Abundance and diversity of insects on apple water tree during fruit season using different colours and different height placement of sticky trap

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Abstract. The objective of this research were to determine the abundance and diversity of insects on apple water tree and to measure the effectiveness of several colours and height placement of sticky trap on fruit flies and other insects on apple water tree during fruit season. Sampling of insects was conducting in an apple water field during fruit season in Demak Central Java Indonesia using sticky trap with methyl eugenol attractant. There were three different sticky trap colours i.e., yellow, white, and blue; and two height of trap placement i.e., one meter and three meter, were used. Parameters observed included the number of fruit flies in each colour, height placement of sticky trap, and the taxon of insects. The data was analysed into Shannon-Wiener diversity and abundances of insects on each colours and height placement of sticky traps. The results showed that the insects found consist of 5 orders (Diptera, Hymenoptera, Coleoptera, Lepidoptera, and Odonata), and 21 families. Most families are found in the order Diptera (8 families), Hymenoptera (4 families), and Coleoptera (3 families). The Diptera family consists of Tephritidae, Culicidae, Agromyzidae, Muscidae, Asillidae, Mycetophyllidae, Drosophyllidae, Bombyllidae. In short, the insects on apple water tree were more abundant in 3 meter height and they tend to be attracted on yellow sticky trap.

1. Introduction
Fruit fly (Bactrocera sp.) is one of the most harmful pest groups which cause fruits production losses globally including in Indonesia [8]. The species of Bactrocera that can cause severe damage to horticultural crops in Asia (especially Southeast Asia) is B. dorsalis (Hendel). This species is also an important pest in western Indonesia [16]. As an impact of the free trade, the fruit trade is now increasing globally. Consequently, fruit flies from one country can spread easily to other countries [6].

Fruit flies are a very destructive pest of horticultural crops, especially fruit and vegetable crops [3]. Fruit flies can cause rotten fruit or fall prematurely, hence the fruit quality decreases [1]. The level of damage caused by fruit flies can reach 75%. This pest has a very high dispersal ability and has a wide distribution of host, including mango, cashew, guava, chili, papaya, jackfruit, orange, melon, cucumber, tomato, avocado, banana, and starfruit [1]. Currently flies from the family Tephritidae is already spread almost throughout the Asia Pacific region and has more than 26 species of host plants. These pests cause losses, both in quantity such as the loss of some young fruit or unripe fruit. Meanwhile, quality losses, such as fruits or vegetables become rotten and contain maggots.

Traps that are used to control the population of fruit flies generally use attractants. Attractant is a compound that can attract insects. Attractants may be used to control fruit fly in three ways: a)
detecting or monitoring fruit fly populations, b) attracting fruit flies to be killed with traps and c) confusing fruit flies in mating and feeding behaviour. Methyl eugenol serves as sex attractants which can generally attract at least 90% of the male species of the genus *Dacus* [13]. This compound is an important component in the synthesis of sexual pheromones in the body of male *Bactrocera* sp. Since this attractant is volatile, its reachability is far enough, reaching hundreds of meters, even thousands of meters, depending on the direction of the wind. The capability of attractants is varied depending on location, weather, commodity and the ripen of the fruit in the field. Several studies have shown that the use of methyl eugenol can decrease the intensity of fruit flies in mangoes by 39-59% [13].

The effectiveness of methyl eugenol as fruit flies attractant has already proven in several countries. Meanwhile, the effectiveness of different colours and the placement position of insect trap on apple water tree have not been studied yet. In addition, the effect of different colour and height position of sticky trap on the attractiveness of other insects have also not been known yet. The objective of this research were to determine the abundance and diversity of insects on apple water tree and to measure the effectiveness of several colours and height placement of sticky trap on fruit flies and other insects on apple water tree during fruit season.

2. Materials and Method
The location of this research was in the apple water field in surrounding Betokan Village, Demak Subdistrict, Semarang Regency in March 2018 during fruit season. Sampling of insects was conducting using sticky trap with methyl eugenol attractant. There were three different sticky trap colours i.e., yellow, white, and blue; and two height of trap placement i.e., one meter and three meter, were used. Parameters observed included the number of fruit flies in each colour, height placement of sticky trap, and the taxon of insects. Each height of sticky trap was installed with three the colour, and the treatment was done 3 times. The data was analysed into Shannon-Wiener diversity and abundances of insects on each colours and height placement of sticky traps. The caught insect were then calculated and morphologically identified up to family level.

3. Results and Discussion
The result showed that the insects caught consist of 5 orders and 20 families. Most families found in this study belong to Diptera order which was 9 families (Table 1). Hymenoptera and Coleoptera were found the second and the third divers i.e., 5 families and 4 families respectively. Generally, the trend which showed Diptera as the most diver found in apple water indicates the preference of Diptera, specially family Tephritidae, to choose apple water as their habitat. Our experiments confirm that family Tephritidae as the largest number of orders Diptera. Fruit fly *Bactrocera* sp. is the main pest that attacks fruits and belongs to the family Tephritidae.

**Table 1.** Abundances, richness, diversity, and evenness of insects in various of colours and height placement of sticky trap on apple water tree in Demak during fruit season.

| Taxa          | Number of insects |
|---------------|-------------------|
|               | Yellow 1 m | Yellow 3 m | White 1 m | White 3 m | Blue 1 m | Blue 3 m |
| **DIPTERA**   |             |             |             |            |          |          |
| Tephritidae   | 9           | 13          | 9           | 11         | 6         | 11        |
| Culicidae     | 4           | 3           | 4           | 4          | -         | -         |
| Agromyzidae   | 8           | 10          | 9           | 12         | 9         | 8         |
| Muscidae      | 2           | 1           | 3           | 4          | 1         | 2         |
| Asilidae      | 5           | 4           | 2           | 7          | 6         | 7         |
| Mycetophyllida| 4           | 11          | 9           | 8          | 4         | 10        |
| Drosophyllida | 7           | 9           | 4           | 6          | 5         | 5         |
| Bombyllida    | -           | 1           | -           | -          | -         | -         |
| Phoridae      | -           | -           | -           | -          | 1         | -         |
HYMENOPTERA
- Chalcididae: 2
- Formicidae: 7
- Sphecidae: 2
- Braconidae: 1
- Tiphidae: -

LEPIDOPTERA
- Oecophoridae: -

COLEOPTERA
- Melyridae: -
- Gyrinidae: 1
- Curculionidae: 1
- Buprestidae: -

ODONATA
- Calopterygidae: -

|                | Yellow | White | Blue |
|----------------|--------|-------|------|
| Height (meter) | 1m     | 3m    |      |
| Number of insects (individual) | 53     | 63    | 49   |
| Number of taxa, S | 13     | 13    | 12   |
| Shanon-Wiener diversity, H' | 2,33   | 2,16  | 2,22 |
| Evenness, e      | 0,91   | 0,84  | 0,89 |

According to Kardinan (2005), the new larvae of *Bactrocera* sp. out of the eggs soon can be abundant food. Larvae use their mouthparts in the form of destructive enzymes and digesters. This enzyme can accelerate the decay and subsequently emit a strong aroma that is thought to be derived from alcoholic compounds so as to attract the attention of other insects along with decaying the flesh, the decaying bacteria also heightens the activity so that the fruit becomes damaged. Fruit flies often attack and destroy crops during the rainy season because the humidity triggers the pupa to break out into adult flies.

![Figure 1](image)

**Figure 1.** The 3 meter of height placement of sticky trap combined with methyl eugenol perform significant effect on the percentage of attracted canopy insects.

Generally our study found that the insects caught in the 3 meter height of sticky trap placement were more abundant than in the 1 meter position, regardless of the colour of the sticky trap (Figure 1). This trend was occurred in yellow, white, and blue sticky trap consistently. The order Diptera as the dominant group in this study contribute greatly to the abundance of insects in the 3 meter position.
Either family Tephritidae, Agromyzidae, Asilidae, Mycetophyllidae, and Drosophyllidae were more abundant in the 3 meter height rather than in the 1 meter position. This shows that the majority insects in surrounding environment of the apple water fruits in Demak prefer to form clump distribution in higher position. The addition of methyl eugenol on each sticky trap did not affect at all on the preference of insect to the lower position of sticky trap.

Figure 2. The different colours of sticky trap combined with methyl eugenol performed not significantly different on the percentage of attracted insects.

The treatment of sticky trap colour showed that yellow colour attracted insects more (37%) than white (33%) and blue colour (30%) (Figure 2). This support previous findings that insects tend to attract to yellow colour generally. However, the intensity of the insect preference on colour of sticky trap performs not so significant. This trend might likely due to methyl eugenol application which affect stronger than the attraction of the colour of sticky trap.

Insects can differentiate colours because of differences in retinal cells in the eyes of insects. The range of wavelengths that can be accepted by insects is 2540-6000 Å. Insects use a number of visual cues or chemical cues to find a host in the form of fruit or vegetables. Suitability of visual cues and chemical cues will cause insects to be more interested in finding the host. Experiments have been carried out, among others, insect interest in colour which is a visual stimulus and provide certain responses to more insects trapped in yellow traps. One important factor that influences the presence and diversity of fruit flies is the presence of hosts that act as food sources (Nismah & Susilo., 2008).

In insects, single eyes or ocelli and compound eyes or omatidia are the means of receiving light stimuli. The single eye has a single corneal lens while the compound eye has many omatidium coated with a hexagonal corneal lens. The single eye serves to distinguish the intensity of the light received. While compound eyes function as shadows in the form of mosaics. Basically, many insects are colour blind. But not a few can distinguish colours. The recipient of light stimuli in insects is single or ocelli and compound eyes or omatidia. The basic component needed for vision is a lens to focus light onto photoreceptors - cells that contain sensitive light molecules - and a complex nervous system to process visual information.

4. Conclusion
To conclude, during the fruit season the insects on apple water tree were more abundant in 3 (three) meter height and they tend to be more attracted on yellow colours. On the other hand, the diversity of insects on apple water tend to be more diverse in 1 (one) meter height, except in blue sticky trap. To control fruit flies pest on apple water tree using sticky trap with methyl eugenol, the yellow colours and three meter height placement proved to be the most effective.

5. Acknowledgments
Our biggest thanks to Faculty of Science and Mathematics, Diponegoro University for supporting us research funding through the PNBP scheme.
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