULTS AND DISCUSSION

Total Number of Fruit fly Trapped

There were less number of fruit flies trapped due to the decline in population of fruit fly in months of February and March and trapping was done in this months. This statement corroborates with the study of Kudan (2007) that population density of fruit fly decreased during the months of February and March in La Trinidad.

The total number of trapped male and female fruit fly is presented in table 1. There was more female fruit fly trapped as compared with the male. This is because the female fruit fly requires more food to support its egg development and searches for oviposition site on ripened fruits. This corroborated with the study of Dagdag in 2008 that female searches a site on the surface of the fruit and inserts its sharply pointed ovipositor and lays its egg within the tissue. Due to this behavior of female fruit fly, mated female are more attracted to the fermented fruit juice. Results have also shown that the fermented guava fruit extract is capable of attracting both male and female fruit fly. The result corroborated with the study of Nigg *et al.* in 2005 that extracts of cattle guava was equal in attractiveness to males and females of Caribbean fruit fly. The result supported the study of Hwang *et al.* (2007) that a volatile component of guava fruits attracted male and female adults of oriental fruit fly. It also corroborate with the report of Dekker and Messing (n.d) that mixes of vinegar, water and yeast have attracted both males and females of Dipteran species which includes fruit fly.

Table 1. Total number of trapped male and female fruit fly

FRUIT FLY SPECIES	SEX OF FRUIT FLY		TOTAL
	MALE	FEMALE	
Strauzia longipennis	0	2	2
Tephritis formosa	1	0	1
Bactrocera tryoni (Froggatt)	3	9	12
Bactrocera invadens	0	1	1
Bactrocera sp. 1	1	5	6
Bactrocera sp. 2	1	4	5
Bactrocera sp. 3	1	0	1

Fruit fly Trapped

There were a total of seven fruit fly species trapped from the formulated guava attractants. These were *Strauzia longipennis* (Figure 8a), *Tephritis formosa* (Figure 8b), *Bactrocera tryoni* (Froggatt) (Figure 8c-d), *Bactrocera invadens* (Figure 8e) and three other *Bactrocera* species (Figure 8f-j) that were not identified. Fruit fly trapped is shown in the figures below:

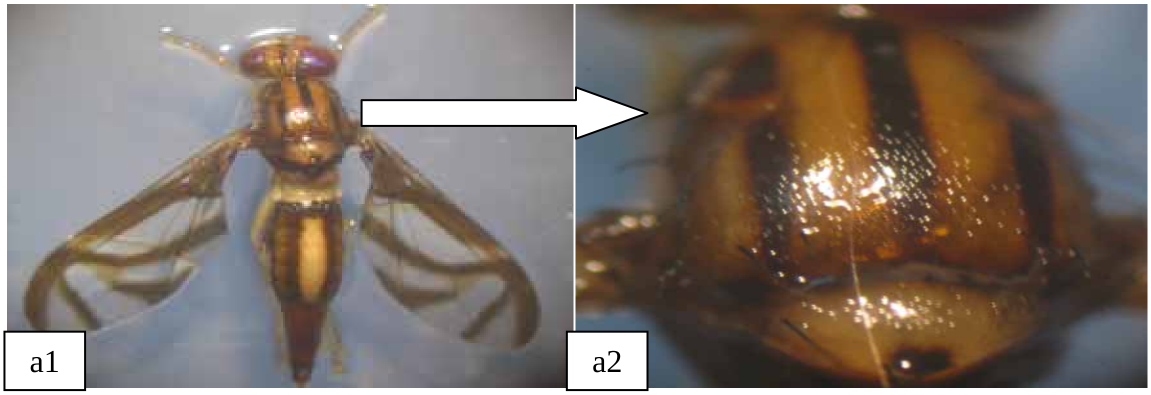
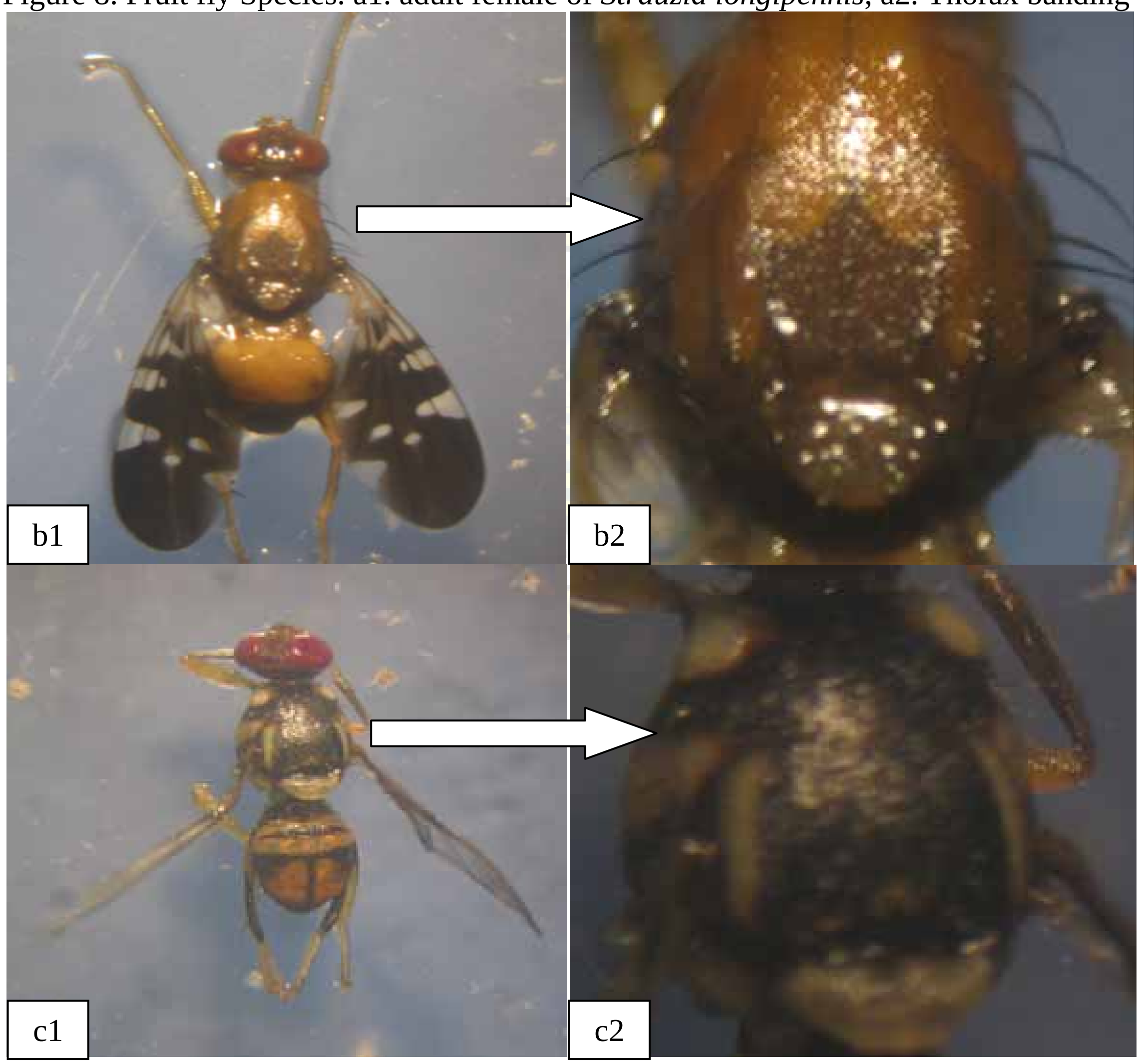


Figure 8. Fruit fly Species. a1. adult female of *Strauzia longipennis*, a2. Thorax banding



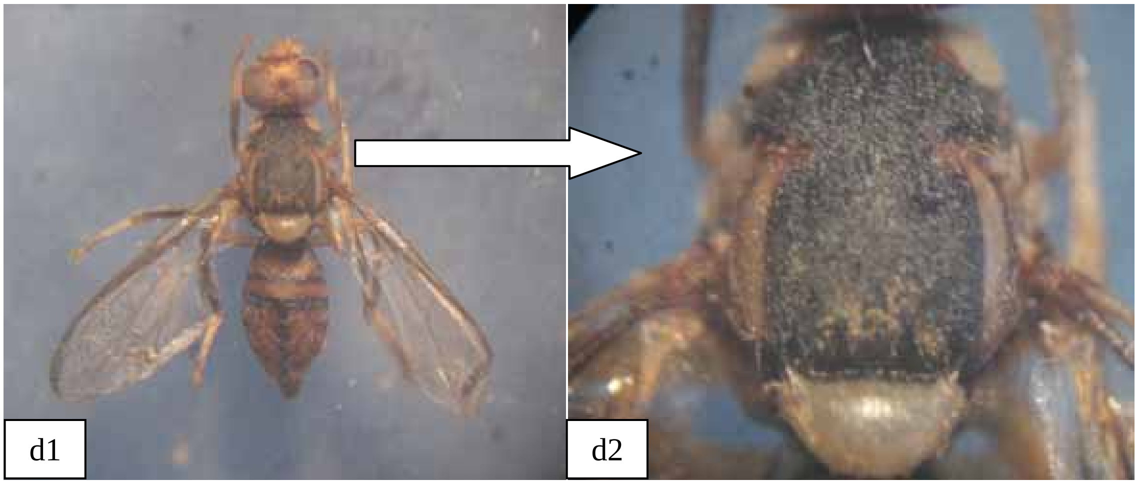
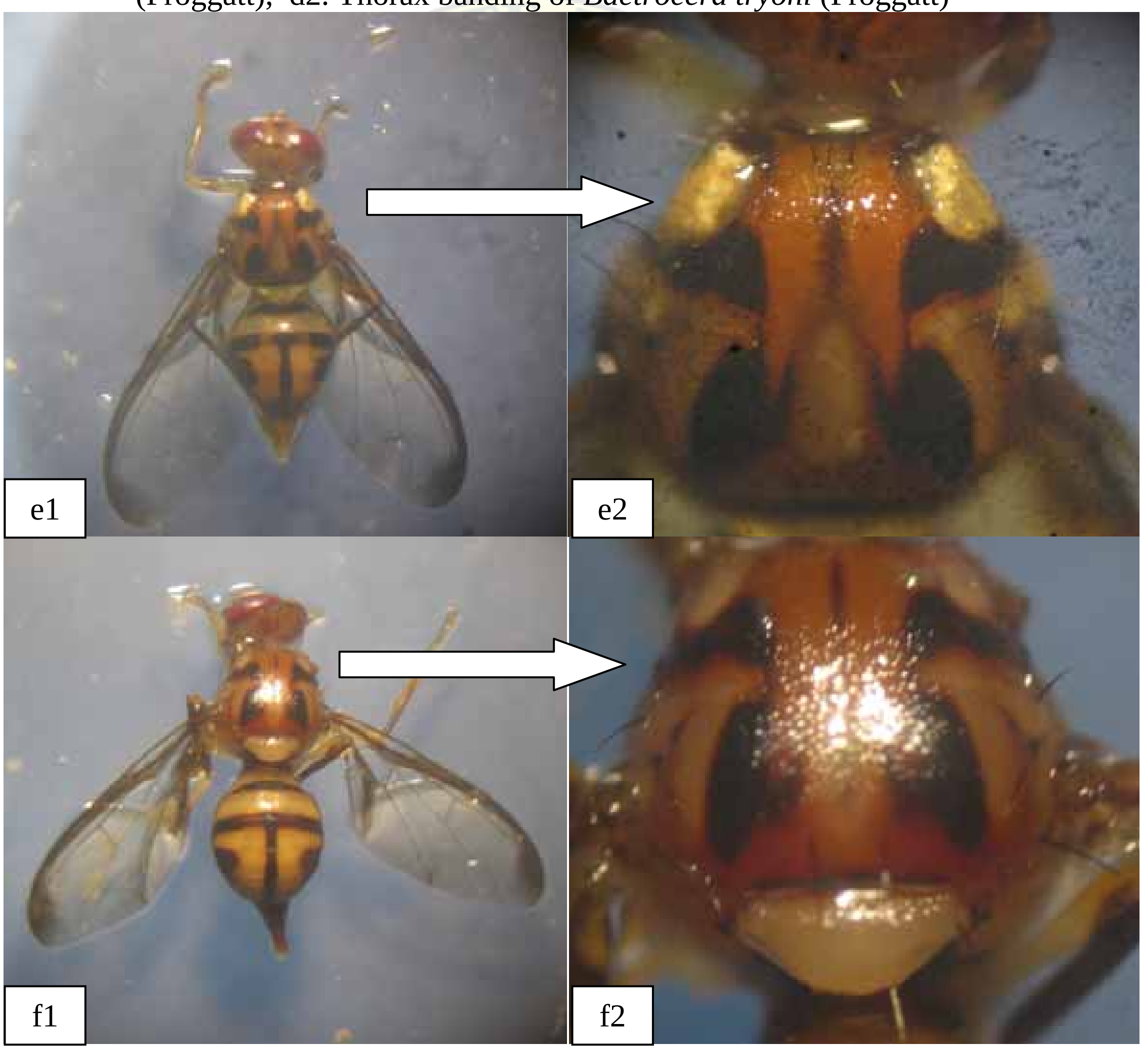


Figure 8a. b1. Adult male of *Tephritis formosa*, b2. Thorax banding of *Tephritis formosa*, c1. Adult male of *Bactrocera tryoni* (Froggatt), c2. Thorax banding of *Bactrocera tryoni* (Froggatt), d1. Adult female *Bactrocera tryoni* (Froggatt), d2. Thorax banding of *Bactrocera tryoni* (Froggatt)



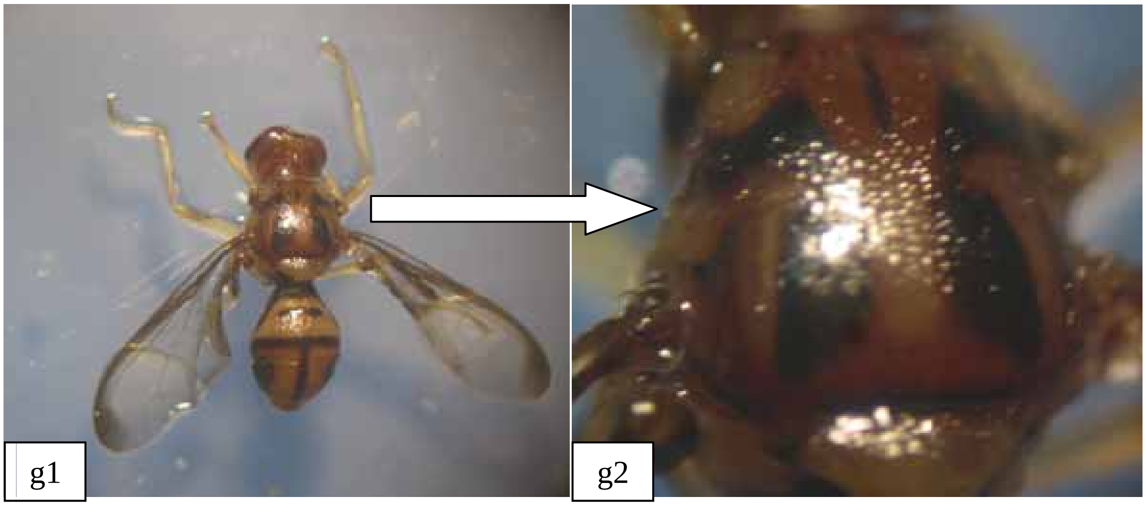
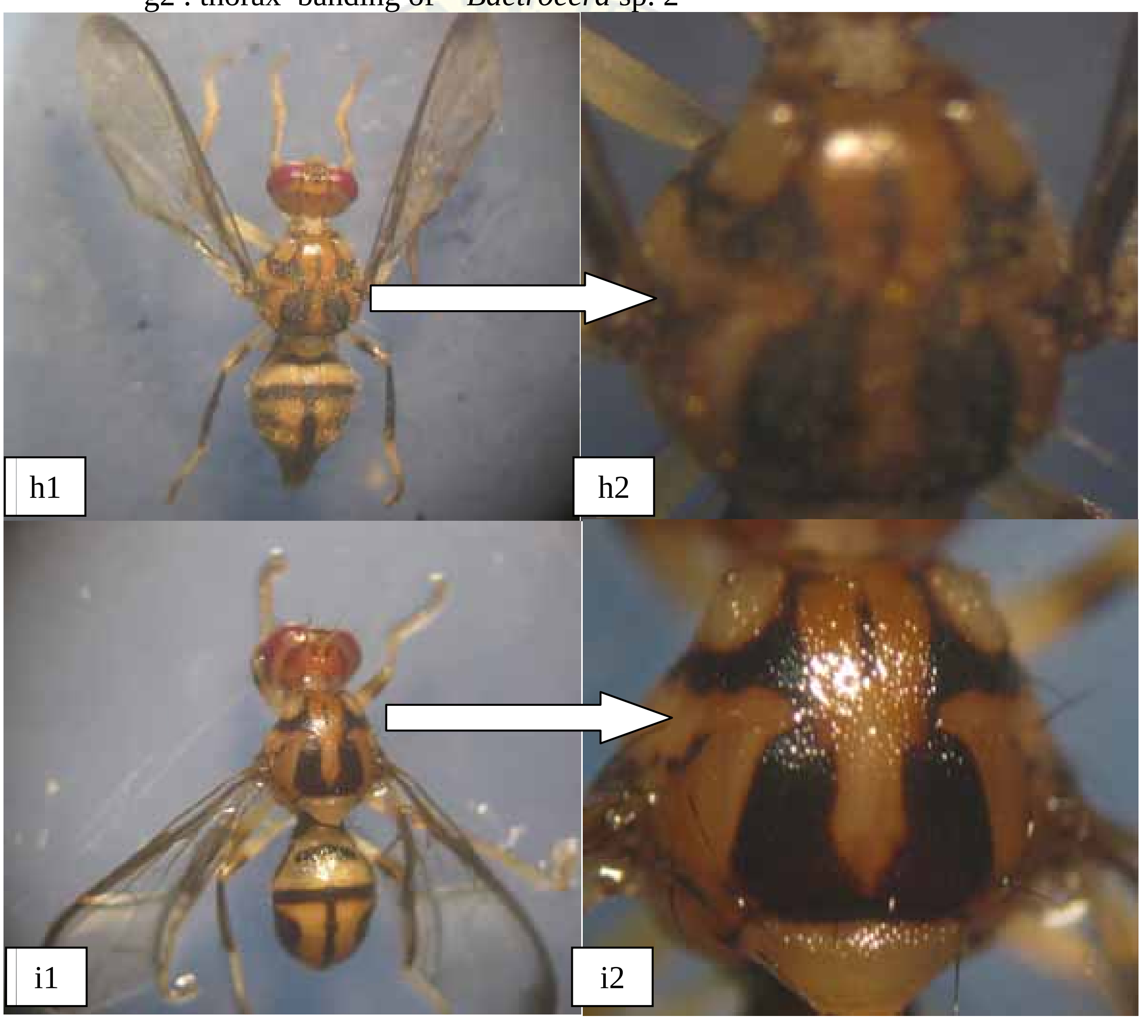


Figure 8b. e1. Adult female of *Bactrocera invadens*, e2. Thorax banding of *Bactrocera invadens*, f1. Adult female of *Bactrocera* sp. 2, f2. Thorax banding of *Bactrocera* sp. 2, g1. Adult male of *Bactrocera* sp. 2, g2 . thorax banding of *Bactrocera* sp. 2



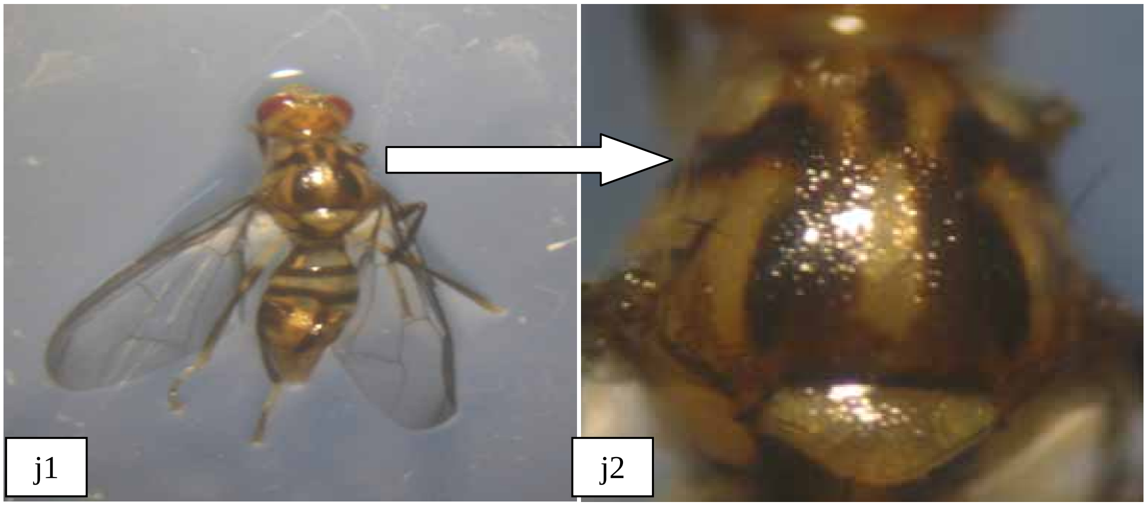


Figure 8c. h1. Adult female *Bactrocera* sp 3, h2. Thorax banding of *Bactrocera* sp. 3 i1. Adult male of *Bactrocera* sp. 3, i2. Thorax banding of *Bactrocera* sp. 2, j1. Adult male *Bactrocera* sp .2, j2. Thorax banding of *Bactrocera* sp. 3

Total Number of Fruit fly Trapped
in each Guava Variety,
Parts and Treatments

The mean of fruit fly trapped in the two guava variety, the apple guava and native guava is presented in Table 2. Apple guava attracted the most number of fruit fly but was not significantly different from native guava through analysis of variance. This implies that in trapping fruit flies, either apple guava or native guava can be used. The result corroborated with the study of Bashir in 2003 that guava (*Psidium guajava* L.) as attractant has proved to be effective in trapping fruit fly.

The mean of fruit fly trapped in each guava fruit parts is presented in Table 3. Results have shown that there is no statistical difference on the different guava fruit parts in attracting fruit fly.

Either the peelings, peeled or unpeeled guava fruit can be used for fermentation in making the natural trap. The result corroborated with the study of Swicegood in 1999 that fragrant fruit attracts fruit flies.

Table 2. The mean of fruit fly trapped in each guava variety

GUAVA VARIETY	MEAN
V_1 – Apple Guava	0.17[a]
V_2 – Native Guava	0.07[a]

*Mean with the same letter is not significantly different at 5% level of DMRT

The mean of fruit fly trapped in each treatment is presented on Table 4. The treatments have shown no significant differences but the pure FPJ trapped the highest number of fruit fly. Fruit flies were known to feed on the juice released from fruits (Dagdag, 2008) which implies that the fruit flies have favored the pure FPJ. Prasad in 2007 also stated that traps baited with attractive material fermented sugar and molasses is effective in trapping fruit fly.

Table 3. The mean of fruit fly trapped in each guava fruit parts

GUAVA FRUIT PARTS	MEAN
P_1 – Peelings	0.13^{a}
P_2 – Peeled	0.11^{a}
P_3 – Unpeeled	0.11^{a}

* Mean with the same letter is not significantly different at 5% level of DMRT

Table 4. The mean of fruit fly trapped in each treatment

TREATMENTS	MEAN
T_0 - Water	0.00^{c}
T_1 - 200 ml VJ	0.03^{bc}
T_2 - 200 ml FPJ	0.37^{a}
T_3 - 20 ml FPJ + 200 ml VJ	0.13^{bc}
T_4 - 40 ml FPJ + 200 ml VJ	0.23^{ab}
T_5 - 60 ml FPJ + 200 ml VJ	0.00^{c}
T_6 - 80 ml FPJ + 200 ml VJ	0.10^{bc}
T_7 - 100 ml FPJ + 200 ml VJ	0.07^{bc}

* Mean with the same letter is not significantly different at 5% level of DMRT

Family of Other Arthropods Trapped

There were 59 families of insects that were identified and three other arthropods. Bruchidae (Figure 9a), Cerambycidae (Figure 9b), Chrysomelidae (Figure 9c-f), Curculionidae (Figure 9g-i), Elateridae (Figure 9j), Meloidae (Figure 9k-l), Nitidulidae (Figure 9m-o), Scarabaedae (Figure 9p), Anthicidae (Figure 10a), Carabidae (Figure 10b), Coccinellidae (Figure 10c-h), Staphilinidae (Figure 10i-l), Calliphoridae (Figure 11a-b), Chironomidae (Figure 11c), Culicidae (Figure 11d), Drosophilidae (Figure 11e-f), Muscidae (Figure 11g), Psychodidae (Figure 11h), Sarcophagidae (Figure 11i), Tabanidae (Figure 11j), Tipulidae (Figure 11k-l), Micropezidae (Figure 12a-b), Dolichopodidae (Figure 12c-d), Scatopsidae (Figure 12e), Sepsidae (Figure 12f-h), Syrphidae (Figure 12i), Alydidae (Figure 13a), Aleyrodidae (Figure 13b), Aphididae (Figure 13c), Cercopidae (Figure 13d-e), Cicadellidae (Figure 13f-g), Membracidae (Figure 13h), Pentatomidae (Figure 13i), Geocoridae (Figure 14a), Microphysidae (Figure 14b), Apidae (Figure 15a-b), Braconidae (Figure 15c-g), Chalcididae (Figure 15 h-i), Ichneumonidae (Figure 15j-o), Pompilidae (Figure 15p), Vespidae (Figure 15q-r), Formicidae (Figure 16a-b), Hemerobiidae (Figure 17a), Chrysopidae (Figure 17b), Acrididae (Figure 18a), Gryllidae (Figure 18b), Tettigoniidae (Figure 18c-d), Psocidae (Figure 19a), Termitidae (Figure 20a) Forficulidae (Figure 21a), Arctiidae (Figure 22a), Noctuidae (Figure 22b-c), Nymphalidae (Figure 22d), Pterophoridae (Figure 22e), Plutellidae (Figure 22f), Sesiidae (Figure 22g), Sphingidae (Figure 22h-i), Papilionidae (Figure 23a), Blatellidae (Figure 24a), and three other arthropods namely mite (Figure 25a), pill bug (Figure 25b) and spider (Figure 25c).

Order Coleoptera

Non-beneficial Coleoptera

Figure 9. Non-beneficial Coleopterans. a. Bruchidae, b. Cerambycidae, c-f. Chrysomelidae, g-i. Curculionidae, j . Elateridae, k-l. Meloidae, m-o. Nitidulidae, p. Scarabaedae

Beneficial Coleoptera

Figure 10. Beneficial Coleopterans. a. Anthicidae, b. Carabidae, c-h. Coccinellidae, i-l. Staphilinidae

Order Diptera

Non- beneficial Diptera

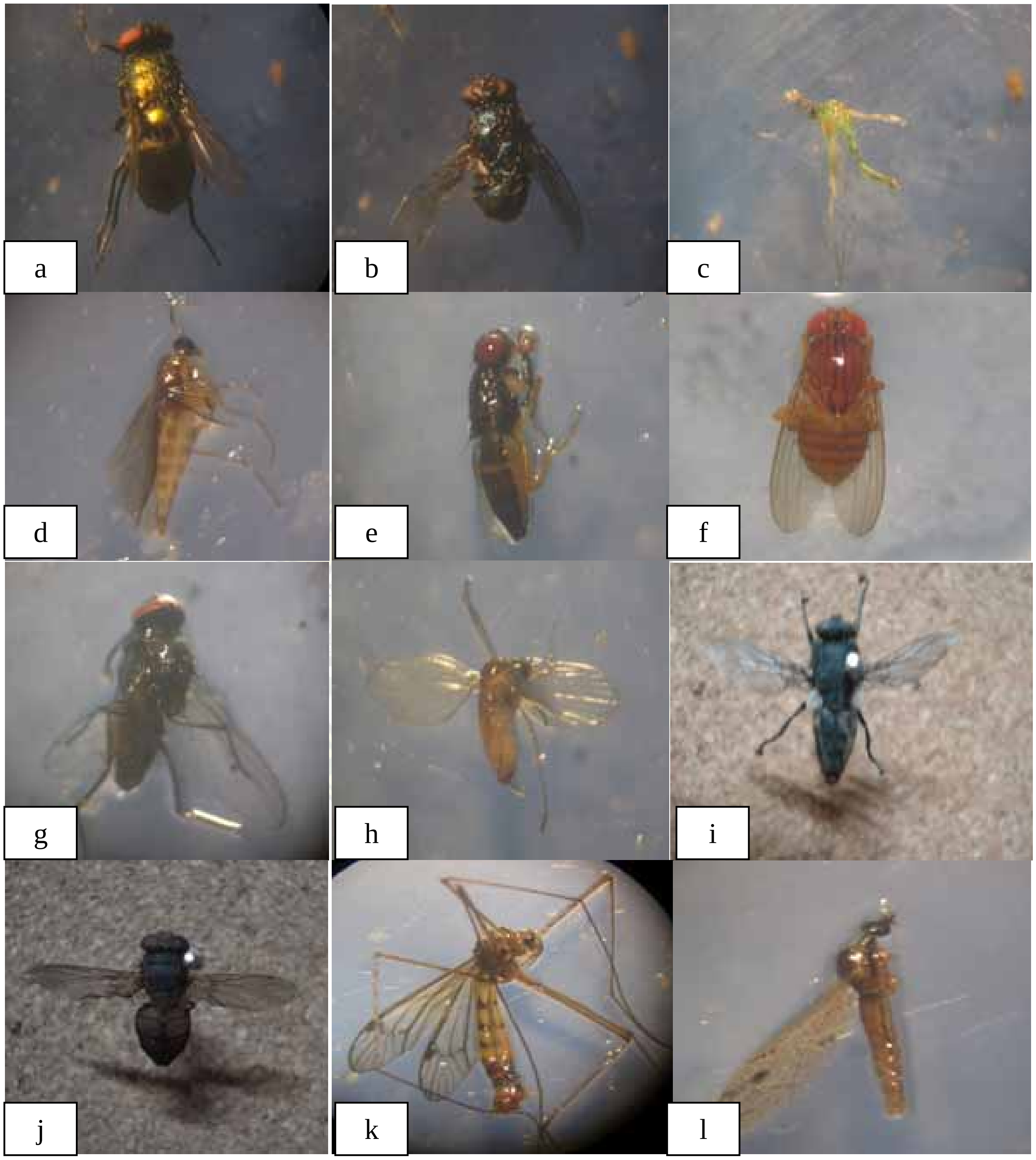


Figure 11. Non-beneficial Dipterans. a-b. Calliphoridae, c. Chironomidae, d. Culicidae, e-f. Drosophilidae, g. Muscidae, h. Psychodidae, i. Sarcophagidae, j. Tabanidae, k-l. Tipulidae

Beneficial Diptera

Figure 12. Beneficial Dipterans. a-b. Micropezidae, c-d. Dolichopodidae, e.Scatopsidae, f-h. Sepsidae, i. Syrphidae

Order Hemiptera

Non- beneficial Hemiptera

Figure 13. Non-beneficial Hemipterans. a. Alydidae, b. Aleyrodiae, c. Aphididae, d-e. Cercopidae, f-g. Cicadellidae, h. Membracidae, i. Pentatomidae.

Beneficial Hemiptera

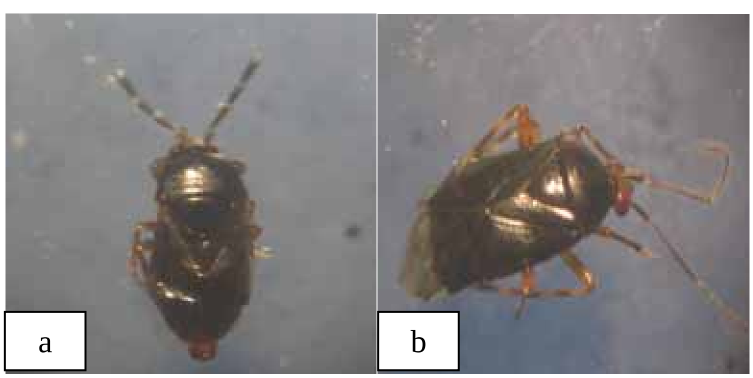


Figure 14. Beneficial Hemipterans. a. Geocoridae, b. Microphysidae

Order Hymenoptera

Beneficial Hymenoptera

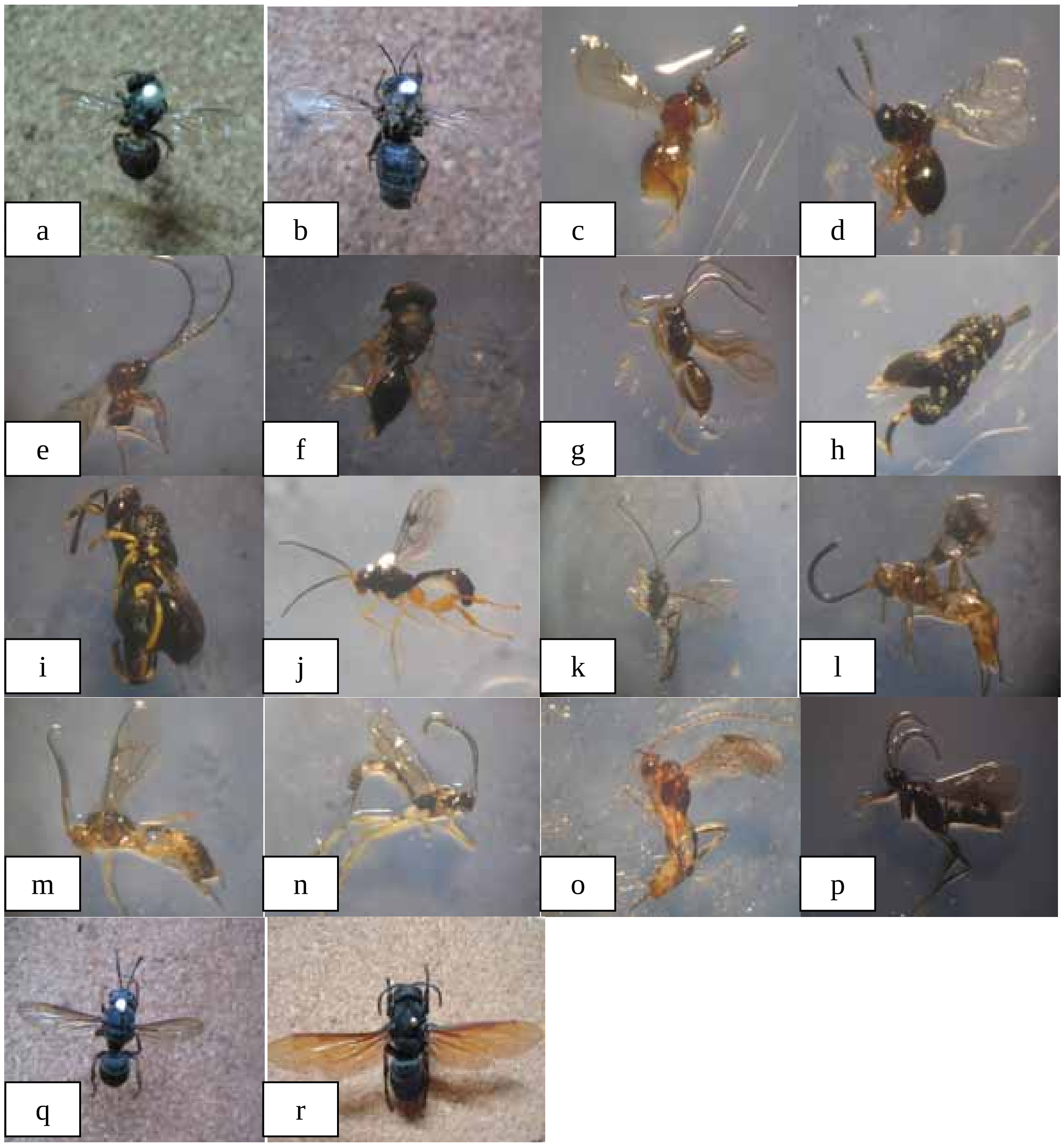


Figure 15. Beneficial Hymenopterans. a-b. Apidae, c-g. Braconidae, h-i. Chalcididae, j-o. Ichneumonidae, p. Pompilidae, q-r. Vespidae

Non-beneficial Hymenoptera

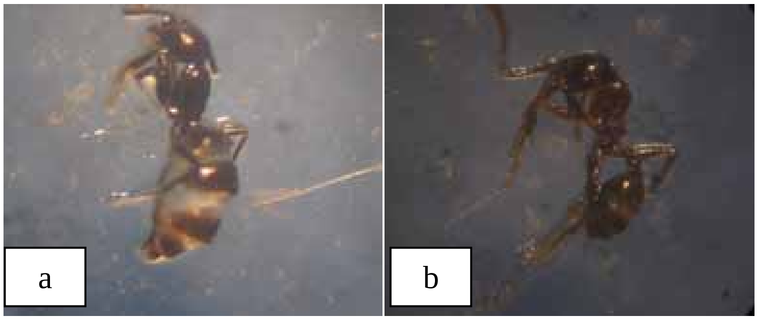


Figure 16. Non Beneficial Hymenopterans. a-b. Formicidae

Order Neuroptera

Beneficial Neuroptera

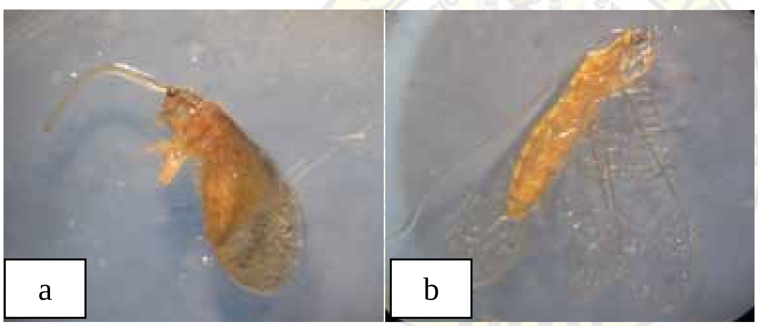


Figure 17. Beneficial Neuropterans. a. Hemerobiidae, b. Chrysopidae

Order Orthoptera

Non-beneficial Orthoptera

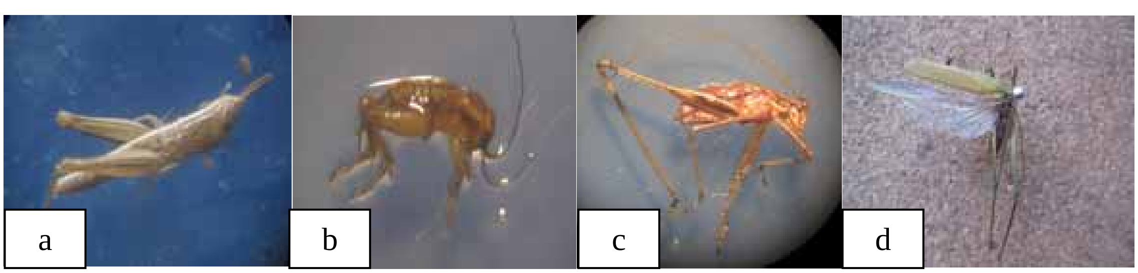


Figure 18. Non Beneficial Orthopterans. a. Acrididae, b. Gryllidae, c-d. Tettigoniidae

Order Psocoptera

Non-beneficial Psocoptera

Figure 19. Non Beneficial Psocoptera. a. Psocidae

Order Isoptera

Non-beneficial Isoptera

Figure 20. Non Beneficial Isoptera. a. Termitidae

Order Dermaptera

Beneficial Dermaptera

Figure 21. Beneficial Dermaptera. a. Forficulidae

Order Lepidoptera

Non-beneficial Lepidoptera

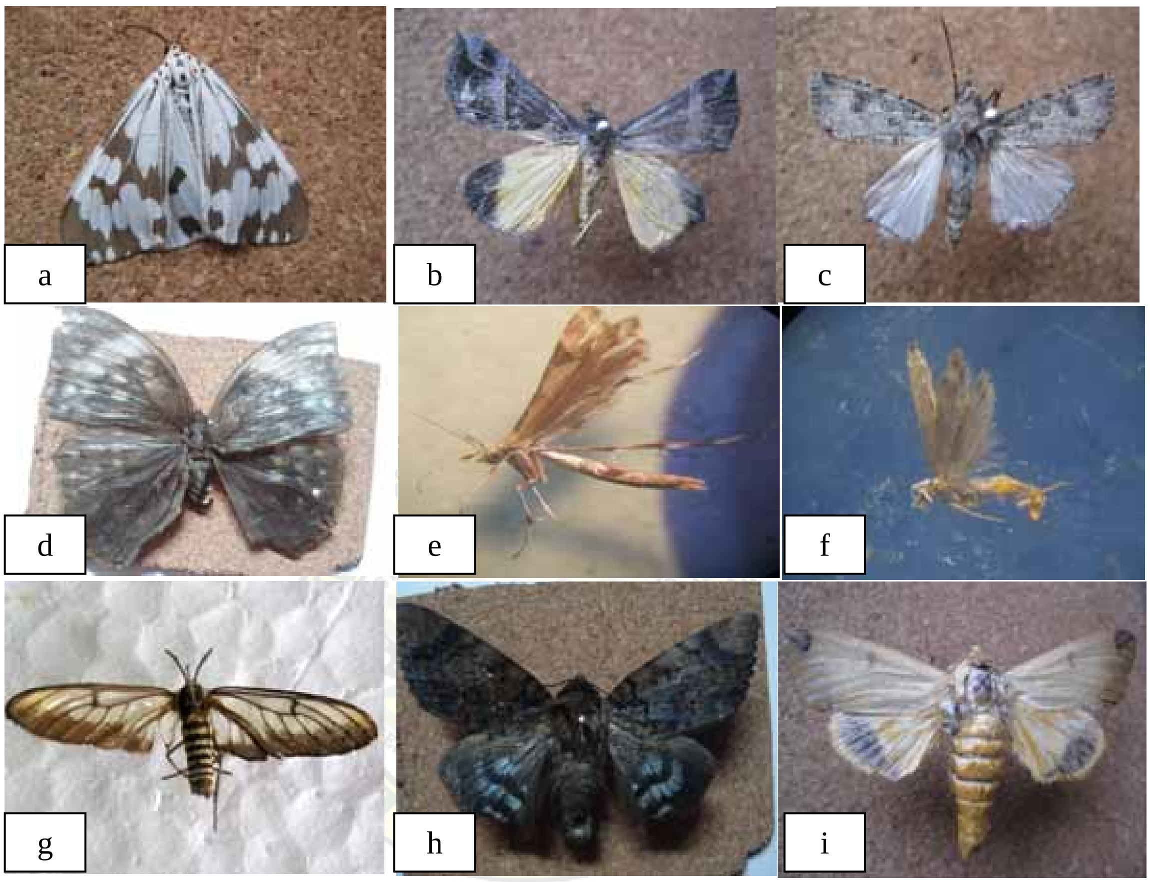


Figure 22. Non Beneficial Lepidoptera. a. Arctiidae, b-c. Noctuidae, d. Nymphalidae, e. Pterophoridae, f. Plutellidae, g. Sesiidae, h-i. Sphingidae

Beneficial Lepidoptera

Figure 23.Beneficial Lepidoptera. a. Papilionidae

Order Blattodea

Non-beneficial Blattodea

Figure 24. Non Beneficial Blattodea. a. Blatellidae

Other arthropods

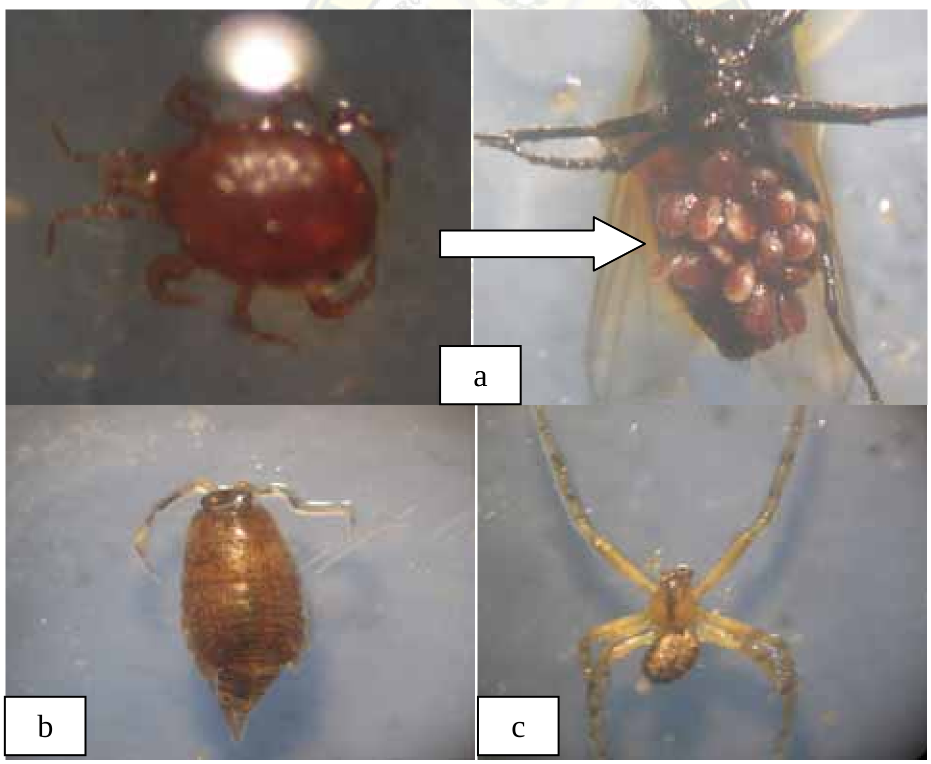
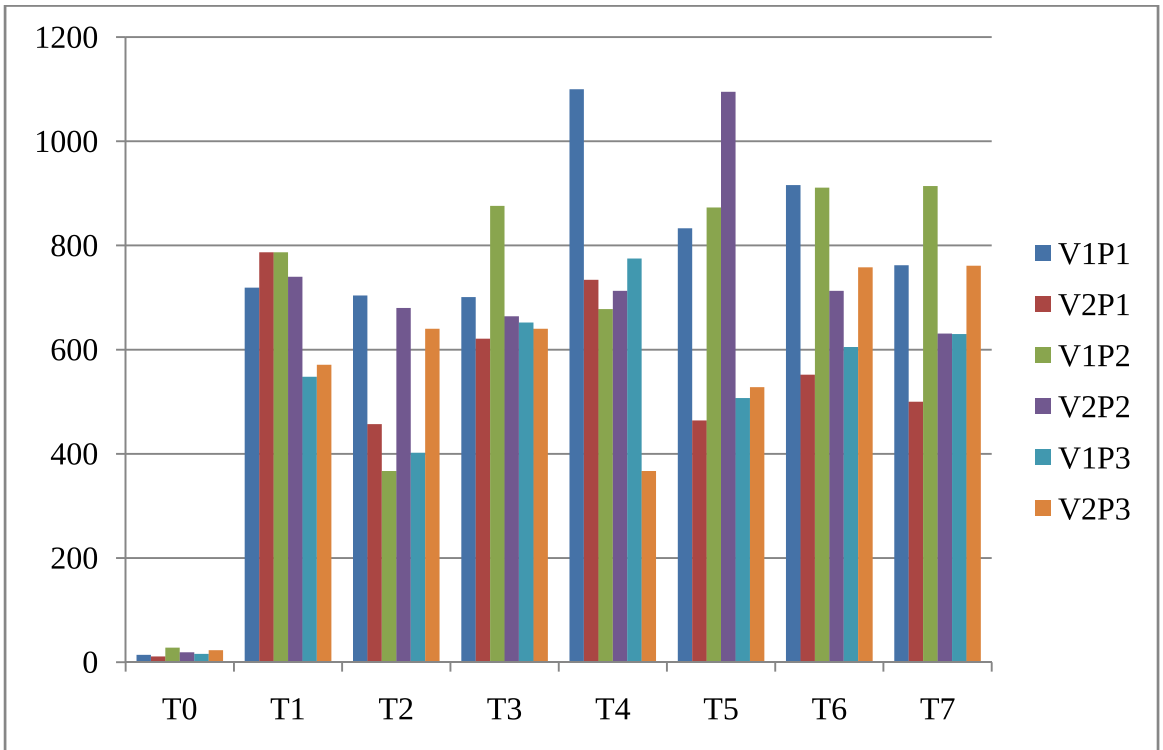


Figure 25. Other arthropods. a. mite, b. pill bug, c. spider

The total population of trapped arthropods from each factors and treatments is presented in Figure 26. The graph shows that water has low population of arthropods trapped as compared to the treatments showing a high population of trapped insects and other arthropods.

The result implies that the natural trap was effective in trapping arthropods. The fume released by the trap has proven to be attractive to arthropods.



V1 – Apple guava P1 – Peeling P3 – Unpeeled

V2 – Native guava P2 – Peeled

Figure 26. The total population of trapped arthropods from each factor and treatments.

Duration of Consumption of the Natural Trap

The natural trap was consumed after eight days of exposure to the environment. The vinegar juice was observed to evaporate leaving the muscovado sugar settled below the trapping material and has solidified. Although solidified, it was still capable of attracting insects and other arthropods.

The total number of insect population trapped in native guava and apple guava fruit parts daily is presented at Figures 27 and 28 respectively. In native guava, the peeled guava trapped the highest number of trapped insects and other arthropods from day one to day five followed by the unpeeled and the peelings. At day six, the peelings attracted the most number of insects and other arthropods followed by the unpeeled and peeled. At day seven and day eight, the peeled again trapped the most number of insects trapped followed by peelings and unpeeled respectively.

In apple guava, it reached the highest number of total insects and other arthropods at day three except for the unpeeled which reached its peak at day six.

The results implies that the natural trap increases its effectiveness as it is exposed to the environment due to the effect of heat which makes the trap release its fume. As it was exposed to the environment, the fume from the natural trap is spread in the area allowing insect and other arthropods to track the scent. The decrease in total number of insects and other arthropods on the following days was due to the decrease in the amount of trap as it was consumed by the trapped insects and other arthropods. The heat is also a factor since it makes the trap evaporate thus, reducing the amount of trap.

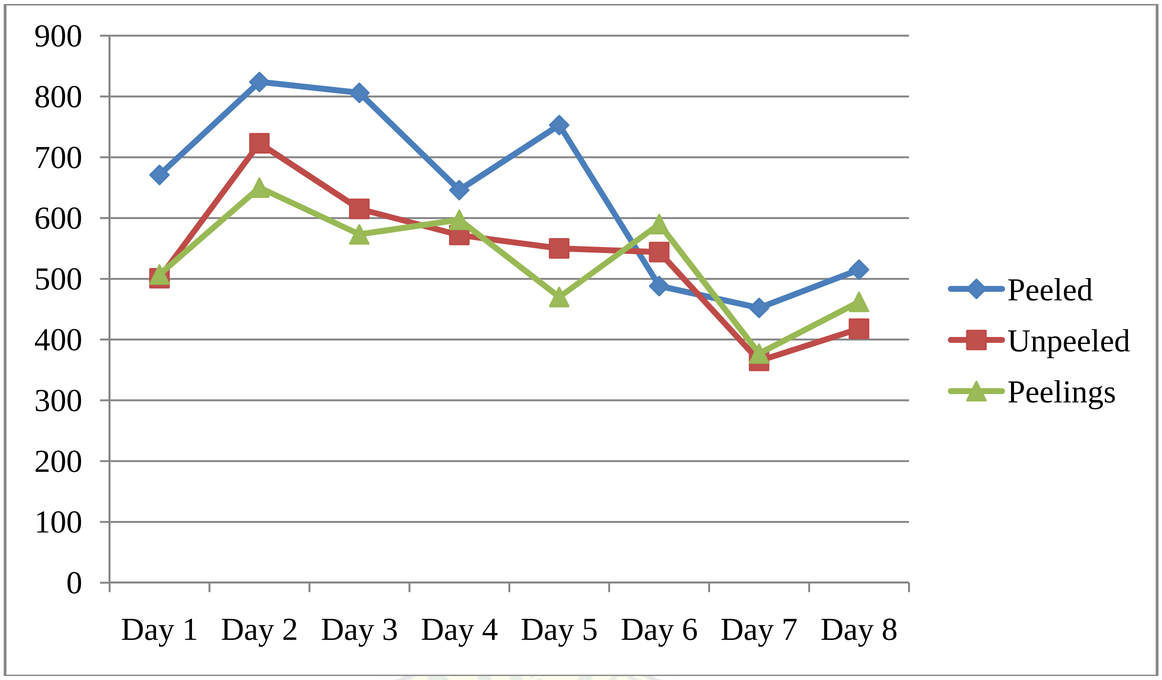


Figure 27. Total number of insect population on different native guava fruit parts daily

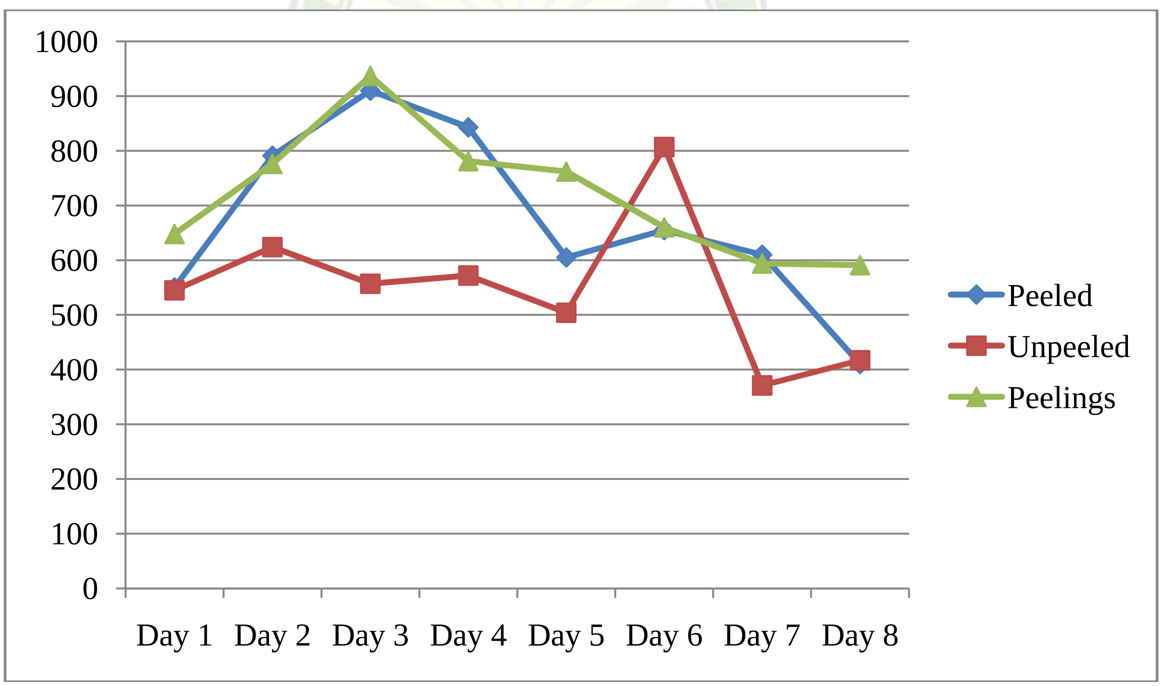


Figure 28. Total number of insect population on different apple guava fruit parts daily

The comparison on the total number of trapped insect in the two guava varieties daily is presented in Figure 29. The native guava attracted more insects and other arthropods as compared to apple guava. During the fermentation process, the native guava was known to have stronger scent than the apple guava that is a reason why there were more population of insect and other arthropods trapped in the fermented native guava.

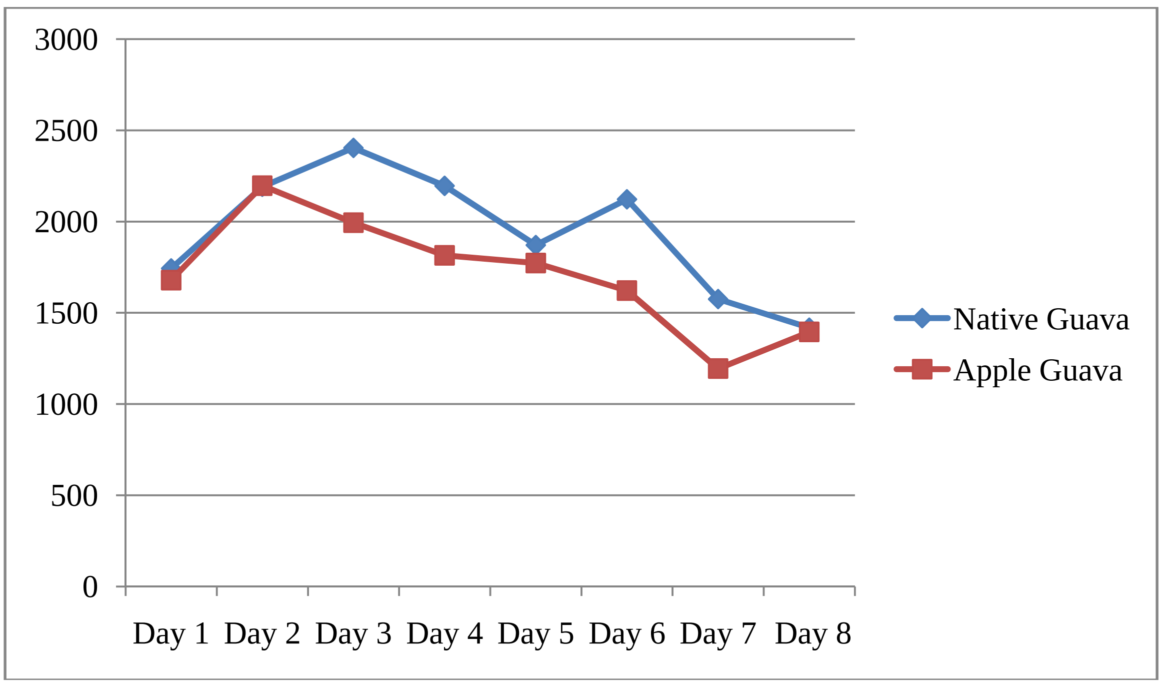


Figure 29. Comparison of total number of trapped insect in the two guava varieties daily

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The study was conducted at Balili Experimental Station, La Trinidad, Benguet from October 2010 to April 2011. The study aimed to determine the effectiveness of guava fruit extract as adult fruit fly attractant, determine the guava variety and the parts of guava fruit that attract adult fruit fly, determine the duration and the best proportion of natural trap that is capable of attracting adult fruit fly and other arthropods, identify the species of fruit fly caught in the trap and identify insects and other arthropods that are attracted to the guava fruit extract.

The natural guava trap was proven to be effective since it was able to trap a total of 28 adult fruit fly. It was found out that the cause of low population of fruit fly trapped was due to the decrease of fruit fly population during the conduction of the study. Both the variety and the guava parts were able to attract male and female adult fruit fly however, the pure fermented plant juice shows the highest number of adult fruit fly trapped. The natural trap lasted for eight days and observed to trap the highest number arthropods at day two and three but decreases at the following days. The sudden increase and decrease of trapped arthropods population was affected by the exposure of the natural trap to the environment and decrease in its amount as it was consumed by the trapped arthropods.

There were a total of seven fruit fly species trapped from the formulated guava attractant namely *Strauzia longipennis*, *Tephritis formosa*, *Bactrocera tryoni* (Froggatt), *Bactrocera invadens* and three other *Bactrocera* species that was not identified. A total of 60 families of insects were also identified and three other arthropods in the study.

Conclusions

Regardless of guava variety, part or proportions, the natural guava trap is effective in attracting adult fruit fly whether it is a male or a female. The natural trap is also capable of attracting any insect that has the ability to fly.

Recommendations

It is recommended to use guava as a natural attractant against fruit fly. For better results, use the natural guava trap on months of high fruit fly population. The natural trap can also be used for monitoring insect population and diversity in an area.

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APPENDICES

Appendix Table 1. Total number of trapped fruit fly from each factor and treatments

Native Guava

TREATMENTS	PEELED							UNPEELED							PEELINGS						
	REPLICATION							REPLICATION							REPLICATION						
	1	2	3	4	5	T	M	1	2	3	4	5	T	M	1	2	3	4	5	T	M
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	1	1	.2	0	0	0	0	1	1	.2	1	0	0	0	0	1	.2
3	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	2	.4
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	.2
7	0	0	0	0	0	0	0	0	0	0	0	1	1	.2	0	0	0	0	0	0	0

Apple Guava

TREATMENTS	PEELED							UNPEELED							PEELINGS						
	REPLICATION							REPLICATION							REPLICATION						
	1	2	3	4	5	T	M	1	2	3	4	5	T	M	1	2	3	4	5	T	M
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	1	0	0	0	1	.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	1	0	0	4	5	1	0	2	0	0	1	3	.6	0	0	0	0	0	0	0
3	0	0	0	0	1	1	.2	1	0	0	0	0	1	.2	0	1	0	0	0	1	.2
4	0	0	0	0	0	0	0	0	0	0	0	1	1	.2	0	2	1	0	1	4	.8
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	1	0	0	1	2	.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	1	0	0	0	1	.4	0	0	0	0	0	0	0

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F VALUE	TABULAR F	
					.05	.01
Treatment Combination	47	10.7333				
Variety (V)	1	0.6000	0.6000	3.84^{ns}	3.89	6.76
Part	2	0.0083	0.0042	0.03^{ns}	3.04	4.71
Trap	7	3.4000	0.4857	3.11**	2.05	2.73
V x P	2	0.3250	0.1625	1.04^{ns}	3.04	4.71
V x T	7	0.7333	0.1048	0.67^{ns}	2.05	2.73
P x T	14	3.9250	0.2804	1.79*	1.74	2.17
V x P x T	14	1.7417	0.1244	0.80^{ns}	1.74	2.17
Error	192	30.0000	0.1563			
TOTAL	239	40.7333				

** - Highly significant
* - Significant
^{ns} – Not significant

cv – 338.82 %
Sx (V) – 0.044
Sx (P) – 0.044
Sx (T) – 0.072
Sx (V x P) – 0.063
Sx (V x T) – 0.102
Sx (P x T) – 0.125
Sx (V x P x T) – 0.177

Appendix Table 2. Total number of trapped female fruit fly from each factor and treatments

Native Guava

TREATMENTS	PEELED							UNPEELED							PEELINGS						
	REPLICATION							REPLICATION							REPLICATION						
	1	2	3	4	5	T	M	1	2	3	4	5	T	M	1	2	3	4	5	T	M
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	1	1	.2	0	0	0	0	0	0	0	1	0	0	0	0	1	.2
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	2	.4
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	.2
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Apple Guava

TREATMENTS	PEELED							UNPEELED							PEELINGS						
	REPLICATION							REPLICATION							REPLICATION						
	1	2	3	4	5	T	M	1	2	3	4	5	T	M	1	2	3	4	5	T	M
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	1	0	0	0	1	.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	1	0	0	4	5	1	0	1	0	0	1	2	.4	0	0	0	0	0	0	0
3	0	0	0	0	1	1	.2	1	0	0	0	0	1	.2	0	1	0	0	0	1	.2
4	0	0	0	0	0	0	0	0	0	0	0	1	1	.2	0	2	0	0	0	2	.8
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	1	0	0	1	2	.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F VALUE	TABULAR F	
					.05	.01
Treatment Combination	47	7.9625				
Variety (V)	1	0.5042	0.5042	3.84^{ns}	3.89	6.76
Part	2	0.2250	0.1125	0.86^{ns}	3.04	4.71
Trap	7	2.3292	0.3327	2.54*	2.05	2.73
V x P	2	0.5083	0.2542	1.94^{ns}	3.04	4.71
V x T	7	0.7292	0.1042	0.79^{ns}	2.05	2.73
P x T	14	2.3083	0.1649	1.26^{ns}	1.74	2.17
V x P x T	14	1.3583	0.0970	0.74^{ns}	1.74	2.17
Error	192	25.2000	0.1313			
TOTAL	239	33.1625				

* - Significant

^{ns} – Not significant

cv – 414.04 %

Sx (V) – 0.033

Sx (P) – 0.041

Sx (T) – 0.066

Sx (V x P) – 0.057

Sx (V x T) – 0.094

Sx (P x T) – 0.115

Sx (V x P x T) – 0.162

Appendix Table 3. Total number of trapped male fruit fly from each factor and treatments

Native Guava

TREATMENTS	PEELED							UNPEELED							PEELINGS						
	REPLICATION							REPLICATION							REPLICATION						
	1	2	3	4	5	T	M	1	2	3	4	5	T	M	1	2	3	4	5	T	M
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	1	1	.2	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	1	0	0	0	1	.2	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	.2
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	1	1	.2	0	0	0	0	0	0	0

Apple Guava

TREATMENTS	PEELED							UNPEELED							PEELINGS						
	REPLICATION							REPLICATION							REPLICATION						
	1	2	3	4	5	T	M	1	2	3	4	5	T	M	1	2	3	4	5	T	M
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	1	1	.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	.2
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	1	0	0	0	1	.2	0	0	0	0	0	0	0

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F VALUE	TABULAR F	
					.05	.01
Treatment Combination	47	1.1958				
Variety (V)	1	0.0042	0.0042	0.14^{ns}	3.89	6.76
Part	2	0.0583	0.0292	1.00^{ns}	3.04	4.71
Trap	7	0.1625	0.0232	0.80^{ns}	2.05	2.73
V x P	2	0.0583	0.0292	1.00^{ns}	3.04	4.71
V x T	7	0.2292	0.0327	1.12^{ns}	2.05	2.73
P x T	14	0.2750	0.0196	0.67^{ns}	1.74	2.17
V x P x T	14	0.4083	0.0292	1.00^{ns}	1.74	2.17
Error	192	5.6000	0.0292			
TOTAL	239	6.7958				

^{ns} – Not significant

cv – 585.54 %
Sx (V) – 0.016
Sx (P) – 0.019
Sx (T) – 0.031
Sx (V x P) – 0.027
Sx (V x T) – 0.044
Sx (P x T) – 0.054
Sx (V x P x T) – 0.076