Field Exercise Guide
on
Fruit Flies Integrated Pest Management

For farmer's field school and training of trainers courses on Fruit flies Integrated Pest Management

Area-wide Integrated Pest Management of Fruit Flies in South and Southeast Asia

February 2011

Field Exercise Guides on Fruit Flies Integrated Pest Management

for Farmer's Field Schools and Training of Trainers

Area-Wide Integrated Pest Management of Fruit flies in South and Southeast Asian Countries

Participating Agencies from Mekong River Basin Countries:

Project Partners:

Project Donor:

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How to obtain the digital copy:

The Field Exercise Guide on IPM for Fruit Flies for Farmer's Field School and Training of Trainers can be electronically down loaded from the http://ipm.ait.asia and www.vegeableipmasia.org.

About the project

"*Area-wide Fruit Fly Integrated Pest Management in South and Southeast Asia*" is a regional initiative coordinated by the Asian Institute of Technology with funding support from Taiwan's ICDF (www.icdf.org.tw). The project has a focus on adaptation and adoption of fruit fly IPM practices among vegetable and fruit smallholder using Farmer's Field School (FFS) in the Mekong river basin countries. While the Asian Institute of Technology (AIT; www.ait.asia); Bio-Control Research Laboratory (BCRL; http://www.pcilindia.com/bcrl.html), Bangalore, India, and the FAO Regional IPM Programme (http://www.vegetableipmasia.org/) are the collaborating project partners, the project is implemented by National IPM Programmes in Lao PDR, Cambodia, Vietnam; Department of Agriculture Extension (DoAE) Thailand, and Ministry of Agriculture and Irrigation (MAI) in Myanmar. The project is intended to test, promote and socialize among smallholder farmers a range of novel IPM options for fruit fly management within the context of ongoing IPM farmer training and action research programmes in the Mekong basin countries.

Contact

The Regional Office of the project is housed in its host institute Room # 207, AFE Bld. AIT, Bangkok, Thailand. Further information on project could be obtained from the following contact:

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Preface

A range of technical sessions are carried out in a Farmer's Field School /Training of Trainers courses to facilitate enjoyable learning experiences for IPM farmers and trainers. These exercises follow non-formal education methodologies based on adult learning principles as the core of its design and allow a participatory learning process on selected topics. A range of exercise guides have been developed on many pests an, crops and have been very successfully used in implementing FFS and/or TOT in many geographical areas of the world.

This is the first such attempt to develop a range of exercises on key technical aspects on fruit flies. It has been developed through a participatory and collaborative effort during the FAO/AIT *Regional Training on IPM for Fruit Flies*, held at the Southern Fruit Research Institute (SOFRI), Tien Giang, Vietnam from 07-14TH December 2010. This regional training was held under the auspices of the Asian Fruit Fly IPM Project, involving a group of selected IPM trainers from the Asian region and resource persons.

The document is divided into two parts, part I[1] provide basic information on various aspects of fruit flies and part II contains the exercise guides. In addition, technical information on identification on three commonly occurring fruit fly species are included in the Annex of this document.

We are hopeful that the selection of structured learning exercises presented in the manual will provide good inspirational tools to the IPM trainers, extension personnel and farmers to create stimulating learning experiences for FF IPM trainers and farmers leading to sound scientific knowledge base for sustainable management of fruit flies.

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[1] Information provided in Part I is based upon a detailed compiled paper on the topics of "Fruit Fly in Asia' by Dr. Paul Ferrar, AICAR IPM presented during the Inception and Planning Workshop of the Asian Fruit Fly IPM Project, 1-3 September 2010, AIT, Bangkok (see http://ipm.ait.asia/test/inception/IWS_DOCS/FRUIT%20FLIES%20IN%20ASIA%20paper-Paul-27%20Aug.%202010.pdf).

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Part I: Background Information on Fruit Flies

1. Introduction

Improving productivity and quality of fruits and vegetables enhances food security, employment and trade opportunities. The Asian region (East, Southeast, and South) is among the top three regions worldwide — for both exporters and importers of fruits and vegetables. Among the various sub-regions in Asia, the Mekong river basin countries are major producers of a range of economically-important fruits and vegetables for domestic consumption, regional and international trade. In 2004, for example, Asian countries produced 178 million tons of tropical fruits which amounted to 66% of the total global production and earned US$ 2.5 billion (Somsri *et al.,* 2007). However, several factors constrain fruit and vegetable production such as tephritid fruit flies (*Bactrocera dorsalis* and *Bactrocera cucurbitae* and possibly others like *B. correcta*). These fruit flies cause direct damage to fruits and vegetables which can lead to up to 90-100% yield loss depending on fruit fly population, locality, variety and season. In addition, to the direct losses, fruit fly infestation can result in serious losses in trade value and export opportunity due to strict quarantine regulations imposed by most importing countries.

1.1 Fruit Flies in Asia

The tephritid fruit flies of genus, with more than 500 species currently described constitutes important pests of reproductive stages of a number of fruits and vegetable crops in Asian countries. A number of economically important and widely prevalent species of this genus such as *B. dorsalis* (Oriental Fruit Fly, OFF), *B. correcta* (Guava fruit fly, GFF), *B. cucurbitae* (Melon fly, MF), *B. papayae* (Asian papaya fruit fly), *B. carambolae* (Start fruit fly) are commonly found in SE and South Asia (see table 1 for a summary of the common species commonly found in Asia).

B. dorsalis is one of the most common species and it is similar to the closely related species *B. carambolae*, *B. papayae*, *B. occipitalis*, *B. philippinensis* and *B. invadens* in color pattern and referred as a species complex.

Table 1: Fruit flies in the genus *Bactrocera* (Diptera: Tephritidae) of economic importance in Asia[2]

No.	Scientific name	Common name	Current Distribution	Host range	Pest status	Male lure	Entry potential [1]	Colonization potential [2]
1.	*albistrigata*	Asian Terminalia Fruit Fly	Andaman islands, central to southern Thailand, Malaysia, Kalimantan (Borneo, Inodonesia east to Sulawesi, Christmas Is.	11 host plant species	Medium	Cue lure (CUE)	Low	**High**
2	*carambolae*	Carambola Fruit Fly	Southern Thailand, Malaysia, Kalimantan (Borneo, Inodonesia east to Sumbawa. Adventive in Andaman Is, Surinam, Frenh Guiana, Brazil	78 host plant species from 27 plant families	Major	Methyl eugenol (ME)	High	**High**
3	*caryeae*	Indian Fruit Fly	Southern India and Sri Lanka	Guava, mango, citrus, Barbados cherry	Major	ME	Medium	**High**
4	*caudata*	none in use	Widespread across S.E. Asia	Flowers of commercial/edible	Major	CUE	Low	**Low**

[2] Mission Report on Regional Training on IPM for Fruit Fly, Tien Giang, Vietnam, 7-14 December 2010. Dr. Vijaysegaran Shanmugam, FAO Consultant

				Cucurbitaceae				
5	*correcta*	Guava Fruit Fly	Sri Lanka, India, Nepal, Pakistan, Myanmar, northern Thailand, southern Vietnam, Cambodia, southern China (Yunnan)	62 host plant species from 30 plant families	Major	ME	High	**High**
6	*cucurbitae*	Melon Fly	S.E. Asia and Asia. Adventive in Hawaiian Islands, P.N. Guinea to Solomon Is, Nauru, African continent, Mauritius, Reunion, Egypt	A very wide range of Cucurbitaceae, but also recorded on other fruits of economic importance	Major	CUE	High	**High**
7	*diversa*	none in use	Sri Lanka, India, Nepal, Bhutan, China, Thailand	Flowers of commercial/edible Cucurbitaceae	Major	ME	Low	**Low**
8	*dorsalis*	Oriental fruit Fly	Cambodia, Laos, Vietnam, Myanmar, Thailand, southern China, Taiwan, Sri Lanka, India, Nepal, Bhutan	123 host plant species from 41 plant families	Major	ME	Major	**Major**
9	*invadens*	none in use	Sri Lanka, southern India. Adventive in Africa	A wide range of commercial and	Major	ME	High	**High**

				edible fruits. Severe in Africa				
10	*kandiensis*	Sri Lankan Fruit Fly	Sri Lanka	21 host plant species	Medium	ME	Low	**High**
11	*latifrons*	Solanum Fruit Fly	Cambodia, Laos, Vietnam, Myanmar, Vietnam, Thailand, Malaysia, Sri Lanka, India, Pakistan to southern China, Taiwan. Adventive in Hawaii	17 host plant species primarily in the family Solanaceae	Medium	none	High	**Medium**
12	*minax*	Chinese Citrus Fruit Fly	Northeast India, Sikkim, Bhutan, southern China	Major pest of citrus and *Fortunella* species (Rutaceae)	Major	none	Low	**Low**
13	*occipitalis*	Bezzi Fruit Fly	Philippines, Sabah (east Malaysia), Brunei, Kalimantan (Borneo)	8 known host plant species. Needs more host surveys	Major	ME	High	**High**
14	*papayae*	Asian Papaya Fruit Fly	Southern Thailand, Malaysia, Kalimantan (Borneo), Indonesia. Now in P.N. Guinea, Irian Jaya and northern Torres Strait Islands	About 200 host plant species from 50 plant families. Considered the most virulent and serious fruit fly species	Major	ME	Very High	**Very High**

15	*philippinensis*	none in use	Philippines	Mango, papaya, breadfruit, *Syzygium* species. Full host surveys lacking	Major in the Philippines	ME	High	**High**
16	*pyrifoliae*	none in use	Northern Thailand, northern Vietnam	7 host plant species, importantly in the family Rosaceae	Medium (to major in peach)	none	low	**Low**
17	*scutellaris*	none in use	China, India, Myanmar, Nepal, Pakistan, Thailand, Vietnam, Bhutan	Flowers of 4 species of commercial/edible Cucurbitaceae	Medium	Cue Lure (CUE)	Low	**Low**
18	*scutellata*	none in use	Bhutan, China, Japan, Taiwan, Thailand, Vietnam	Flowers of commercial/edible Cucurbitaceae	Medium	CUE	Low	**Low**
19	*tau*	none in use	Southern China, Taiwan, Thailand, Malaysia, Indonesia (Kalimantan)	24 host plant species, primarily in the family Cucurbitaceae. Also on some edible fruits	Medium	CUE	Low	**Low**

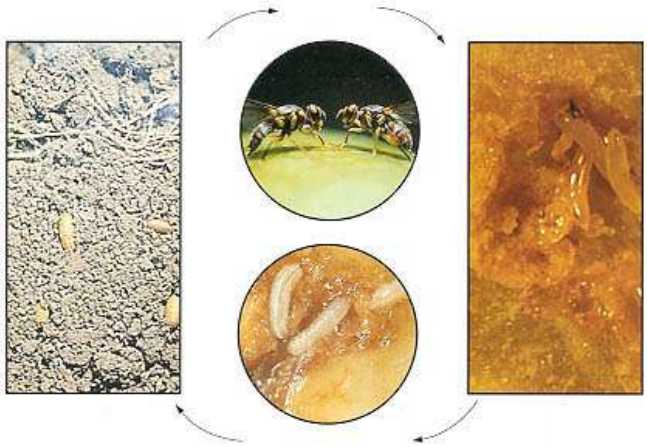
20	*tuberculata*	none in use	China, Myanmar, Thailand, Vietnam, Cambodia	A range of commercial fruit incl. peach, mango papaya and *Syzygium* species	Medium	ME	Low	**Low**
21	*umbrosa*	none in use	Widespread across S. E. Asia. P.N. Guinea, south Pacific islands to Vanuatu and New Caledonia	A range of edible *Artocarpus* species, especially, jackfruit and breadfruit	Medium	ME	Low	**Low**
22	***zonata***	**Peach Fruit Fly**	**Sri Lanka, India, Pakistan, Thailand, Vietnam, Mauritius and Egypt**	**20 host plant species from 15 plant families**	**Major**	**ME**	**High**	**High**

Entry potential **:** The potential to spread to areas/countries outside its present known distribution based on inter-country movement in the host fruit commodity through trade and passenger/tourist movement.

[2] **Colonization potential:** The ability or potential for the species to establish itself and become a pest in a new area after its entry or introduction.

1.2 Life cycle and Biology of Fruit Flies

The life cycle of fruit flies (see picture below[3]) is typical of higher flies (Diptera: Cyclorrhapha) – the female lays eggs into host fruits, and these eggs hatch to larvae (or maggots). The larvae that hatch initially are small and delicate first instar (or first stage) larvae. They moult into slightly more robust second instar larvae, and these in turn moult into quite stout and tough third instar larvae. When the third instars have finished feeding they leave the fruits, fall to the ground, and crawl away to a sheltered spot (usually in the soil) where they pupate. The larval skin becomes barrel-shaped, tanned brown and hard, and is known as the puparium. The true pupa is formed inside this puparium "shell". The pupa turns into an adult fly, which escapes from the puparium by splitting open the anterior end and squeezing out. Female flies do not develop eggs for several days after emergence, and need a protein feed to be able to do this. This is why protein baits mixed with insecticide are an effective control method. Most fruit flies are facultative breeders that will lay eggs whenever their host fruits are available, and so may have many generations per year depending on host fruit availability.



[3] Source: http://www.agnet.org/library/ac/1998h/

1.3 Fruit fly damage and crop losses

The damage starts when the female fruit fly punctures the fruit with its long and sharp ovipositor. The fruit skin is breached, and bacteria enter and the fruit starts to decay. The larvae that hatch from the eggs feed on the decaying fruit tissue, and on the yeasts and bacteria that multiply in it. It is believed that some (maybe all?) fruit fly females carry bacteria with them that they inject into the fruit at oviposition so that the fruit decays faster (making it more nutritious for the larvae).

Fruits with fruit fly larvae in them decay quickly. It is sometimes possible to cut out the damage for home consumption of the remaining part of the fruit, but infested fruits are generally unsalable, and can certainly not be exported. Crop losses can vary from a few per cent up to 100%, and losses of 90% or over are common. In some cases losses can be reduced by other treatments applied by the farmers in an area, e.g. against another orchard pest, or in another crop intercropped in the orchard.

1.4 Management options for Fruit Flies

Common techniques used for FF IPM[4]

a.) ***Biological control:*** eggs and larvae are main stage. Hymenopteran parasitoids are commonly employed; biological control alone does not provide high degree of control on sustainable basis

b.) ***Crop hygiene/sanitation:*** removal of fallen fruits/old crops; each fruit can produce up to 400 FF adults. Removal and destruction is very import for FF IPM; collected fruits should be buried 6 inches deep in soil; some part of China achieved good success in reducing population of FF using sanitation

c.) ***Bagging/ netting***: young fruits should be completely bagged; bags must not have any holes; prevent oviposition. Initially labor intensive ; increases cosmetic value of fruits; age of bagging of different fruits varies

d.) ***Insecticides:*** Not recommended in IPM as there are other robust tools available; however in citrus fruits FF can be suppressed by a single spray; limited use of pesticides in protein baits

e.) ***Bait sprays***: adult FF needs protein for their reproductive functions; beer waste based protein baits or other mixed with insecticide have been successfully used in Vietnam for past 7-8 years

f.) ***Early harvesting:*** Due to color preferences for oviposition, some fruits at early stage are not host , in such cases this method could be employed; e.g. Green mango are not hosts of FF

g.) ***Male annihilation***: using lures (ME) and cue- lures; large number of traps are needed; traps are excellent tools for ministering flies population

h.) ***Sterile Insect Technique (SIT):*** available in some countries like in Thailand; good when working with a low population; can also be used in combination of other methods

[4] Source of information: Dr. Vijay Shanmugam (formally at university of Griffith, Australia), Regional Training on IPM for Fruit Flies, 7-14 December 2010, SOFRI, Tieng Giang, Vietnam.

Part – II: Exercise Guides

Exercise 1: Identification of the three commonly occurring fruit flies

Introduction:

There are many kind of fruit flies that can attack fruits or vegetable. The loses from fruit flies can be caused by single species of fruit flies or as result of several species which attack the same plant in the same time. Understanding how to identify the species of fruit flies is the important issue for fruit flies management. Wrong identification may lead to mismanagement. Simple identification methods can be applied under loupe or binocular microscope, if available. The identification can be made by examining the ***face mark, thorax and abdominal band and marks on the wing.***

Sex ratio of fruit flies is around 1:1. Only adult females can attack the crop. The female inject the eggs into fruit flesh or vegetable using an ovipositor. Ovipositor is a needle like organ situated on the tip of the abdomen of the female. Male fruit flies are not harmful. Morphological characteristics of adult fruit flies can be observed from the presence or absence of an ovipositor.

When is this exercise most appropriate?

- In FFS and TOT sessions, when fruit flies are considered to be major pests of fruits and vegetables in farming communities; and
- When farmers want to understand the damage symptoms and related losses caused by fruit flies to help them make decisions on the most appropriate fruit fly management strategies in their farming communities.

How long will this exercise take?

- Thirty minutes for field walks, observations, specimen collection, interaction with farmers;
- One hour for brainstorming session to prepare specimen, discussion and re-confirmation among the small group ; and
- Thirty minutes for group presentations.

Materials

- Pictorial guide on identification for *B. dorsalis*, *B. correcta* and *B. cucurbitae*
- Razor blade
- Styrofoam
- Pin set
- Samples of adult fruit flies
- Loupe or binocular microscope (if available).
- (Micro) needle

Time:

2 hours

Procedures:

- ✓ Cut the Styrofoam to form a cube.
- ✓ Using pin set take one adult fruit fly.
- ✓ Mount the fruit fly sample by inserting the micro needle across the dorsal thorax. Set the micro needle into Styrofoam.
- ✓ Examine the sample under loupe or microscope.
- ✓ Record the color and number of lateral bands in the thorax region. Is the dorsal thorax band present? How many lateral bands are there? Is the middle band present or absent?
- ✓ Examine color and form of dorsal abdominal band. Is the black "T" form of abdominal band present?
- ✓ Examine the color and black marking or spot in the wing area. Are these present? Is the whole wing area clear or are some spot marking present? Is there a spot marking on the tip of the wing?
- ✓ For sexing the fruit flies, please examine carefully the tip area of abdomen. Is the abdomen rounded? Is the ovipositor present?

Some suggested questions for processing and discussions

- ✓ How can you distinguish between Melon fly and oriental fruit fly?
- ✓ How is *B. correcta* different from the other two species?
- ✓ Which FF is commonly found on vegetable?
- ✓ How do the wing markings of these 3 species differ?
- ✓ How can you distinguish between males and females?
- ✓ What is the function of the ovipositor?

Exercise 2: Study on damage symptom studies of fruit flies commonly infesting fruits and vegetables

Introduction:

In this exercise, participants will try to study the damage symptoms and their characteristics and later relate these learning experiences in designing more appropriate fruit fly management strategies in their respective communities. Normally farmers and trainers encounter the insect-pest that causes direct damage by feeding from the various plant parts and in some case indirect damage by virus transmission, etc. Fruit flies cause damage by ovipositing eggs into the fruit/vegetable flesh. Eggs upon hatching develop into maggots, which feed from bacterial induced rotting of flesh resulting into complete losses of the produce. Further, unlike other insect-pest, the trainers and farmers need to learn that threshold for fruit flies are very low as even with few signs of oviposition puncture the marketability of produce is reduced considerably.

When is this exercise most appropriate?

- In FFS and TOT sessions, when fruit flies are considered to be major pests of fruits and vegetables in farming communities; and
- When farmers want to understand the damage symptoms and related losses caused by fruit flies to help them make decisions on the most appropriate fruit fly management strategies in their farming communities.

How long will this exercise take?

- Thirty minutes for field walks, observations, specimen collection, interaction with farmers;
- Thirty minutes for brainstorming session in processing data and information;
- And, if needed, 1-2 weeks of incubation of damaged fruits to learn about the progressive damage symptoms

(Note: However it is advised that farmers should collect damaged fruits from early until late symptoms to learn about the progressive damage symptoms)

Learning objectives

- To learn about damage symptoms and degree of damage caused by fruit flies; and
- To be able to relate the damage to help participants in designing the most appropriate fruit fly management strategies in their farming communities.

Materials

- Office supplies (e.g., notebooks, ball pens, marking pens, crayons, papers);
- Other supplies (e.g., magnifying lens, plastic bags, and paper bags); and
- Fruit fly infested fruits and vegetables from learning and adjoining fields.

Methodology

- Field walks, hands-on activities, and brainstorming

Procedure:

1. Divide participants in small groups and ask them to conduct field walks, observe, and collect 100 pieces per group (or as many as possible from early damage to late or completely damaged and/or rotten fruits/vegetables by FF) for each kind of fruits and vegetables showing suspected fruit flies damage symptoms or infestation in learning and adjoining fields. Take note of oviposition behavior from the field (if possible). Interview farmers and observe their crop protection practices, if necessary. List down all observations related to pest occurrence, crops or weeds infested, degree and characteristic of damage, among others.

2. Go back to processing area. Facilitate each participant to do hands-on exercise on fruit flies damage symptoms as follows:

   - ✓ Examine each fruit and look for localized areas showing fruit fly oviposition marks or fractures;
   - ✓ Take note of characteristic damage and other related observations;
   - ✓ Separate suspected fruit fly damaged fruits from the undamaged fruits;
   - ✓ Dissect all suspected fruit fly damaged fruits to confirm the presence of fruit fly eggs or larvae;
   - ✓ Compute for percentage of fruit fly damaged fruits; and
   - ✓ Take note of all relevant observations and experiences during this activity.

3. Brainstorm in small groups and present output to the big group. Consolidate data obtained in the field and summarize in a table, as shown below:

AREA OBSERVED	NUMBER OF FRUIT FLY DAMAGED FRUITS							
	NON-IPM FARMERS				IPM FARMERS			
	No Symptom	With Symptoms		% Damaged Fruits	No Symptom	With Symptoms		% Damaged Fruits
		Without Larvae	With Larvae			Without Larvae	With Larvae	
A. Fruit Tree Area								
B. Vegetable Area								

4. Conduct participatory discussion to allow sharing of experiences among participants and facilitators. Motivate farmers to share their learning experiences on fruit fly infestation in their respective farms or communities.

Some suggested questions for processing discussion

- How do fruit flies lay eggs?
- Which crop growth stages are vulnerable to fruit fly damage?
- Have you found any difference in egg laying in fruits and vegetable crops? What are those differences and what could be implications for management?
- Why does a FF infested fruit start to rot?
- How does the FF larvae feed inside the fruit/vegetable flesh?
- What is the difference does having few oviposition marks on the fruit compared to many have on their market value?

Exercise 3. Life Cycle Studies of fruit flies commonly infesting fruits and vegetables

The genus *Bactrocera* contains most of the important pest species in Asia and the South Pacific. Many major pest species in this genus belong to the *Bactrocera dorsalis* complex, which is composed of closely related species that look very similar to the Oriental fruit fly, *B. dorsalis*, but infest different host fruits and are found in different regions.

Most fruit flies are facultative breeders that will lay eggs whenever their host fruits are available and so, may have many generations per year depending on host fruit availability. The life cycle of the fruit fly is typical of higher flies. It undergoes complete metamorphosis that consists of four stages, namely:

1. Egg, where female lays into fruit with a sharp, pointed ovipositor and in the process may also inject fruit-rotting bacteria;
2. Larva, that feeds on fruit and undergoes three larval instars
3. Pupa, where mature third instars larva drops into the ground, crawl usually into soil or leaf litter and develops into a pupa inside a hard shell of third instar larval skin called puparium; and
4. Adult, that emerges and feeds on protein and sugar to become sexually mature and then mates.

In this exercise, participants will try to identify common fruit fly species and study the fruit fly life cycle as well as their damage characteristics and relate these learning experiences in designing more appropriate fruit fly management strategies in their respective communities. In this regard, practical and worthwhile experiences can be shared and enriched by farmers and facilitators in FFS to improve current fruit fly management practices through participatory, discovery-based, and experiential learning approaches.

When is this exercise most appropriate?

- In FFS and TOT sessions, when fruit flies are considered to be major pests of fruits and vegetables in farming communities; and
- When farmers want to understand the life cycle of fruit flies to help them make decisions on the most appropriate fruit fly management strategies in their farming communities.

How long will this exercise take?

- Thirty minutes for field walks, observations, specimen collection, interaction with farmers;
- Thirty minutes for brainstorming session in processing area and hands-on insect zoo identification exercise; and
- Thirty minutes (cumulative time) for daily insect zoo observations of fruit fly life cycle stages.

Learning objectives

- To learn how to identify species, life cycle stages, damage symptoms, and degree of damage caused by fruit flies; and
- To understand the life cycle and damage characteristics of fruit flies to help participants in designing the most appropriate fruit fly management strategies in their farming communities.

Materials

- Office supplies (e.g., notebooks, ball pens, marking pens, crayons, white papers);
- Other supplies (e.g., magnifying lens, plastic bags, and paper bags);
- Ordinary microscope, and
- Fruit fly infested fruits and vegetables from learning and adjoining fields.

Methodology

- Field walks, hands-on activities, and brainstorming

Procedure:

1. Facilitate each participants to do hands-on exercise on preparing insect zoos to further understand fruit flies damage symptoms, life cycle stages, and species identification, as follows:

- ✓ Gather relatively moist soil in farmers field and place in a suitable plastic container;
- ✓ Place confirmed fruit fly infested fruits (e.g., with eggs or larvae) at the bottom of plastic container with moist soil;
- ✓ Cover plastic container with fine-mesh cloth and place in a secure area;
- ✓ Observe daily the development of fruit fly life cycle stages, noting changes in size, color, feeding activity, and other relevant information;
- ✓ Replace severely rotten or consumed host fruits as often as necessary;
- ✓ Record number of days it takes to complete from one life cycle stage to another;

- ✓ Upon emergence from puparium, catch each adult fly and identify species and sex by looking at its salient distinguishing characteristics; and
- ✓ Take note of all relevant observations and experiences during this activity.

2. Brainstorm in small groups and present output to the big group. Consolidate data obtained in the exercise and summarized in a table, as shown below:

LIFE CYCLE STAGE	NUMBER OF DAYS TO COMPLETE LIFE CYCLE STAGE		
	B. dorsalis	*B. correcta*	*B. cucurbitae*
Group I ▪ Egg ▪ Larva ▪ Pupa ▪ Adult			
Total			
Group II ▪ Egg ▪ Larva ▪ Pupa ▪ Adult			
Total			
Group III ▪ Egg ▪ Larva ▪ Pupa ▪ Adult			
Total			
Group IV ▪ Egg ▪ Larva ▪ Pupa ▪ Adult			
Group V ▪ Egg ▪ Larva ▪ Pupa ▪ Adult			
Total			
AVERAGE TOTAL			

3. Conduct participatory discussion to allow sharing of experiences among participants and facilitators. Motivate farmers to share their own knowledge in understanding life cycles and identifying life cycle stages of fruit flies in their respective farms or communities.

4. Synthesize and summarize output of small groups into one big group output. Draw up conclusions and recommendations from this exercise.

Some suggested questions for processing discussion

- Where do fruit flies lay their eggs?
- How does the larvae look like and how and where do they feed from?
- Where does it pupate?
- Describe the life cycle of fruit flies commonly infesting fruits and vegetables in the community.
- Which life cycle stages are most damaging to fruits and vegetables in the community?
- How does the adult stage of the fruit fly feed? Does it cause direct damage to fruits and vegetables?

Exercise 4: Fruit fly damage assessment

Introduction:

The damage from fruit flies normally starts when the female fruit fly punctures the fruit with its long and sharp ovipositor. The fruit skin is breached, bacteria enter, and the fruit starts to decay. The larvae that hatched from the eggs feed on the decaying fruit tissue, and on the yeasts and bacteria that multiply in it. It is believed that fruit fly females carry bacteria with them that they inject into the fruit at oviposition so that the fruit decays, making it more nutritious for the larvae.

The most common problems associated with fruit fly infestations can be described, as follows:

1. Fruit fly stings cause blemishes and rot and at early stage of fruit development may results into premature fruit drops;
2. Stung fruit is unsuitable for storage or for sale;
3. Most fruits and vegetables have very low tolerance for fruit fly damage;
4. Fruit damage can range from 40% to 100% in unprotected orchards;
5. Fruit flies exist in high populations in many habitats: in native forests, fruit orchards, home gardens, housing estates, and urban areas; and
6. Even one gravid (full of eggs) female fly is a threat.

The assessment should not only be done on the number or percentage of infestation, but also on the "history of treatment" of the orchard. By understanding the percentage of infestation in the orchard and relating this with the other conditions and "treatment history" of the orchard, the farmers' group can develop ideas for better management to reduce fruit fly population and build a healthier orchard.

When is this exercise most appropriate?

- In FFS and TOT sessions, after the exercise on 'Life Cycles and Damage Characteristics of Fruit Flies; and
- Before the various management strategies are introduced to the farmers' group to provide them with tools to assesses damage by fruit flies.

How long will this exercise take?

- Thirty minutes for field walks, observations, sampling, interaction with farmers;
- Thirty minutes for processing the information;
- Thirty minutes for brainstorming session;
- Thirty minutes for large group presentation on findings and arriving at consensus and conclusions.

Learning objectives

Farmers / FFS groups can:

1. Understand and become capable in carrying out assessment of Fruit Fly infestation in their field
2. Understand the infestation of Fruit Fly in their orchard
3. Develop ideas for better management to reduce fruit fly population and build a healthier orchard

Materials

- Bags (made of paper or plastic) for collecting samples
- Knife
- Flipchart, marker and tapes (for discussion)

Procedures:

After discussing the background and objective of the session, farmers divide themselves into small groups to do three main activities:

Activity 1: Collecting Information about the Fruit Fly and the Orchard Condition and "Treatment History"

1. Each small group prepares a set of questions related to fruit fly in the orchard.

   Example:

   - Do you know about fruit fly? (It will be better if the orchard owner can show the fly).
   - What is the pattern of fruit fly population in this orchard?
   - What is the pattern of fruiting season in the orchard and surrounding area?
   - What control measures are usually done? What are the results?
   - How much do you earn? How much do you spend on control measures? Can this be improved?
   - What is the environmental and health impact of the control measures that are used?
2. The group then asks questions to the owner of the orchard and makes important notes from the discussion.

Activity 2: Assessment of Fruit Fly Infestation

1. Each small group goes to the orchard and collects 100 fresh ripe fruits randomly. The fruit sample may be taken directly from the tree or from the fresh fallen fruits on the ground.
2. Observe the 100 samples for any external symptom of FF infestation and separate fruits into two categories: possibly infested (indicated by the presence of puncture mark or other relevant signs) and not infested.

3. The groups record: "how many are possibly infested; how many are not infested"
4. Each sample from the category of "possibly infested" fruits will then be dissected as to confirm the presence of FF larvae inside
5. The group's record: from the "possibly infested" category how many fruits are confirmed to have FF larvae inside, and then count the percentage of confirmed infested fruits (number of confirmed infested fruits / 100 samples x 100%)?

Activity 3: Analysis and Discussion

1. Each group analyzes the relationship between result of the assessment and the information from the owner of orchard (plus their own observation on the condition of the orchard)
2. Each group presents on the results of their work
3. All groups make conclusion about:
   - Status of infestation of fruit fly in the orchard
   - Relationship between the infestation and the condition and treatment history of the orchard
   - Ideas for management of fruit fly population and growing a healthy orchard.

Exercise 5: Use of lures, cue lures and protein baits as management options for fruit flies commonly infesting fruits and vegetables

Introduction:

The damage from fruit flies normally starts when the female fruit fly punctures the fruit with its long and sharp ovipositor. The fruit skin is breached, bacteria enters, and the fruit starts to decay. The larvae that hatched from the eggs feed on the decaying fruit tissue, and on the yeasts and bacteria that multiply in it. It is believed that fruit fly females carry bacteria with them that they inject into the fruit at oviposition so that the fruit decays, making it more nutritious for the larvae. The most common problems associated with fruit fly infestations can be described, as follows:

1) Fruit fly stings cause blemishes and rot and at early stage of fruit development may results into premature fruit drops;
2) Stung fruit is unsuitable for storage or for sale;
3) Most fruits and vegetables have very low tolerance for fruit fly damage;
4) Fruit damage can range from 40% to 100% in unprotected orchards;
5) Fruit flies exist in high populations in many habitats: in native forests, fruit orchards, home gardens, housing estates, and urban areas; and
6) Even one gravid (full of eggs) female fly is a threat.

As a component of fruit fly management, lures are used to trap the male insects. Males of many fruit flies are attracted by one or more of certain chemical compounds called male lures. The best known and most used of these lures are:

1. Cue lure, chemically known as 4-(*p*-acetoxyphenyl)-2-butanone, that attracts males of many *Bactrocera* and *Dacus* species; and

2. Methyl eugenol (ME), chemically known as 4-allyl-1, 2—dimethoxybenzene, that attracts males of many *Bactrocera* species, but not members of the sub-genus *Zeugocadus,* which includes the melon fly *(B. cucurbitae*), and also *B. caudata* and *B. tau*).

Cue lure (e.g., from up to 300 m away) and methyl eugenol (e.g., from up to 500 m away) attracts male flies but not the female flies. Some preliminary studies suggest that it may be possible to develop female lures, but none is commercially available at this moment. Thus, in addition to lures that only attract males, there are food baits and other attractants to draw both sexes, usually females somewhat more than males. These include yeasts, certain bacterial odors, and hydrolyzed proteins. More recently, a yeast autolysate has been used, produced by enzymatic autolysis of yeast. In both the lure and protein traps, insecticide is usually mixed with the trap so that the flies die and remain within the trap.

In this exercise, participants will try to learn how protein baits, lures, and other management options are used as a component in designing more appropriate fruit fly management strategies in their respective communities. In this regard, practical experiences and lessons learned can be shared and enriched by farmers and facilitators in FFS to improve current fruit fly management practices through participatory, discovery-based, and experiential learning approaches.

Finally it should be noted here that for the implementation of Asian Fruit Fly IPM project, lures and cue lures are planned to be used only for monitoring purposes.

When is this exercise most appropriate?

- In FFS and TOT sessions, after the exercise on 'Life Cycles and Damage Characteristics of Fruit Flies'; and
- When farmers want to learn how protein baits, lures, and other management options can be used to design the most appropriate fruit fly management strategies in their respective farming communities.

How long will this exercise take?

- Thirty minutes for field walks, observations, bait preparation, trap installation, data collection, interaction with farmers;
- Thirty minutes for hands-on insect zoo (e.g., net cage) exercise to demonstrate effect of protein baits on fruit fly population;
- Thirty minutes for observations and interpretation of results of insect zoo activities on effect of protein baits on fruit fly population; and
- Thirty minutes for brainstorming session in processing area to solicit suggestions and recommendations on how to integrate protein traps as a component of current fruit fly management strategies in their respective farming communities.

Learning objectives

- To learn how to prepare baits, install traps, as well as collect and interpret field data on the use of protein baits for fruit fly management; and
- To understand how protein baits can be used as a component of most appropriate fruit fly management strategies in fruit and vegetable farming communities.

Materials

- Office supplies (e.g., notebooks, ball pens, marking pens, crayons, Manila papers);
- Other supplies (e.g., hand sprayer, plastic bags, and paper bags);
- Ordinary microscope, magnifying lens, and two sets of 2-ft^3 fine-mesh insect net cages;
- Materials for protein baits preparation (e.g., empty mineral water bottles, protein baits, insecticide, and wood blocks);
- Fruit fly adults (one-week and five-week old adults).

Procedures:

- Field walks, hands-on activities, and brainstorming

Exercise 5a: Use of male lures as component of fruit fly management strategy

1. Divide participants in small groups and ask them to prepare cue lure (CL) and methyl eugenol (ME) baits, install bait traps, conduct field walks, observe, and collect data for each kind of installed trap for every test fruit and vegetable crop in the learning and adjoining fields. Interview farmers, if necessary. List down all other related observations;
2. Go back to processing area. Brainstorm in small groups and present output to the big group. Consolidate data obtained in the field and summarize in a table, as shown below:

REPLICATES	FRUIT TREE AREA (Number of Trapped Adult Fruit Flies)				VEGETABLE CROP AREA (Number of Trapped Adult Fruit Flies)			
	Methyl Eugenol		Cue Lure		Methyl Eugenol		Cue Lure	
	B. dorsalis	*B. correcta*	*B. cucurbitae*	**others**	*B. dorsalis*	*B. correcta*	*B. cucurbitae*	**others**
I								
II								
III								
TOTAL								
FTD*								

*Number of Fruit fly/trap/day (FTD) = Total number of adult fruit flies in all traps Number of traps in days (how many days the traps were in the field)

3. Conduct participatory discussion to allow sharing of experiences among participants and facilitators. Motivate farmers to share their best experiences in using male lures to control fruit fly infestation in their respective farms or communities.

Exercise 5 b: Understanding effect of protein baits on fruit fly population

4. Facilitate each participant to carry out hands-on insect zoo (e.g., net cage) exercise on understanding effect of protein baits on fruit fly population, using the following procedure:

   - ✓ Collect at random and introduce 200 one-week and 200 five-week old mass-reared fruit fly adults into separate 2-ft^3 net cages, respectively;
   - ✓ Mark 0.5-ft^2 area at the top-center of each of the two cages;
   - ✓ Prepare 50 ml solution (e.g., recommended mixture) each of methyl eugenol and protein bait and place separately in two hand sprayers;
   - ✓ Spray the solution on the marked area at the top-center of each of the two cages;
   - ✓ Observe fruit fly mortalities before (e.g., at 0 minute) and after (e.g., at 5, 10, 15, 20, 40, and 60 minutes) lure and protein bait spray application;
   - ✓ Compute for percentage of fruit fly mortalities; and
   - ✓ Take note of all relevant observations and experiences during this activity.

5. Brainstorm in small groups and present output to the big group. Prepare a summary table of data collected by each small group for big group presentation, as follows:

TIME OF OBSERVATION	NUMBER OF DEAD ADULT FRUIT FLIES (N=200)			
	Protein Bait-treated 1-week old *Bactrocera dorsalis*		**Protein Bait-treated 5-week old *Bactrocera dorsalis***	
	Males	**Females**	**Males**	**Females**
Before Treatment				
10 Minutes After Treatment				
15 Minutes After Treatment				
20 Minutes After Treatment				
40 Minutes After Treatment				
60 Minutes After Treatment				
TOTAL				

6. Conduct participatory discussion to allow sharing of experiences among participants and facilitators. Motivate farmers to share their best experiences in controlling fruit fly infestation in their respective farms or communities.

7. Synthesize and summarize output of small groups into one big group output. Draw up conclusions and recommendations from this exercise.

Some suggested questions for processing and discussions

- What is the difference between lure baits and protein baits when used as a component strategy for fruit fly management in fruits and vegetable crops?
- Which bait is more effective when used as a component strategy in fruit fly management for fruits and vegetable crops?
- What pest management strategies can be used to complement the use of lure baits and protein baits for fruit fly management in fruits and vegetable crops? Do you think it is the most practical approach?

- Have you observed farmers using lure bait and protein bait traps to control fruit flies in their communities? Did farmers practice other innovative methods against fruit flies? What are these methods?
- What other cultural management strategies can you use to complement use of lure bait and protein bait traps to manage fruit fly infestations in your community?

Exercise 6: Sanitation measures and fruit bagging as management option against fruit flies

Introduction:

Among others, crop hygiene, sanitation, and fruit bagging are very practical and environment-friendly methods for fruit fly management. Crop hygiene and sanitation are accomplished by preventing old infested fruits lying on the ground that are acting as reservoir of fruit flies from infesting crops in the next fruiting cycle. Fruit bagging, on the other hand, is the practice of covering the fruits with some sort of protective layer that prevents fruit flies from laying eggs in the fruits. Various kinds of cheap bagging materials may be used and can be very effective when applied at a stage of fruit development before the fruits have become attractive to fruit flies. Oftentimes, fruit bagging increases fruit quality and consequently increases also its selling price. Other cultural management options can be employed to complement crop hygiene, sanitation, and fruit bagging. These include the following:

1) Growing of less susceptible varieties; and
2) Early harvesting of fruits, i.e., before fruit fly attack the fruits. (This is for fruit fly species that infest almost-ripe fruits but not for species that attack small, green, and un-harvestable fruits).

In this exercise, participants will try to learn how crop hygiene, sanitation, and fruit bagging will complement other management options as components in designing more appropriate fruit fly management strategies for their respective communities. In this regard, practical experiences and lessons learned can be shared and enriched by farmers and facilitators in FFS to improve current fruit fly management practices through participatory, discovery-based, and experiential learning approaches.

When is this exercise most appropriate?

- In FFS and TOT sessions, after the exercise on 'Use of Lures and Protein Baits Against Fruit Flies'; and
- When farmers want to learn how crop hygiene, sanitation, and fruit bagging can complement other management options to design the most appropriate fruit fly management strategies in their respective farming communities.

How long will this exercise take?

- Thirty minutes for field walks, observation of hygiene and sanitation practices, preparation and installation of bags from different kinds of bagging materials, data collection, and interaction with farmers;
- Thirty minutes for hands-on insect zoo (e.g., net cage) exercise to demonstrate effect of crop hygiene, sanitation, and fruit bagging on fruit fly population;
- Thirty minutes for observations and interpretation of results of insect zoo activities on effect of crop hygiene, sanitation, and fruit bagging on fruit fly population; and
- Thirty minutes for brainstorming session in processing area to solicit suggestions and recommendations on how to integrate crop hygiene, sanitation, and fruit bagging as a component of current fruit fly management strategies in their respective farming communities.

Objectives

- To learn how to prepare and install fruit bags, as well as collect and interpret field data on crop hygiene, sanitation, and fruit bagging for fruit fly management;
- To understand how crop hygiene, sanitation, and fruit bagging can be used as components of most appropriate fruit fly management strategies in fruit and vegetable farming communities.

Materials

- Office supplies (e.g., notebooks, ball pens, marking pens, crayons, Manila papers);
- Other supplies (e.g., hand sprayer, plastic boxes, absorbent foam, table sugar, autolysed yeast, and water);
- Ordinary microscope, magnifying lens, and four sets of 1-ft^3 fine-mess insect net cages;
- Materials for fruit bags preparation (e.g., plastic bags, old news papers, used bond papers, and others); and
- Fruit fly adults (e.g., mixture of sexually matured male and female adults).

Methodology

- Field walks, hands-on, and brainstorming

Exercise 6 a: Fruit bagging for the control of fruit flies

1. Divide participants in small groups and ask them to prepare bags using different kinds of bagging materials, install fruit bags, conduct field walks, observe sanitation practices employed, and collect data for each kind of fruit bag for every test fruits and vegetables in learning and adjoining fields. Interview farmers, if necessary. List down all other related observations;
2. Go back to processing area. Brainstorm in small groups and present output to the big group. Consolidate data obtained in the field and summarize in a table, as shown in the example below:
3.

CROPS OBSERVED	Bagging Materials Used*					Time of Bagging	Crop Hygiene and Sanitation Practices Employed
	PB	BP	NP	FC	OM		
Fruit Crops:							
1. Carambola							
2. Guava							
3. Mango							
4. Papaya							
5. Rose Apple							
6. Sapodilla							
7. Star Apple							
Vegetables:							
1. Bitter Gourd							
2. Bottle Gourd							
3. Eggplant							
4. Luffa							
5. Tomato							

*Paper Bags (PB); Brown Paper (BP); News Paper (NP); Fine-mess Cloth (FC); Other Materials (OM)

4. Conduct participatory discussion to allow sharing of experiences among participants and facilitators. Motivate farmers to share their best experiences on crop hygiene, sanitation, and fruit bagging practices to control fruit fly infestation in their respective farms or communities.

Exercise 6 b: Understanding effect of crop hygiene and sanitation practices

5. Facilitate each participant to carry out hands-on insect zoo (e.g., net cage) exercise on understanding effect of crop hygiene and sanitation practices on fruit fly population, using the following procedure:

   - ✓ Collect at random and introduce 25 mass-reared mature and protein-fed fruit fly adults in each of four (4) 1-ft^3 fine-mess net cages;
   - ✓ Place 4-5 pieces ripe fruits (e.g., one kind of fruit) in each of the four (4) net cages;
   - ✓ Observe behavior of the introduced fruit flies;
   - ✓ Leave overnight;
   - ✓ After 24 hours, observe the fruits again for oviposition marks;
   - ✓ Dissect one fruit vertically through the oviposition marks and observe the eggs inside the fruit flesh within the oviposition marks;
   - ✓ Return fruits inside the net cages and repeat observation process daily for four more days;
   - ✓ After eight days, dissect fruits containing third instar larvae and leave on sawdust and observe for emergence of adults; and
   - ✓ Take note of all relevant observations and experiences during this activity.

6. Brainstorm in small groups and present output to the big group. Prepare a summary table of data collected by each small group for big group presentation, as shown in the example below:

FRUITS TESTED	Numbers After 24 Hours			Days to Complete Stage			
	Fruit Fly Adults	Oviposition Marks	Eggs Deposited	Egg	Larva	Pupa	Adult
1. Barbados Cherry	25						
2. Carambola	25						
3. Jujube	25						
4. Rose Apple	25						

7. Conduct participatory discussion to allow sharing of experiences among participants and facilitators. Motivate farmers to share their learning experiences relating to crop hygiene and sanitation practices as fruit fly management strategies in their respective farms or communities.

8. Synthesize and summarize output of small groups into one big group output. Draw up conclusions and recommendations from this exercise.

Some suggested questions for processing discussion

- How many oviposition marks were made by female fruit flies on the different fruits? How many eggs were deposited in each oviposition mark on the different fruits? How many days did it take to complete each life cycle stage on the different fruits?
- What crop hygiene and sanitation practices be effectively employed for fruit fly management in fruits and vegetable crops?
- What kinds of fruit bagging materials can we use to prevent fruit fly infestation in fruit and vegetable crops? Which fruit bagging material is more effective when used as a component strategy in fruit fly management for fruits and vegetable crops?
- What pest management strategies can be used to complement crop hygiene, sanitation, and fruit bagging for fruit fly management in fruit and vegetable crops? Do you think it is the most practical approach?
- Have you observed farmers using crop hygiene, sanitation, and fruit bagging as strategies to control fruit flies in their communities? Did farmers practice other innovative methods against fruit flies? What are these methods?
- What other cultural management strategies can you use to complement crop hygiene, sanitation, and fruit bagging practices to manage fruit fly infestations in your community?

Exercise 7: Natural enemies of fruit flies

Natural enemies and mortality factors are important balancing mechanisms in a sound ecosystem to help control pest populations in a dynamic equilibrium with other components. Extending seasons of growing, use of artificial flowering agents and large scale cultivation of the same species of crops are known to be causes of fruit fly damage. Despite large amounts of effort devoted to the use of biological control agents (e.g., predators and parasitoids) to control fruit flies, there have been relatively few instances that may be regarded as sustainable successes. In this regard, a healthy ecological balance supplements a range of natural enemies, both vertebrate and non-vertebrate, that are known to reduce fruit fly population fruit and vegetable crops[5].

The design of discovery-based exercises on natural enemies of fruit flies must be started with field walks, observations, and collection of live specimens (including parasitized and disease-infected fruit flies) in fruit and vegetable fields. Sorting and identification of collected live specimens by the participants will be then conducted in small groups. Validation of output in big group with assistance of facilitators follows and the participants, together with technical experts, will summarize the activity by classifying collected specimens as follows[6]:

1. *Predators.* A group of organisms that is free-living throughout their entire life cycle. Each predator consumes a number of pests, called preys, in its lifetime. Fruit fly predators may include spiders, ants, carabid beetles, assassin bugs, staphylinid beetles and probably others. Weaver ants are very efficient in protecting fruit trees from pests like fruit flies. Generally, predators have little effect on fruit fly populations in an orchard or vegetable production situation.

[5]Kumar, P. 2010. Natural Enemies of the Fruit Flies. PowerPoint slide presentation during a Regional Training on IPM for Fruit Fly conducted at Tien Giang, Vietnam on 7-14 December 2010. U.N. Food and Agriculture Organization Regional IPM Programme for Vegetable in South and Southeast Asia. 33 slides.
[6]Medina, J.R. 1998. As cited in: Callo, Jr., D.P., L.B. Teofilo, and H.A. Tauli (eds). 2002. Field Guide of Discovery-based Exercises for Vegetable IPM, Volume II. SEAMEO Regional Center for Graduate Study and Research in Agriculture (SEARCA), Los Baños, Laguna, Philippines. pp169-172.

2. *Parasitoids.* These are insects, mostly wasps and flies that lay eggs on or near insect pests of fruits and vegetables. Upon hatching, parasitoid larvae feed on hosts, either internally or externally and kill hosts during their development. Adult parasitoids feed mostly on flowers. Most common parasitoids of fruit flies belong to the families Braconidae, Chalcididae, and Eulophidae. Some examples are *Psyttalia fletcheri* Silvestri, *Diachasmimorpha kraussi*, and *Diachasmimorpha longicaudata*.

3. *Pathogens.* These are parasitic microorganisms used to control fruit flies commonly infesting fruits and vegetables. Some insect pathogens infecting fruit flies are viruses, bacteria, and fungi. Both viruses and bacteria infect their host when eaten. Endo-symbiotic bacteria of the genus *Wolbachia are known to* induce cytoplasmic incompatibility, thelytokous parthenogenesis, and male-killing or feminization. Fungal pathogens can infect their hosts by penetrating directly through surfaces of host's body. A few examples are green (*Metarhizium anisopliae*) or GMF and white (*Beauveria bassiana*) or WMF muscardine fungi.

When this exercise is most appropriate?

- In FFS and TOT sessions, after conducting at least 3 or 4 weekly AESA in fruits or vegetable learning field; and
- When farmers want to identify and learn functions of different natural enemies of fruit flies in their fruit or vegetable crops ecosystem.

How long will this exercise take?

- Thirty minutes for field walks, observations, and collection of different insects and other small animals in fruit or vegetable crops field; and
- Thirty minutes to one hour for identification and sorting of specimens according to ecological functions, and brainstorming session in the processing area.

Objectives

- To develop participants' skills in observing and recognizing shapes, colors, and functions of natural enemies of fruit flies found in agro-forestry ecosystem; and
- To encourage participants to differentiate insect pests, 'unknown' insects, and other small animals based on their ecological functions instead of their technical descriptions.

Materials

- Fruit and vegetable crops grown in learning and adjoining fields;
- Collecting equipment (e.g., plastic bags, jars, sweep net, aspirator, fine hair paintbrush); and
- Other materials (e.g., alcohol to kill insects, white plates or trays to spread insects for sorting, hand lenses, news print paper and markers.

Methodology

- Field walks, observation, collection, sorting, identification, and brainstorming

Procedure

1. Divide participants in small groups and ask them to conduct field walks, observe, and collect insects and other small animals in fruit and vegetable crops learning and adjoining fields. Take note of feeding characteristics of these animals. Interview other farmers, if necessary. List down all observations related to occurrence, insects infested or infected, degree and characteristic of damage to pests, among others.

2. Facilitate each small group to sort and identify collected specimens based on their similarities in color, shape, and ecological functions as observed in fruit or vegetable crops learning field. Have a 'competition' with prizes for small groups that can collect:

   - ✓ Largest number of different insects and other small animals;
   - ✓ Biggest insect or other animal; and
   - ✓ Smallest insect or other animal.

3. Go back to processing area; brainstorm in small groups and present outputs to big group. Allow small groups to kill insects by putting in a bag with a little alcohol and quickly sort them on white trays or plates into groups of different types of insects. While small groups are sorting specimens, facilitators draw up a matrix table on a flip chart paper for competition results. Fill in competition results and give candies to winning groups and all other groups for working so hard, as shown in the example below:

GROUP	HOW MANY KIND	LARGEST	SMALLEST	TOTAL
1				
2				
3				
4				
5				
TOTAL				

4. Conduct participatory discussions and motivate farmers to share their ideas and knowledge on similarities, differences, and functions of collected specimens in fruit or vegetable crops ecosystem. Facilitate each small group to make a list of different ways of grouping specimens that are useful when observing fruit or vegetable crops ecosystem and making management decisions, like:

   - ✓ What does it do (e.g., predator, parasitoid, insect pathogen, insect pests, pollinator, or decomposers)?
   - ✓ Where is it found (e.g., on fruits, flowers, plants, or soils as well as on larvae, pupae, or adults of fruit fly)?
   - ✓ What stage is it (e.g., egg, larva, nymph, pupa, or adult)?
   - ✓ How does it move (e.g., flying, jumping, or crawling)?
   - ✓ How many are there (e.g., in groups or single)?
   - ✓ What type of insect or animal (e.g., spider, fly, beetle, butterfly, bug, wasp, frog, slug, etc.)?

5. Each small group take each animal that they have collected, goes down the list and makes a check against each group that it belongs to. Each group makes a table/matrix with all the different ways of grouping listed like this:

WAYS OF GROUPING	TALLY/CHECK	TOTAL NUMBER
A. What it does?		
1. Predator	~~IIII-IIII-IIII-~~III	13
2. Parasitoid	~~IIII-IIII-IIII-IIII-IIII-~~III	28
3. Pathogen-Infected	~~IIII-~~I	6
4. Insect Pests	~~IIII-IIII-IIII-IIII-IIII-IIII-IIII-IIII~~	40
5. Unknown	~~IIII-~~I	6

B. What stage it attacks?

1.	Egg	IIII	4
2.	Larva	~~IIII~~-~~IIII~~	10
3.	Pupa	~~IIII~~-III	8
4.	Adult	~~IIII~~-~~IIII~~-III	13

6. Synthesize and summarize outputs of small groups into one big group output. Draw up conclusions and recommendations from this exercise.

Some suggested questions for processing discussion

- How many natural enemies of fruit flies did you have difficulty in grouping? How many were insect pests? How many were 'unknowns'?
- What characteristics did you use in grouping natural enemies of fruit flies that you know?
- If you did not know the animal, how did you find out its characteristics?
- What insect parts or life cycle stage did the natural enemy attack or feed on?
- What insects did the insect-feeders feed on?
- What need to be done to conserve these natural enemies of fruit flies in fruit or vegetable crops fields?
- What cultural practices do you know will help conserve and encourage reproduction of naturally occurring enemies of fruit flies commonly infesting fruit and vegetable crops?

Exercise 8 : Knowledge & Skill Development Evaluation Exercise (example for pre and post ballot box tests)

Introduction:

Assessing the pre and post training knowledge and skill development of the participants in the FFS and/or TOT is an integral part of these trainings. Normally such test are designed as practically as possible and focuses on key aspects that could help the learners to decide on making informed decision on fruit fly management.

A set of questions as example are mentioned here as inspirational tool for the IPM trainers to adapt it for their locally training situations. For many of the questions the trainers need to organize the fresh specimens, damaged fruits and other requires materials prior to conducting this test.

A. Diagnostics

Q1: This Bactrocera fruit fly adult is identified as:

A. *B. dorsalis* B. *B. cucurbitae* C. *B. correcta*

Q2: These fruit flies can be identified as the following species:

A. *B. dorsalis* B. *B. correcta* C. mix of *B. correcta* & *dorsalis*

B. Nature of damage by Fruit fly and damage symptoms

Q3 : This fruit is likely infected with

A. *B. cucurbitae* B. *B. dorsalis* C. *B. correcta*

Q4: This fruit is likely damaged by:

A. Oriental fruit fly B. cucurbit fly C. fruit borer

C. Life cycle and ecology

Q5: Duration of the fruit fly life cycle is generally:

A. 12-14 days B. 20-25 days C. 35-40 days

Q6: The pupa of the fruit fly is normally found:

A. On leaves B. Inside fruits C. In soil

Q 7. For artificial fruit infestation study of Fruit Flies, one needs

A. Only sugar B. only water C. Sugar and water

D. Monitoring skills

Q8: The methyl eugenol lure attracts the male adult flies of the following species:

A. *B. dorsalis* B. *B. correcta* C. *B. cucurbitae*
C. mix of *B. correcta* & *dorsalis*

Q9: The CueLure attracts the male adult flies of the following species:

A. *B. dorsalis* B. *B. correcta* C. *B. cucurbitae* C. mix of *B. correcta* & *dorsalis*

Q10: If you find a total of 50 adult flies in 5 traps after 2 days of setting up the traps than the FTD count is:

A. 50 B. 25 C. 10 D. 5

E. Management of the fruit flies

Q 11. The protein baits attracts

A. Only male B. only female C. both males and female

Q12: The best-bet area wide fruit fly management strategy to be employed within the context of the FAO/AIT fruit fly management project will likely be:

A. Sanitation, lures & protein baits for adult fly control
B. Sanitation, protein baits and lures for monitoring only
C. Sanitation, protein baits & bagging

Q 13. Bagging of all fruits should be done at

A. 1 week after pollination B. 2 weeks after pollination

B. 3 weeks after pollination D. depends on fruit variety

Q 14. Which of the following stage of fruit flies are normally parasitized by parasitoids?

A. Only egg B. only larval C. only pupal D. only adults
adult E. Eggs and larvae

Q 15. Protein bait spray on cucurbits should be carried out on:

A. Every row B. Every plant C. alternate row
D. Alternate plants

Q. 16. Protein baits spray on fruit trees in an orchard should be applied to:

A. Every second tree B. Every third tree C. Every tree

Q. 17. The recommended volume of spot spray is:

A. 100mL B. 50mL C. 25mL

Q. 18. The recommended volume of protein bait spray to be applied weekly per hectare of crop is:

A. 50-100 liters B. 25-50 liters C. 10-20 liters

Q.19. The best time to apply protein bait is

A. At night B. Early in the morning C. Late in the afternoon.

Q.20. After handling ME and CUE blocks, wash your hands with

A. Soap and water B. Oil C. Alcohol first, then soap and water

Field Notes

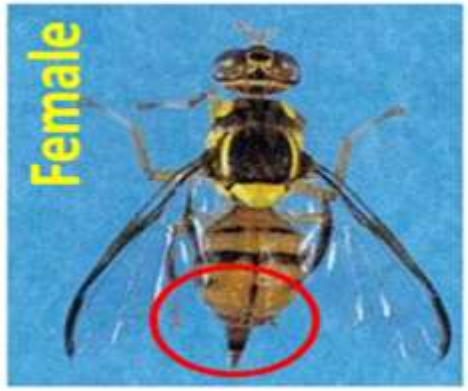
Annexes

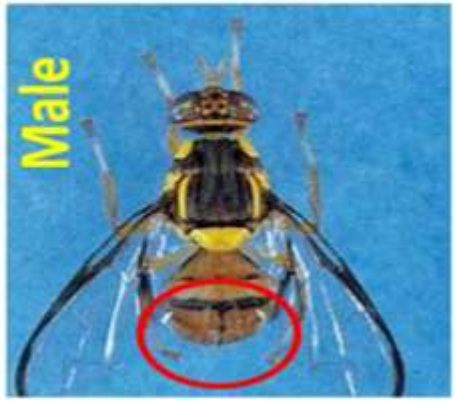
Annex 1: Pictorial Guide on Identification of three commonly occurring Fruit Fly Species in the Greater Mekong Sub-region countries (Source of pictures http://www.forestryimages.org)

A. *Check the wings*[7]

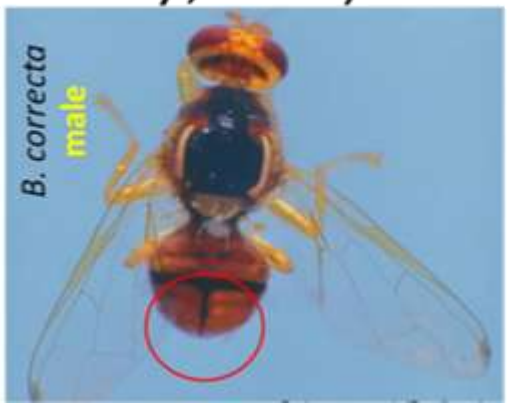
B. Adult female and male

B. dorsalis (Oriental Fruit Fly; OFF)





B. correcta (Guava Fruit Fly; GFF)



B. cucurbitae (Melon Fly)