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Do you want to bet on baits? An evaluation of Various Baits for Jackfruit Fruit Fly, *Bactrocera umbrosa Fabr*. (Diptera: Tephritidae)

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Abstract

The efficiency of the various baits namely: baker's yeast, brewer's yeast and pheromone on fruit flies, *Bactrocera umbrosa* Fabr. was studied under the laboratory and field conditions. In the laboratory, 120 starved fruit flies were subjected to experiment in a choice test. The field trapping experiment was conducted at the Pomology Experimental Station of the Visayas State University, Visca, Baybay City, Leyte using an improvised yellow trap to test the effectiveness of the yeast-based baits and pheromone as baits to the insect under field condition. The laboratory assay experiment showed that pheromone attracts the most number of flies compared to other treatments. However, only males are attracted to pheromone. It is followed by the baker's and brewer's yeast which attracted both female and male flies. In field trapping, results showed that pheromone, and yeast-based baits were able to trap flies. Nonetheless, pheromone significantly trapped the number of flies. Thus, pheromone is the most effective amongst treatments while yeast-based baits showed potential results and merit further study to optimize its use.

Key words: *Bactrocera umbrosa*, pheromones, yeast-based baits, brewers's yeast, baker's yeast.

Introduction

Female fruit flies (*Bactrocera* spp.) need protein for egg maturation while males need protein to produce pheromone, renew the sperm supply, and produce male accessory gland secretions (Drew & Yuval 2000). Likewise, both sexes need to feed regularly on carbohydrates and water in order to survive (Bateman, 1972; Christenson & Foote, 1960). This nutritional requirement of adult flies has been the basis for developing protein baited traps. Protein baits have several advantages over insecticide cover sprays because "they limit the amount of insecticide used, they leave lower residue on crops and in the environment, they do not harm beneficial insects (pollinators and parasites) and are therefore essential components in Integrated Pest Management programs" (Lloyd & Drew, 1997). On the other hand, sophisticated attractants known as pheromones are being studied to control many insect pests in the world. Pheromones are naturally occurring and environmentally friendly compounds. Its ability to control insect populations through manipulations of specific sexual communication without affecting the other species, especially the beneficial organism is the reason why pheromones are safe for insect control. Several studies conducted on the use of protein

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bait have shown promising results utilizing alternative sources of protein and baits that are ready and commercially available. Various yeast-based baits have been used in mango fruit fly and showed good results in the study conducted by Tomambo (2011). While, the effectiveness of pheromones such as the product available in Philippine Root Crops Research Center at the Visayas State University is yet to be explored on its effect to fruit fly.

In this study, various baits were tested against the Jackfruit fruit fly, (*Bactrocera umbrosa* Fabr.). Jackfruit, (*Artocarpus heterophyllus* Lam.) locally known as "nangka" or "langka" is a favorite dessert of Filipinos. It is one of the most widely grown fruit crops in the Philippines (Martinez, 1999). It was also reported that it is one of the famous fruits in the world because it produces the largest edible fruit that weighs as much as 50kg. Jackfruit is common in Southeast Asia and found occasionally in Pacific Island home gardens, where it finds a place among other favorite multipurpose plants (Eleivitch & Manner., 2006). In the Philippines, jackfruit is widely distributed and cultivated particularly in Eastern Visayas Region. In fact, the Department of Agriculture (DA) has made jackfruit one of its banner commodities, attesting to the fruit's foreign earning generation. But the full commercialization of jackfruit, like other crops, encounters numerous problems which all results in low yields and poor quality. Insect pest attack is the most predominant constraint to the growth of the industry. Jackfruit is attacked by fruit flies, (*Bactrocera umbrosa* Fabr.) during the fruiting period (Coronel, 1986). This fruit fly is highly specialized species that attack and breeds only in jackfruit and other *Artocarpus* species (PCARRD, 2009). The fruit fly lays its eggs under the skin of the fruit and hatch within 24hrs. The larvae work their way into the fruit, eventually causing rot and making it unfit for market. The larva comes out of the fruit and falls to the ground to pupate in the soil. An adult lays about 100 eggs in one oviposition. In Eastern Visayas, it is considered as the major pest attacking jackfruit. The insect feedings considerably destroy the fruit of the crop (Martinez et al., 2007). Aside from the losses related to direct destruction of fruit by the larvae, economic losses are also due to cost of materials and labor for preventive treatments, the costs of monitoring the possible presence of flies even in fly-free regions, and costs of quarantine and fruit shipment fumigation. These fruit flies are serious pests and the damages caused by them are multiple in nature (Christenson & Foote, 1960). Thus, the exploration of economical, effective and environment-friendly control measures are needed to answer this perennial problem of jackfruit growers. With the goal of developing an affordable and accessible technology for farmers, this study aims to evaluate the potential of locally available materials and commercial pheromones as food bait for fruit fly, (*B. umbrosa*.). Specifically, to determine the attractiveness of yeast-based baits and pheromone to jackfruit fruit fly, (*B. umbrosa*); and to test the effectiveness of the yeast-based baits and pheromone as baits to the insect under field conditions.

Materials and methods

Collection and Rearing of Fruit Flies: Wild populations of fruit flies were obtained

from infested jackfruits inside the VSU campus. Collected fruits were kept in plastic containers covered with mesh cloth until the larvae pupated. Larvae were kept in a container containing sterilized sawdust and were brought to the laboratory of the Department of Pest Management, Visayas State University (VSU), Visca, Baybay City, Leyte. Newly emerged adult flies were segregated according to sex and transferred into plastic cages (21.5 x 16.5 x 16 cm) provided with water and an artificial diet at 1:3 ratio table sugar and yeast. An artificial diet served as a protein source for female flies. The sexes were maintained separately for two weeks until sexual maturation. Matured male and female flies were combined in improvised plastic cage to facilitate mating. Slices of jackfruit were placed inside the cage as oviposition substrate and were replaced daily to separate test insects by cohort. Pupation media were composed of a container with one cm deep sawdust. Pupae were saved from the media and transferred to a separate screened cage prior to adult emergence. Sugar and water were placed in these cages in order for the flies to have an access to food any time after emergence.

Preparation of Baits: Pheromone for fruit fly was obtained from the Philippine Root Crops Research and Training Center (PRCRTC) of Visayas State University while Brewer's yeast (Rhea®) was purchased from a pharmaceutical store, and Baker's yeast (Redstar®) from a local market (Figure 1). The yeast-based baits were prepared with water and muscovado sugar, the proportion of which are shown in Table 1. For treatments using brewer's yeast and baker's yeast, the solutions were subjected to 70°C in an oven for seven hours and were allowed to cool down at room temperature. These baits were used within 24 hrs after hydrolysis. The pheromone baits were prepared following the recommendation in the label.

Table 1: Yeast-based baits formulation

Yeast Formulation	Brand Name	g/1L	Muscovado Sugar
Brewer's yeast	(Rhea®)	420g	50g
Baker's yeast	(Redstar®)	420g	50g

Figure 1. Sources of formulation. (A) Suebeehoney (B) Rhea® brewer'syeast (C) Red Star® baker's yeast (D) Capture 5-OC pheromone.

Laboratory Assay Experiment: Attractancy of the prepared baits to the fruit flies from both sexes were evaluated in the laboratory, using 20 males and 20 females. All the test insects were provided with sugar and water upon adult emergence. Prior to the experiment, flies that were used were starved and provided only with water for 14 hours. The experiments were performed

from 0800 to 1200 hrs. The choice attractancy test was done following the protocol used by Tomambo (2011). A cylindrical mesh net cage of 1.30 m x 1.80 m was used. Forty flies were introduced into the cage for 10 minutes prior to the test in order to accustom them to the experimental conditions. Five mature jackfruit leaves with the similar leaf area were washed and dried, then labelled and hung inside the cage arranged equidistantly in circular formation. Three setups or trials were made. At the start of each; water and 10% honey solution were applied with a paint brush (round tip, two cm diameter) to two separate leaves and each of the prepared bait to the other leaves. The leaves were rotated every five minutes until they occupy all positions inside the cage. Observations were done in 25 minutes. Flies alighting on the leaves were removed and put inside the vials labelled with the corresponding treatments. Total number and sex of the flies were counted and recorded.

Field Trials: Improvised traps were made from a yellow opaque plastic bottle of 1L capacity (Figure 2). Four equidistant holes facing different directions were made around the middle part of the cylinder. To each trap, 200 ml of the bait was placed to facilitate the drowning of trapped flies. Three sets (one set = 5 traps for the different baits including a control) of traps were hung at about 2 to 4 m above the ground equidistant to each other within the canopy layer, in semi-shaded spots, preferably in the upward part of the canopy.The traps were hung in such a manner that branches and leaves are nearby, but not touching the trap. Each set of traps were hung 10 m from the other. Fruit flies trapped from each type of bait were collected daily for seven consecutive days. After seven days, baits were replaced with fresh baits. Replacement of baits and collection of fruit flies was done in four weeks. Collected insects were preserved in 95% alcohol for identification. Numbers and sex of each fruit fly were counted and recorded.

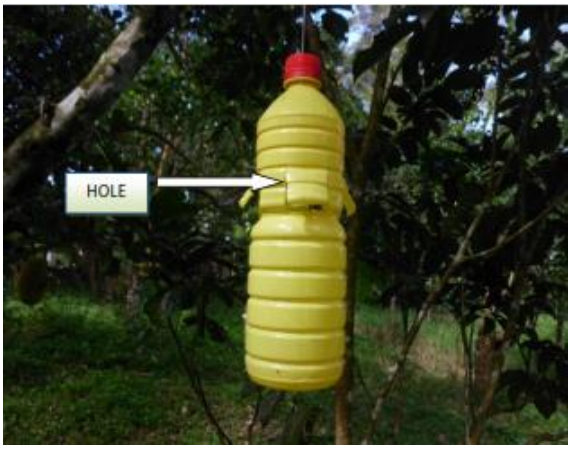

Figure 2. Improvised yellow plastic trap with four equidistant holes

Design and Analysis of Data: The experimental set-up under laboratory conditions was laid out in Complete Randomized Design (CRD) while field experiment was laid out in a Randomized Complete Block Design (RCBD). The data were statistically analyzed and differences among means were compared using Tukey's Honest Significant Difference. All treatments were replicated three times.

Data Gathered: The efficacy of different traps against jackfruit flies was evaluated in terms of number of jackfruit flies trapped per treatment. The number of other insects attracted to traps was also determined and identified according to order.

1. Number of jackfruit flies in individual trapped. The trapped jackfruit flies

were collected daily for seven consecutive days. These were counted and sorted according to sex. The numbers of male and female were recorded.

2. A number of other insects trapped. Other insects that were trapped were collected and examined under the stereomicroscope. The insects were identified according to order.

Results

Attractiveness of Various Baits under Laboratory Conditions: To determine the attractiveness of *Bactrocera umbrosa* to various baits, a laboratory experiment was conducted. Table 2 shows the mean number of flies attracted to these baits. Females were found to be more attracted to baker's yeast, which is comparable with brewer's yeast having a mean number of 6.33 and 5.33, respectively. While, 10% honey attracted 3.33, water 1.66 flies and none were attracted to pheromones.

On the other hand, males were attracted to all treatments, although pheromone attracts the most number of flies with a mean of 12.33 followed by baker's yeast with 3.33 and brewer's yeast with 1.33 flies. Generally, pheromone attracts the most number of male flies compared to other treatments. This is followed by baker's yeast, brewer's yeast, 10% honey and water (Figure 3). Consequently, mean number of flies attracted to pheromone and the two yeast-based baits were significantly different with one another while the difference between brewer's yeast and 10% honey was also significant whereas,as the difference between 10% honey and water was not significant.

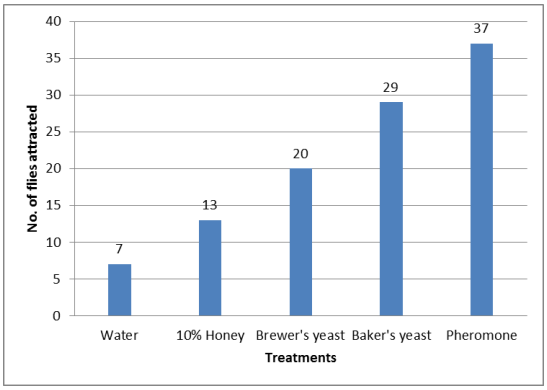

Figure 3. Cumulative number of *B. umbrosa* attracted to various baits under laboratory conditions within the three trials

Field trapping: To determine the effectiveness of various baits in attracking *B. umbrosa* under field conditions, field traps were set-up in selected jackfruit trees at Pomology Experimental Station, Visayas State University from January to February 2013 using an improvised yellow cylindrical containers. Traps containing various baits were placed equidistantly. *Bactrocera umbrosa* and other insects trapped in the different baits were counted and classified.

Table 3 shows that pheromone trapped the most number of flies, all males, throughout the four-week sampling period with a mean number of 22, 19.33, 24 and 24.67 on week one, two, three, and four, respectively (Table 4). Although statistically, the number of flies trapped in brewer's and baker's yeast are not significantly different, numerical value proved that baker's yeast trapped more flies than brewer's yeast (Figure 4 and Figure 5). Baker's yeast having a mean number of 5.33, 6.33, 4.33 and 7.0 flies trapped in week-one to week-four, respectively, compared to brewer's yeast with only 2.33,4.0,2.67 and 2.0, respectively.

Table 2: Mean number of *B. umbrosa* caught by various baits under laboratory condition

Treatments	Number of Individual					
	Female	StD	Male	StD	Total	StD
Water	1.66[c]	±.58	0.66[c]	±..82	2.33[d]	±.58
10% Honey	3.33[b]	±.58	1.00[c]	±.0	4.33[dc]	±.58
Brewer's Yeast	5.33[a]	±.58	1.33[cb]	±.58	6.66[c]	±0
Baker's Yeast	6.33[a]	±.58	3.33[b]	±.58	9.66[b]	±1.15
Pheromone	0.00[d]	± 0	12.33[a]	±1.53	12.33[a]	±1.53
CV (%)	15.49		21.87		13.67	

Means in a column followed by common letter/s are not significantly different at 5% LSD.

Table 3: Mean number of *B. umbrosa* trapped by different baits under field conditions

Treatments	Number of Individuals							
	Week 1	StD	Week 2	StD	Week 3	StD	Week 4	StD
Water	0.00 [c]	±0	0.00 [d]	±0	0.00[b]	±0	0.00 [c]	±.0
10% Honey	1.66 [c]	±1.15	1.66 [cd]	±1.15	2.00[b]	±2	1.33 [c]	±.58
Brewer's Yeast	2.33 [cb]	±1.15	4.00 [cb]	±1	2.67 [b]	±2.08	2.00 [cb]	±1.73
Baker's Yeast	5.33 [b]	±1.15	6.33 [b]	±1.15	4.33 [b]	±2.52	7.00 [b]	±3.46
Pheromone	22.00[a]	±2	19.33 [a]	±2.52	24.0[a]	±1.73	24.73 [a]	±1.52
CV (%)	20.18		23.66		23.66		27.66	

Means in a column followed by common letter/s are not significantly different at 5% LSD

The results further substantiate the data obtained in laboratory trial on the ability of pheromone as bait compared with other treatments. Although it has been observed that the number of flies trapped by pheromone followed a downward trend as the days passed by nevertheless it is still superior to the yeast- based baits which followed a fluctuating trend until day-seven (Figure 4). The average daily counts of fruit flies trapped by pheromone peaked at day one and decreased thereafter. This is because at this time, the pheromone was newly dispensed thus, the compound was still fresh. This implies that the efficacy of pheromone is high when newly applied and efficacy wears off with time. Other insects trapped by the different baits were identified and counted. A total of 185 other insects trapped by all baits for the whole duration of the study were shown in Table 4. Dipterans represented by Calliphoridae, Drosophillidae, Neriidae and Sarcophagidae ranked the most

number of other insects trapped with 66.14% of the total number. The remaining 33.86% was distributed to Lepidopterans with 21.69%, mostly Noctuidae followed by Blattodea with 7.93% and Coleopterans with 4.23%.

Table 4: A total number of other insects collected by different baits at Pomology Experimental Station, Visayas State University, from January to February 2013.

TAXA	Water	10% Honey	BWY	BKY	Pheromone	Total	%
DIPTERA							66.14
Callophoridae	0	4	18	48	0	70	
Neriidae	0	1	2	4	0	7	
Sarcophagidae	0	0	2	1	0	3	
Drosophillidae	0	23	12	10	0	45	
BLATTODEA							7.93
Blatellidae	0	3	4	3	0	10	
Blattidae	0	1	2	2	0	5	
COLEOPTERA							
Coccinelidae	0	5	1	2	0	8	4.23
LEPIDOPTERA							
Noctuids	0	20	15	6	0	41	21.69
Total	0	57	56	76	0	189	

Legend: BWY- Brewer's Yeast ,BKY- Baker's Yeast

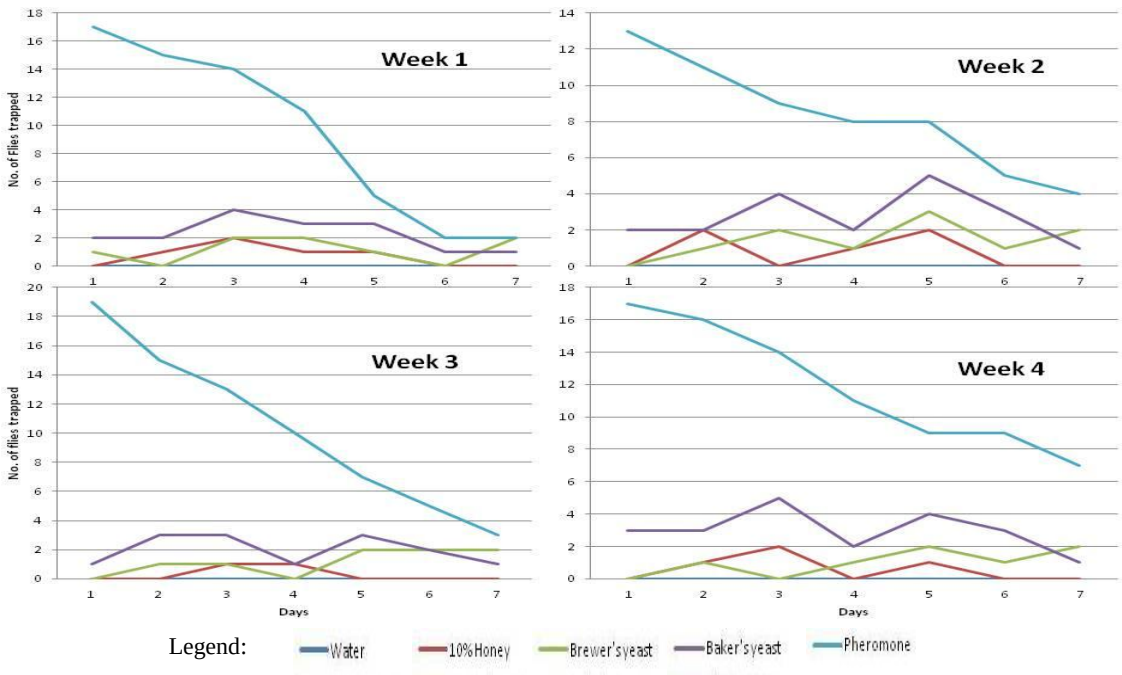

Figure 4. Number of *B. umbrosa* trapped by various baits under field conditions at Pomology Experimental Station, Department of Horticulture from January to February 2013.

The majority of this group was comprised of flies under the family Calliphoridae, 48 of which were trapped in baker's yeast and 18 trapped in brewer's yeast. On the other hand, 12 under Drosophilidae were trapped in brewer's yeast and 10 in baker's yeast. Fifteen Notuidae under the order Lepidoptera were also trapped in brewer's yeast while six in baker's yeast.

The majority of the dipterans belonging to the family Drosophilidae were trapped in 10% honey solution as well as Calliphoridae and Neriidae with a total number of 23, 4, and 1, respectively and 20 Noctuidae which belong to the order Lepidoptera. Another group under the order Coleoptera were trapped in 10% honey, brewer's yeast and baker's yeast with the total number of 5, 1, and 2, respectively, in four-week sampling period. While a group of scavenger cockroaches under family Blatellidae and Blattidae were found trapped in 10% honey, brewer's yeast and baker' s yeast.

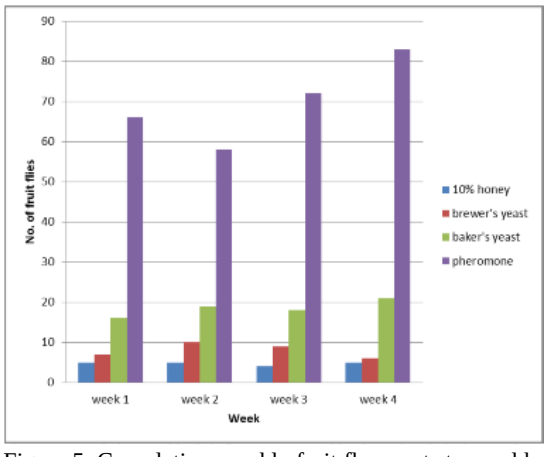

Figure 5. Cumulative weekly fruit fly counts trapped by the various baits in Pomology Experimental Station, Department of Horticulture, Visayas State University, Visca Baybay City, Leyte from January to February 2013.

Discussion

A Pheromone attracts male fruit fly alone as expected. Pheromones are naturally produced by some species of insects to communicate or interact with the other members of the same species. These compounds are often termed as "sex pheromones" which female produces to attract males. It is considered biochemically ideals to control fruit flies, because generally they are species-specific, environmentally safe, being non-toxic to the target species. In addition, its ability to control insect populations through manipulations of specific sexual communication without affecting the other species, especially the beneficial organism is the reason why pheromones are safe for insect control (Witzgall, 2010). According to Vasquez et al., (1999) the advantages of using pheromone are its low toxicity to all forms of animal life and do not offer risks
Both brewer's and baker's yeast attract male and female flies. Yeast-based baits are an excellent source of protein and vitamins, especially the B-complex vitamins, whose functions are related to metabolism, as well as other minerals and cofactors required for growth (Lee, 2009). Like many other insects, fruit fly needs protein to attain sexual maturation. After emergence the adults have a maturation period of several days before becoming sexually active (Christenson & Foote, 1960). Although female needs a greater amount of protein than males, which explains the difference in the number attracted to both baits. There were more females attracted to both yeast-based baits than males. According to Bateman (1972),

most of the fruit flies are an autogenous wherein female needs protein for egg maturation while male utilized protein to renew the sperm supply and produce male accessory gland secretions (Drew & Yuval, 2000). The results conformed with the findings of Tomambo (2011) in which he found that between the two yeast-based baits, baker's yeast attracts more number of mango fruit fly compared with brewer's yeast.

The decrease in the number of trapped fruit fly after day one showed that pheromone dissipate along with the wind. The amount of the pheromone left on the cotton balls decreases with time, thereby reducing the trapping efficiency. Pheromone traps are sensitive to bad weather. They are highly volatile, and they have the ability to attract pests from neighboring area and the fact that they generally only attract adults. Although it is the juveniles in many species that are pests (FAS, 2011). Since, the pheromone is sensitive to bad weather, its efficiency has been compromised due to frequent rain during the conduct of the experiment. Although in other area, according to Dr. Erlinda A. Vasquez through personal communication, pheromone used in Northern Luzon remains to be effective for at least one week. On the other hand its ability to attract adults is advantageous to fruit fly control since adult stage, is the most mobile stage, thus trapping is easier.

Trapped flies in 10% honey solution were only observed until day five. The same observation was noted in baker's yeast, wherein a number of flies trapped increases from day one to day five and decreases thereafter. On the other hand, brewer's yeast average daily trap peaked on day five and interestingly to note that on day seven, brewer's yeast continued to attract flies and the trend slightly moves upward, although the number of flies were still inferior to the number that pheromone attracted to the trap. These baits had reduced its attractiveness, while brewer's yeast continued to attract flies. This observation is possibly being due to the effect of the odor the bait produced as it aged.

The attraction of Dipterans to yeast-based baits can be associated with the scavenging behavior of flies which caused them to be attracted to decomposing materials attributed by a foul odor of yeast-based baits. According to Goodman (1964), Calliphoridae are occasional pollinators being attracted to flowers with strong odors resembling rotting meat and use nectars as a source of carbohydrates to fuel flight. Drosophillidae are considered nuisance flies rather than pests, since most species breed in rotting material, and also it is being a serious primary pest of some commercial fruit (DACS, 2007). Martinez et al., (2007) reported that several non-target insects belonging to the orders Diptera and Lepidoptera were trapped using torula yeast. Leblanc et al., (2010) reported several dipteran species, namely, *Ceratis capitata*, *Anastrepha*, and *Bactrocera* species to be trapped in proteinaceous baits and cited further its convenience in catching insects from several insect orders such as Diptera (e.g. Calliphoridae and Tachinidae), Lepidoptera, Hymenoptera, Neuroptera and Orthoptera and in some places small vertebrates, although in this study only

insects were trapped. The same groups of insects reported by Tomambo (2011) were trapped in the field by the different baits used.

Generally, aside from being almost invariably strongly attracted to light and flies at night, Noctuidae is also attracted to sugar and nectar-rich flowers (Mitchell et al., 2006) which explain the high number trapped in 10% honey more than in either yeast-based baits. In addition, baiting has been proven to be an effective technique for sampling noctuids (Wagner et al., 2008). Volatiles and odors emitted by age baits attracted cockroaches which are known to be ground dwellers and usually are found hiding in crevices, under bark, plant litters, rocks or logs and in burrows. Meanwhile, other than those scavengers and secondary invaders mentioned above, there were no natural enemies trapped in the baits which imply that yeast-based baits and pheromone used in the study are safe to use in the field for beneficial insects. Furthermore, the used of the pheromone in the field proved its specificity towards *Bactrocera* spp. Only since no other insects collected in the baits within a four-week sampling period. Pheromones ability to control insect populations through manipulations of specific sexual communication without affecting the other species, especially the beneficial organism is the reason why pheromones are safe for insect control (Witzgall, 2010).

Conclusion

Based on the results the following conclusions can be drawn:

1. Pheromones and yeast-based baits can attract Jackfruit fruit fly, although pheromone significantly attracts more flies than the two other baits.
2. In the field, pheromone proved to be effective in trapping male fruit flies only while yeast-based baits showed potential in trapping both male and female fruit fly, however, the number of flies trapped was significantly less compared to pheromones. Further, between the two yeast-based baits, baker's yeast trapped more flies than brewer's yeast, although the latter showed a prolonged effect as bait compared to the former, the baker's yeast had a higher accumulated weekly count than brewer's yeast.

Although yeast-based baits trapped insects other than *B. umbrosa* none were beneficial insects, thus, these baits are safe and compatible to use with other methods of control in fruit fly management.

References

Adekunle AT, Ikotun T, Fiorini DA, Cardwell KF, 2006. Field evaluation of selected formulations of Trichoderma species as seed treatment to control damping- off of cowpea caused by Macrophomina phaseolina. African Journal of Biotechnology **5**: 419-424.

Bateman, MA, 1972. The ecology of fruit flies. Annual Review of Entomology **17**: 493-518.

Christenson LD, Foote RH, 1960. Biology of fruit flies. Annual Review of Entomology **5**: 171-192.

Coronel, RE, 1986. Promising Fruits of the Philippines. University of the Philippines Los Baños, College of Agriculture, Laguna.

Department of Agriculture and Consumer Services (DACS), 2007. Florida. http://www.doacs.state.fl.us/pi/enpp/ento/zaprionusindianus.html.

Drew RA,I Yuval B, 2000. The evolution of fruit fly feeding behavior, In: Aluja M, Norrbom, A eds. Fruit Flies. CRC, Boca Raton. 731-749.

Eleivitch, CR, Manner HI, 2006. Artocarpus heterophyllus (Jackfruit): Specie Profiles for Pacific Island Agroforestry. 17. Hōlualoa, Hawaii: Permanent Agriculture Resources (PAR). http://www.agroforestry.net/tti/A.heterophyllus-jackfruit.pdf.

Food and Agricultural Sciences (FAS), 2011. University of Florida. http://edis.ifas.ufl.edu/IN080.

Goodman LJ, 1964. The landing responses of insects II. The electrical response of the compound eye of the fly, *Lucilia sericata*, upon stimluation by moving objects and slow changes of light intensity". Journal of Experimental Biology **41**: 403–415.

Lloyd A, Drew R, 1997. Modification and testing of brewery waste yeast as a protein source for fruit fly bait. In Allwood AJ, Drew RAI eds. Management of Fruit Flies in the Pacific, A Regional Symposium. ACIAR Proceedings No. 76. Nadi, Fiji. 192-198.

.

Lee JA, 2009. South East Asia Under Japanese Occupation – Harukoe (Haruku)". (Children & Families) of the Far East Prisoners of War. http://www.cofepow.org.uk/pages/asia_haruku2.htm.

Leblanc L, Vargas RI, Rubinoff D, 2010. Capture of pest fruit flies (Diptera: Tephritidae and non-target insects in biolure and torula yeast traps in Hawaii. Envoronmental Entomology **39**: 1626-1630.

Martinez, MA, 1999. Biology and Control of Jackfruit Fruit borers. DA-RIARC, Balinsasayao, Abuyog, Leyte. http:www.hort.uconn.edu/ipm/veg/htms/vegipmgenl.htm.

Martinez AJ, Salinas EJ, Rendon P, 2007. Capture of *Anasphrepha* species (Diptera: Tephritidae) with multilure traps and biolure attractants in Guatemala. Florida Entomologist **90**: 258- 263.

Mitchell A, Mitter C, Regier C, 2006. Systematics and evolution of the cutwormmoths (Lepidoptera: Noctuidae): Evidence from two proteincoding nuclear genes. Systematic Entomology **1**: 21–46.

Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD), 2009. Highlights 2009 (2010). Disease management strategies against jackfruit fruit fly - AGRIS - FAO_Vol. 37, No. 3, July-September 2009.

Tomambo RD, 2011. Laboratory and Field Evaluation of Yeast-Based Baits for Fruit Flies, *Bactrocera occipitalis* (Bezzi) and *B. philippinensis* Drew and Dancock (Diptera: Tephritidae). LosBaños, Laguna: University of the Philippines, M.Sc. Thesis, p 48.

Vasquez E, Nicole EJ, Smith M, 1999. Sweet Potato Weevil. http/www.lucidcentral.com/keys/sweetpotato/keys/sweetpotato%20diagnos/medial/tml/.

Vasquez E. Philippine Root Crops Research Center, personal communication

Wagner DL, Schweitzer DF, Sullivan JB, Reardon RC, 2008. Owlet Caterpillars of Eastern North America (Lepidoptera: Noctuidae). http://www.eeb.uconn.edu.com. Retrieved 07 March 2011.

Witzgall P, Kirsch P, Cork A, 2010. Sex Pheromones and Their Impact on Pest Management. Journal of Chemical Ecology **36**: 80–100.