Diversity of *Bactrocera* spp. on some mango varieties at Kecamatan Talun, Kabupaten Cirebon

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Abstract. Fruit fly (*Bactrocera* spp.) is a major pest of horticultural crops, especially fruits. Fruit fly larvae feed on the flesh of fruit, and cause the decrease of both quantity and quality of the production. Fruit fly species on certain fruit in an area is important to be identified to make a right decision in choosing the control methods. The objectives of this study were to identify the fruit fly species, and determine the dominant species and diversity index of fruit flies on mangoes Gedong Gincu, Cengkir, and Arumanis at Kecamatan Talun, Kabupaten Cirebon, Indonesia. The survey was carried out by collecting samples of mango fruit attacked by fruit flies from field, wholesaler, and retailer at Kecamatan Talun. The results showed that there were four species that attack mangoes Gedong Gincu, Cengkir, and Arumanis at Kecamatan Talun, namely *B. dorsalis*; *B. carambolae*; interspesific hybrids of *B. carambolae* and *B. dorsalis*; and *B. albistrigata*. The dominant species was *B. dorsalis*. Diversity index (H’) of fruit fly species was 0,05 ≤ H’ ≤ 0,48 (H’ < 1,5), so that the diversity was considered low.

1. Introduction
Mango (*Mangifera indica* L.) is one of the most cultivated horticultural crops in Indonesia. The centers of mango production in Indonesia are West, Central, and East Java. Kabupaten Cirebon is a potential area for mango cultivation in West Java [1]. Many varieties of mango have been cultivated in West Java, such as Gedong Gincu, Arumanis, Dermayu, and Golek [2].

One of the constraints in mango cultivation is plant pest. Fruit fly (*Bactrocera* spp.) is the main pest of mango fruit that cause production loss and prevent mango exportation from Indonesia, because the quality does not meet the export criteria [3]. Fruit fly causes losses on many other horticultural crops, including vegetables and fruits [4]. It causes both quantitative and qualitative damages. The quantitative damage is caused by the low marketable yield, while qualitative damage by the unattractive appearance of the produce that prevent the customers from buying [5].

Abundance and diversity of insect species in an area are affected by both biotic and abiotic factors. Feed availability and climate affect the spread and diversity of fruit fly species in an area [6]. The availability of fruit supports the fruit fly reproduction. High availability will increase the reproduction, vice versa low availability will inhibit it [7]. Each fruit variety has characteristics that in favor or not to the fruit fly. Different varieties of mango in India caused some variation on reproduction time, egg hatching, and fecundity of fruit fly. This condition was affected by some physical characteristics and chemical nutrition of the varieties [8]. Both quality and quantity of fruit affect the population of fruit fly in an area [9].
There were two species of fruit flies that attacked mangoes, namely *B. dorsalis* and *B. carambolae*. The percentage of *B. dorsalis* amounted to 91%, while *B. carambolae* was only 9% [10]. *B. dorsalis* is a species of fruit fly that is caught by many attractants of methyl eugenol in mango plantations in India [11]. The species of fruit fly that predominates in several Land Use Systems in West Lampung was *B. dorsalis*. Its dominance index were 0.76-1.00 [12].

Fruit characteristics can affect the variation of *B. dorsalis* oviposition levels that attack several mango varieties in India, including the level of maturity, size of skin thickness, nutrient content, and fruit color. Mango varieties of Beganpali, Sindhi and Chunsu in India have different characteristics. Chunsu mango varieties have higher nutrition than other varieties, so it is beneficial for the development of fruit fly larvae [8].

Expansive fruit trading causes the spread of fruit fly from place to place [13]. Identification of the fruit fly can be useful in a preventive control method, for an easier management of fruit fly, so the fruit can be competitively traded in local and international markets [14]. Identification of the fruit fly species within an area is required. The information can be applied in making decision, choosing, and preparing the correct control methods, especially in quarantine case [12].

The objectives of this research were to identify the species, and to determine the diversity and dominance of the fruit fly species on mango varieties of Gedong Gincu, Cengkir, and Arumanis at Kecamatan Talun, a center of mango cultivation area in Kabupaten Cirebon, Indonesia.

2. **Materials and Methods**

2.1. **Fruit Sampling**

Samples of mango fruit were purposively collected from the field, wholesaler, and retailer at Kecamatan Talun, Kabupaten Cirebon at 0-130 above the sea level. The temperature was 22°C-30°C and rainfall was 2.260 mm/year. Fruit infested by the larvae of fruit fly were chosen as samples. The symptom on the infested fruit is small puncture spots caused by the adult on eggs oviposition. The samples were collected in three sampling times, i.e. in October, November, and December 2018. The mango varieties were Gedong Gincu, Cengkir, and Arumanis; 10 fruit per unit (mango variety and sampling time).

2.2 **Rearing of Fruit fly**

The mango fruit was placed in a container with sterile sawdust, styrofoam, and tissue paper; one mango fruit per container. The cap of the container was punctured to make a ventilation hole. The hole was covered with a piece of muslin cloth and tissue paper.

The third instar of the larvae would bounce out of the fruit and develop into pupae. The pupae were collected by sifting the sawdust. Number of pupae was counted and 10% of each sample unit was weighed using analytical scale. Then the pupae were put into rearing containers. The emerging adults were fed with ground sugar in a small container with wet tissue paper. The adults were fed for 10-14 days, and ready to be identified.

2.3 **Morphological Identification of Fruit fly**

Adult fruit flies were put into micro tubes, and placed in a refrigerator to immobilize them. The identification was carried out by observing the morphological characteristics, including thorax, abdomen, and wings. The fruit fly sex was then identified by observing the end of the abdomen. Female fruit fly has ovipositor, but the male does not. The ratio of male and female fruit flies was compared.

\[
\text{Sex ratio} = \frac{\text{number of males}}{\text{number of females}}
\]

The abdomen was observed under a stereo microscope (Olympus SZ61). The morphological characteristics were also observed and compared to the identification by Drew [15].
2.4 Diversity Index of Fruit fly Species
The diversity index of fruit fly species was calculated with the equation of Shannon-Wiener index as follow:

\[ H' = - \sum \left( \frac{n_i}{N} \right) \log \left( \frac{n_i}{N} \right) \]

- \( H' \) = Shannon-Wiener Index of diversity
- \( n_i \) = number of spesies i
- \( N \) = Total number

When:  
- \( H' < 1.5 \), the diversity is low  
- \( 1.5 < H' < 3.5 \), the diversity is medium  
- \( H' > 3.5 \), the diversity is high

2.5 Dominance of Fruit fly Species
Dominance of fruit fly species was assessed by counting the number of each species. The species is dominant when the number of that particular species is the highest compared to other species. The dominance index was calculated according to Simpson dominance index as follow:

\[ C = \Sigma \left( \frac{n_i}{N} \right)^2 \]

- \( C \) = Simpson dominance index  
- \( n_i \) = number of spesies i  
- \( N \) = total number

2.6 Analysis of Mango Fruit Content
One mango fruit for each variety was purposively chosen for nutritional content analysis, including carbohydrate, protein, fat, water, and ash contents. Pearson correlation test (SPSS 16.0) was applied to evaluate the correlation between nutritional contents and species diversity index and weight of pupae.

3. Results and Discussion

3.1. Morphological Identification of Fruit Fly
Results of morphological identification of fruit fly showed that there were four fruit fly species on mango var. Gedong Gincu, Cengkir, and Arumanis collected from the field, wholesaler, and retailer at Kecamatan Talun, Cirebon (Table 1). The fruit fly species were \( B. dorsalis \); \( B. carambolae \); interspecific hybrid of \( B. carambolae \) and \( B. dorsalis \); and \( B. albistrigata \). Fig. 1 shows the morphological characteristics of each fruit fly species.

\( B. dorsalis \) and \( B. carambolae \) were found on the three mango varieties. Salmah et al. [10] reported that those species were the most found on mangoes. \( B. carambolae \) and \( B. dorsalis \) were species of fruit flies that have a high level of kinship, thus allowing interspecific mating between the two [16].

Interspecific hybrid of \( B. carambolae \) and \( B. dorsalis \) was only found on some sampling location. It was assumed that the compatibility of interspecific mating between \( B. carambolae \) and \( B. dorsalis \) was lower than same species mating. Schutze et al. [17] reported that the interspecific mating compatibility of \( B. carambolae \) and \( B. dorsalis \) was 57.5-67.8%. Interspecific mating may occur in nature, although it is rare [18]. Juma et al. [19] reported that interspecific hybrid of \( B. carambolae \) and \( B. dorsalis \) was attracted to methyl eugenol.

\( B. albistrigata \) was only found on Cengkir collected from the field. There were guava trees around the mango sampling location in the field. This could be the reason, as guava is the main host of \( B. albistrigata \). Syahfari & Mujiyanto [20] reported that \( B. albistrigata \) was found on mangoes in Balikpapan. The hosts of \( B. albistrigata \) are mango, guava, and jambu air (water apple, \( Syzygium aqueum \)). Guava is the main host of \( B. albistrigata \), but mango is not [13].
Table 1. Fruit fly species on mango at Kecamatan Talun, Cirebon.

| Location   | Mango varieties | Spieses* | a** | b** | c** | d** |
|------------|----------------|----------|-----|-----|-----|-----|
| Field      | Gedong Gincu   | v        | v   | v   | v   | x   |
|            | Cengkir        | v        | v   | v   | v   |     |
|            | Arumanis       | v        | v   | v   | v   |     |
| Wholesaler | Gedong Gincu   | v        | v   | x   | x   |     |
|            | Cengkir        | v        | v   | v   | x   |     |
|            | Arumanis       | v        | v   | x   | x   |     |
| Retailer   | Gedong Gincu   | v        | v   | x   | x   |     |
|            | Cengkir        | v        | v   | x   | x   |     |
|            | Arumanis       | v        | v   | x   | x   |     |

*v = exist
x = does not exist

** a = *B. dorsalis*
b = *B. carambolae*
c = interspecific hybrid of *B. carambolae* and *B. dorsalis*
d = *B. albistrigata*

Figure 1. Morphology of adult *Bactrocera* spp. (a) *B. dorsalis*, (b) *B. carambolae*, (c) interspecific hybrid of *B. carambolae* and *B. dorsalis*, (d) *B. albistrigata*.

3.2. Fruit fly Species Diversity

Fruit fly species diversity on mangoes Gedong Gincu, Cengkir, and Arumanis at Kecamatan Talun, Cirebon was low. The diversity index (H’) was 0.05 ≤ H’ ≤ 0.48 (Figure 2). There were variations in the diversity index values of the three mango varieties in Cirebon. The diversity index variation is due to differences in the number of species and the number of individuals of each species [12]. Low diversity index was influenced by various factors such as season, spatial distribution, environment stability host...
diversity, competition and other complex factors. Low diversity index happens when there was a dominant species. Dominant species is a species that have a high value of abundance [21].

![Graph showing diversity index of fruit fly species on mangoes at Kecamatan Talun, Cirebon.](image)

**Figure 2.** Diversity index of fruit fly species on mangoes at Kecamatan Talun, Cirebon.

The low diversity index of fruit fly species on mangoes Gedong Gincu, Cengkir, and Arumanis may be caused by their preferences to particular fruit and the abundance of the host. High host diversity will cause also high fruit fly diversity [6]. Each fruit fly species prefers different fruit host. Morphological and physiological characteristics of plant affect the feeding and oviposition activities of insect [7]. The fruit fly diversity indices on mangoes collected from wholesaler and retailer were lower than the field. It was assumed that the host availability at wholesaler and retailer were lower than the field.

Fruit fly diversity index on mango Gedong Gincu was lower than on Cengkir and Arumanis (Fig. 2). The number of *B. dorsalis* on Gedong Gincu was higher than on Cengkir and Arumanis (Fig. 3). It seemed that *B. dorsalis* was attracted more to lay eggs on Gedong Gincu rather than Cengkir and Arumanis. [22] also reported that *B. dorsalis* was found more on Gedong Gincu than Cengkir, Arumanis, Bapang, and TO varieties. In contrast, the diversity indices of Cengkir and Arumanis were higher than Gedong Gincu. This was shown by the lower percentage of the number of *B. dorsalis* on Gedong Gincu. Arumanis has dark green but Cengkir has yellowish green peel. It seemed that the preference of *B. dorsalis* was more on lighter peel color or yellow to orange like Gedong Gincu.

### 3.3 Fruit fly Species Dominance

The highest number of fruit fly on each variety of mango was *B. dorsalis* (Fig. 3). The numbers of *B. dorsalis* on mangoes Gedong Gincu, Cengkir, and Arumanis were 94.47%, 85.77% and 86.44% respectively. *B. dorsalis* was dominant at the sampling location because of the agroecosystem condition at the area. There were banana and papaya plants in the surrounding area, which are host of *B. dorsalis*. Susanto et al.[7] reported that high fruit availability supports the high population growth of the fruit fly. Similarly, this may be the cause of the dominant population of *B. dorsalis* at the sampling area. The availability of a high host will cause a high number of fruit fly species as well. The availability of food available throughout the year for fruit fly species will lead to the development of good fruit fly species [12]. Species dominance was caused by various factors including host range, abundance and host distribution, parasitism and other competition[21].
The fruit fly index of dominance on mangoes in the sampling area was close to 1 (Fig. 4). This condition means that the population is dominated by a certain species. The dominance index on Gedong Gincu was higher than Cengkir and Arumanis. It was shown by the higher number of *B. dorsalis* on Gedong Gincu than on Cengkir and Arumanis (Fig. 4). Gedong Gincu has a strong aroma, thin peel (1.13 mm), and yellow to orange peel color that attract *B. dorsalis* to lay eggs[22].

Figure 3. Number of fruit fly at Kecamatan Talun, Cirebon.

| Fruit Fly | Gedong Gincu | Cengkir | Arumanis |
|-----------|--------------|---------|-----------|
| *B. dorsalis* | 94.47 | 85.77 | 86.44 |
| *B. carambolae* | 4.24 | 13.55 | 12.95 |
| Interspecific hybrid of *B. carambolae* and *B. dorsalis* | 1.30 | 0.66 | 0.61 |
| *B. albistrigata* | 0.83 | 0.79 | 0.77 |

Figure 4. Index of fruit fly species dominance on mangoes at Kecamatan Talun, Cirebon.

3.4 Sex Ratio
The fruit fly sex ratios on mangoes Gedong Gincu, Cengkir, and Arumanis were varied. Some had more males than females, in contrary some had more females, and some had equal number of males and females. Bhagat *et al.* [23] reported that normal sex ratio of fruit fly in nature is 1:1. Although there could be some deviation on the population of males versus females in different seasons, but the deviation is not significant.
The number of males and females is affected by the fruit availability in the field. The higher the availability, the more pupae developed into females. In contrast, the lower the fruit availability, the higher the males produced [24]. The differences in sex ratio will affect the fruit fly population. When the female number within an area increases, it can be predicted that the number of the fruit fly offspring will also increase [25].

Table 2. Sex ratio of fruit fly on mangoes at Kecamatan Talun, Cirebon.

| Location | Mango varieties | Sex ratio (♂ : ♀)* | Interspecific hybrid of B. carambolae and B. dorsalis | B. albistrigata |
|----------|-----------------|-------------------|-------------------------------------------------------|----------------|
| Field    | Gedong Gincu    | 0.94:1            | 0.83:1                                                | -              |
|          | Cengkir         | 0.94:1            | 0.71:1                                                | 0:1            |
|          | Arumanis        | 0.96:1            | 0.85:1                                                | 1:1            |
| Field    | Gedong Gincu    | 1.33:1            | -                                                     | -              |
|          | Cengkir         | 1.17:1            | 1:1                                                   | -              |
|          | Arumanis        | 1:1               | 0.67:1                                                | -              |
| Wholesaler | Gedong Gincu  | 1:1               | -                                                     | -              |
|          | Cengkir         | 1.12:1            | -                                                     | -              |
|          | Arumanis        | 0.91:1            | -                                                     | -              |
| Retailer | Gedong Gincu    | 1:1               | -                                                     | -              |
|          | Cengkir         | 1:1               | -                                                     | -              |
|          | Arumanis        | 0.67:1            | -                                                     | -              |

3.5 Analysis of Mango Nutritional Content
Analysis of the nutritional content of the three mango varieties showed various results (Table 3). The variation was caused by some factors such as mango varieties, cultural practices, and weather condition [26].

Table 3. Nutrition content of mango var. Cengkir, Gedong gincu and Arumanis at Kecamatan Talun, Cirebon

| Nutrients   | Gedong Gincu | Cengkir | Arumanis |
|-------------|--------------|---------|----------|
| Water       | 86.56        | 86.30   | 83.79    |
| Ash         | 0.26         | 0.28    | 0.25     |
| Fat         | 0.66         | 0.88    | 0.75     |
| Protein     | 0.23         | 0.18    | 0.14     |
| Carbohydrate| 12.29        | 12.36   | 15.07    |

3.6 Correlation between Nutritional Content of Mangoes and Diversity Indices of Fruit fly species
Results of the correlation test showed that there was no significant correlation between nutritional content of mango fruit and diversity indices of fruit fly species. According to Pearson test, the significance was > 0.05 which meant the correlation was not significant. It seemed that the nutritional contents had already fulfilled the need of the fruit fly. There are also other factors, such as competition. The competition may occur from the larval stage inside the same fruit to the adult stage. An interspecies
competition occurs in nature when a polyphagous species occupies the same area as other species [27]. Tetrasani [28] reported that variation of insect species and insect diversities were affected by biotic factor and pest control method applied by the farmer. Intensive chemical control decreases the insect diversity.

3.7 Correlation between Nutritional Content of Mangoes and Weight of Pupae

The weight of pupae on Gedong Gincu was higher than Cengkir and Arumanis, the mean weight was 0.0142 g (Table 4).

Table 4. Weight of fruit fly pupae on mangoes at Kecamatan Talun, Cirebon

| Mango varieties | Location  | Mean weight of pupae (g) | Mean weight of pupae (g) per variety |
|-----------------|-----------|--------------------------|-------------------------------------|
| Gedong Gincu    | Field     | 0.0148                   | 0.0142                              |
|                 | Wholesaler| 0.0143                   |                                     |
|                 | Retailer  | 0.0137                   |                                     |
| Cengkir         | Field     | 0.0138                   | 0.0131                              |
|                 | Wholesaler| 0.0124                   |                                     |
|                 | Retailer  | 0.0130                   |                                     |
| Arumanis        | Field     | 0.0137                   | 0.0134                              |
|                 | Wholesaler| 0.0139                   |                                     |
|                 | Retailer  | 0.0125                   |                                     |

4. Conclusion

The fruit fly species found on mangoes Gedong Gincu, Cengkir, and Arumanis at Kecamatan Talun, Kabupaten Cirebon were *B. dorsalis*, *B. carambolae*, interspecific hybrid of *B. carambolae* and *B. dorsalis*; and *B. albistrigata*. The low diversity index of fruit fly species on mangoes Gedong Gincu, Cengkir, and Arumanis may be caused by their preferences to particular fruit and the abundance of the host. The dominant species was *B. dorsalis*. *B. dorsalis* was dominant at the sampling location because of the agroecosystem condition at the area. The diversity of species on mangoes Gedong Gincu, Cengkir, and Arumanis at Kecamatan Talun, Kabupaten Cirebon was low; the diversity index (H’) was 0.05 ≤ H’ ≤ 0.48. The nutritional content of mangoes does not show a significant correlation with the diversity of fruit fly species and the average weight of fruit flies pupae. Methyl eugenol is recommended to use as attractant in a mango field, as *B. dorsalis* is dominant on mangoes.

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