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Original Article

THE EXPLORATION OF FRUIT FLIES *Bactrocera* (DIPTERA:TEPHRITIDAE) AND ITS PARASITOID IN MADURA ISLAND REGIONS

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ABSTRACT

Madura is enriched by great diversity despite of its infertile natural condition. This condition influences fruit flies existence and diversity. Purpose of this study was to investigate the diversity and distribution of fruit flies with their host in Madura region. Sampling methods in this study were fruit host collection (rearing) and trapping using Steiner-type trap that were set in 48 locations in several villages in Bangkalan, Sampang, Pamekasan, and Sumenep regencies. Steiner traps were combined with 2 different attractants, such as methyl eugenol (ME) and Cue Lure (CL). There were 5 species of fruit flies obtained from trapping and rearing, namely *Bactrocera carambolae, B. papayae, B. umbrosa, B. albistrigata,* and *B. cucurbitae*. Results indicate that the distribution, diversity, and abundance of fruit flies were influenced by the diversity of fruit host, air temperature, and relative air humidity. It is also identified two species of parasitoid imago from rotten fruits collection, namely *Biosteres vandenboschi* and *Fopius arisanus*.

Keywords: *distribution, Bactrocera, parasitoid*

INTRODUCTION

Fruit flies are the member of mamily Tephritidae of Order Diptera. It is also included into Tribe Dacini, which is divided into two genera, *Bactrocera* and *Dacus*. In addition, *Bactrocera* species is distributed in various regions such as India, Southeast Asia, and Pacific area, while Dacus species is mostly found in African regions (Drew, 2004). In Indonesia, *Bactrocera* is distributed from western to eastern parts of Indonesia, while genus *Dacus* is dominantly observed in eastern part of Indonesia (AQIS, 2008).

Bactrocera has been known for its influence in fruit and vegetable agriculture in Indonesia. It also has been recognized by farmers as the major obstacle to agribusiness due to it can disturb plant growth (Kartini *et al*, 2003). Damages that caused by fruit flies are influence the quantity and quality of farm yield, which can lead to a great economic. It is said that almost all pest insects are not as harmful as fruit flies in inflicting the loss of fresh fruits and vegetables commodities. In accordance to this, international trade has also considered *Bactrocera* fruit flies as the primary threat of contaminant pest with invasive potential. It has been reported many times, fresh fruits and vegetables commodities from Indonesia were rejected by the importing country because of *Bactrocera* fruit flies attack (Suputa, 2006).

One of the important factors influencing the existence and diversity of *Bactrocera* fruit flies is fruit abundance as host and food source (Nishida, 1980). Madura Island has specific character of habitat and soil surface. Plants as the host for fruit flies are also diversified. This condition may be the factor supporting species diversity and higher population rate of fruit flies *Bactrocera*. The other factor that supports fruit flies *Bactrocera* diversity is the presence of commercial plants as the food source or host for fruit flies *Bactrocera*.

Research about fruit flies has been conducted by Hardy (1982, 1983) that has successfully identified 62 *Bactrocera* species in Indonesia, which 26 species of it are identified in Java Island. From all of those identified species, there were only 5 species causing damage to the plants including genus *Dacus* or also known as *Bactrocera dorsalis* (Hendel). According to Kalshoven (1981), this species attacks and cause damage to fruits and vegetables such as mango, star fruit, orange, red pepper, and bird's eye pepper.

Fruit flies have been monitored under the project of agriculture rehabilitation since 1979 to 1983. In Jakarta, it has been implemented to *Bactrocera* through survey that covers Indonesia regions. Based on survey results, there were 40 *Bactrocera* species found, which 16 species of them have been identified by Hardy (1975) and the rest 24 species are remain unknown or not reported yet. The variation of data about *Bactrocera* species is expected caused by the different sampling time and location (Daini, *et al*, 1987). In western part of Indonesia, there are 90 local (indigenous) species of fruit flies that have been identified, but there are only eight of them considered as primary pest such as *Bactrocera albistrigata, B. carambolae, B. dorsalis, B. papayae, B. umbrosa, B. cucurbitae, B. tau* and *Dacus longicomis* (Siwi *et al*, 2006).

Around 4,000 species of *Bactrocera* fruit flies are identified in the worldwide with various attack rates. The

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emergence of *Bactrocera* pest in Indonesia has been recognized since 1920 due to the report about *Bactrocera* fruit flies attacked mango outside Java Island. In 1938, *Bactrocera* fruit flies attacked chili and fruits such as guava, star fruit, and sapodilla (Anonym, 1999). Due to *Bactrocera* fruit flies attack, farmers have suffered great loss of harvest. *Bactrocera* larvae have caused damage to plants in Family Asteraceae (Compositae) by 40 %, it lives and develops within the flower. Other fruit flies species can live in plant tissues such as in leaf, stem and root tissue. The estimation of loss caused by *Bactrocera* fruit flies is about 30-60 % (Kuswadi, 2001).

The population of fruit flies is influenced by abiotic and biotic factors. In one hand, abiotic factors are related to environmental conditions such as rainfall, temperature, humidity, wind speed, and wind direction. Ecological condition of Madura Island regions is low rainfall with high population. Due to it, the common type of agriculture that people used is non-irrigated field (*tegal*). This agriculture method suits to ecological condition of Madura, because it does not need much water. In the other hand, the influence of biotic environments is coming from host and natural enemies such as predator and parasitoid. Parasitoid is one of natural enemies for *Bactrocera* fruit flies because it can lead them to death (Hoffman, 1993). Concern about this, parasitoid has considered to be a good prospect for developing a strategy to control fruit flies population in Indonesia.

The distribution of fruit flies in Madura is originated from the larvae-infected fruits brought by Madurese from the outside of the Island. Related to this, there is fact that infected fruits were sold in several traditional markets in Madura. The larva inside the fruit grow become adult fruit flies then spread over Madura regions.

The number of *Bactrocera* fruit flies species distributed in Madura is remain unclear. Related publication to *Bactrocera* or review about ecological niche and its association with the plant host in Madura are still limited. Considering this matter, the identification and observation of fruit flies diversity in Madura regions is need to be done including their parasitoid diversity and distribution.

Based on to this background, several identifications are done. It is revealed that Madura Island is not the center of fruit production, but it has relative high diversity of fruits and vegetables such as salak, rose apple, banana, sugar apple, jambolan, breadfruit, soursop, papaya, star fruit, mango, orange, jackfruit, watermelon, melon, coconut, cucumber, pumpkin, beans, chili, tomato, and the other palawija plants. Generally, those fruits are obtained from house garden, rice field, or non-irrigated field. Several literatures and interview with East Java Department of Agriculture staffs in (2013) indicate that the number of fruit flies species in East Java regions has not been clearly understood due to the limitation of report about fruit flies pest.

METHODS

This study was conducted from March 2013 to August 2014. Several environmental conditions were measured such as air temperature, wind direction, altitude, air humidity, and light intensity. In addition, agricultural ecosystem and vegetation diversity were also measured. The population of fruit flies was obtained from Bangkalan, Sampang, Pamekasan, and Sumenep regencies. These regions were chosen based on the existence of host plants for *Bactrocera* fruit flies. Samples were taken from 4 districts in each region that covers 3 villages (Fachrul, 1986). The sampling method was purposive sampling, which is mean that each sample represents the other sampling regions (Hadi, 2002).

Data Collection Method

Data were collected from survey and observation. Survey was conducted based on surveillance method suggested by *Australian Center for International Agricultural Research* (McMaugh, 2007). Fruit fly samples were obtained from trapping using modified Steiner trap from cartoon boxes on each selected host plant. Each boxes was added with *methyl eugenol* (petrogenol) and *cue lure*. Captured fruit flies were exterminated with 1 ml of spinosad insecticide 120g/l. The combination ratio of attractant and insecticide was 4:1 (Suputa dkk. 2007). Samples from each village were taken three times in the same location. The boxes were left for a week, after that the trapped fruit flies were identified in laboratory. Beside of that, fruit flies were also obtained from the rotten fallen fruits on the ground containing lots of *Bactrocera* larva. Those fruits were reared in laboratory until the larva becoming pupa then turn into adult fruit flies. In addition, fruit samples were also obtained from market, especially in the main access of Madura Island.

Data Analysis

Trapped fruit flies were cleaned up and separated from the other non-target insects. Samples were then air-dried then arranged in collection boxes with camphor. Specimens were observed with binocular microscope. The identification was based on *The Australian Handbook for the Identification of Fruit Flies* and CABI-key identification software (White and Hancock, 1997). Morphological characters that were observed such as antenna, eye, and face colour, dorsum thorax (abdomen and wing) (Plant Health Australia, 2011). Map of fruit flies distribution in four regencies was made using Geographic Information System (GIS). The correlation between environmental factors and fruit flies population was analyzed using Path Analysis.

RESULTS

There were 5 identified species of fruit flies that specifically attracted to one type of attractant. Methyl eugenol attracted *Bactrocera umbrosa* (Fabricius), *Bactrocera carambolae* Drew & Hancock, and *Bactrocera papayae* Drew & Hancock. In the other side, cue lure attractant attracted *Bactrocera cucurbitae* (Coquillett) and *Bactrocera albistrigata* (de Meijere).

Fruit Flies Distribution

Several fruit flies species were captured, which *B. carambolae* and *B. papayae* dominated in all regencies (Figure 1). The population of both species were relatively similar (± 250 fruit flies), which was six times higher than the population of *B. umbrosa*, *B. albistrigata*, and *B. cucurbitae* (± 40 fruit flies). These indicate that fruit fly distribution in Madura is varied (Figure 2). It can be expected that fruit fly has long-range flight ability in condition where fruit hosts are available. In addition, it allows fruit flies to survive through fruit seasons with broad range of fruit hosts.

In the other hand, trapped fruit flies can also be classified based on the attractant that attracted them. Due to this, suitable attractant is needed in specific fruit fly trapping. Report of Larasati et al (2013) support this fact, utilization of methyl eugenol is more attractive than utilization of cue lure to fruit flies. Tsuruta et al (2005) added that methyl eugenol attractant can be utilized to attract several fruit fly pests.

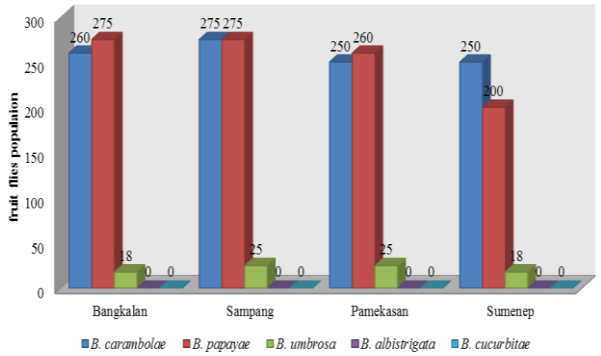

Figure 1. Population of captured fruit flies in several regencies in Madura Island. *B. carambolae* and *B. papayae* dominate in all regencies.

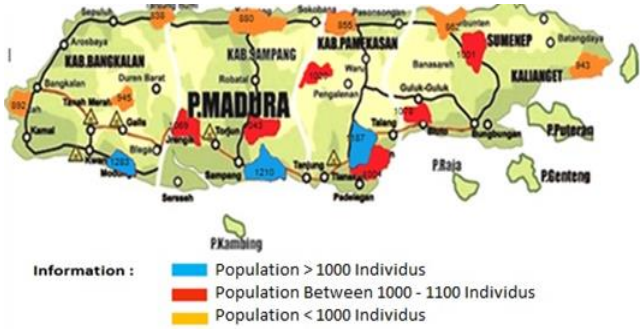

Figure 2. Fruit flies distribution in Madura Island.

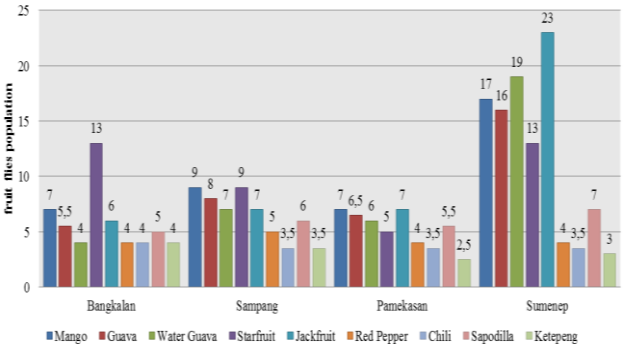

Figure 3. The population number of fruit flies obtained from fruit collections.

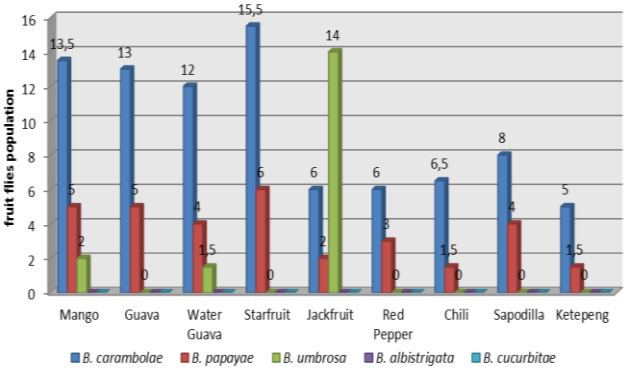

Figure 4. The comparison of fruit flies population in fruit hosts taken from several locations in Madura Island.

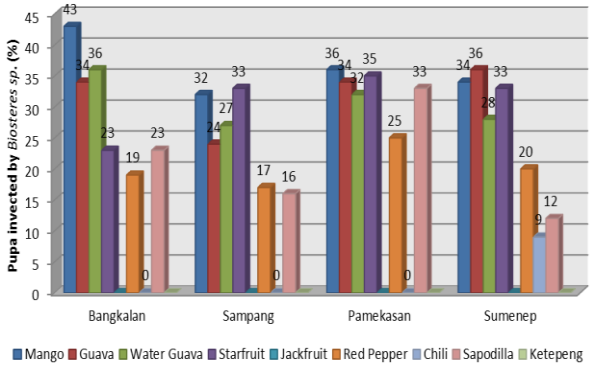

Figure 5. Percentage of fruit flies pupa infected by *Biosteres* sp. in several fruits obtained from Madura Island.

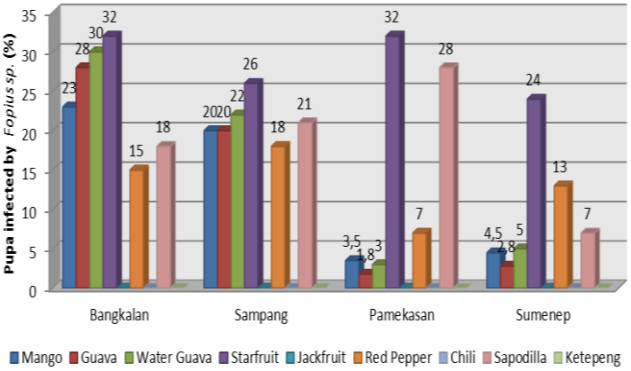

Figure 6. Percentage of fruit flies pupa infected by *Fopius* sp. in several fruits obtained from Madura Island.

The domination of *B. carambolae* and *B. Papayae* is not only in Madura Island but also in several region in Indonesia. As the matter of this fact, Muryati et al (2007) has conducted similar study in Solok Regency and Kundur Island of West Sumatra that resulted there are 45 identified species and 2 unidentified species of fruit flies. In those locations, there was domination of 3 fruit flies, namely *B. albistrigata*, *B. carambolae*, and *B. papayae*. In the other hand, Larasati et al (2013) suggest that cue lure attractant has attracted more fruit flies than methyl eugenol in Bogor regencies (2.2:1). In addition, this study presented similar.

Fruit samples that contain the highest number of fruit flies were taken from Sumenep (Figure 2). The population number of fruit fly in other regencies around 1-1.5 times from the population number in Sumenep (Figure 3). The domination of fruit flies was found in mango, guava, rose apple, star fruit, and jack fruit in all survey location. On the contrary, sapodilla shows relatively low number of population that was similar to fruit flies population in red pepper and bird's eye chili.

The densest fruit flies distribution in Sumenep is related to the abundance of plant host population in this regency, which Sumenep is the centre of horticulture plant commodity (BPS Jawa Timur, 2013). It is supported by observation data of potential fruit as fruit fly host. The data show that *B. carambolae*, *B. papayae*, and *B. umbrosa* can be found in all fruit collections while the other species are not found (Figure 4). The population number of *B. carambolae* is almost twofold of *B. papayae* population in all examined fruit, except in Jackfruit where *B. umbrosa* has the highest number of population. The populations of *B. albistrigata* and *B. cucurbitae* were not found in fruit collection.

In the same way of host availability, parasitoid also influences the population growth of fruit flies. For this reason, it has also been observed parasitoids that attack fruit flies cocoon by rearing method. There were found two kinds of parasitoid attacking fruit flies cocoon, *Biosteres* sp. and *Fopius* sp. (Figure 5 and Figure 6). It is noticable that the pattern of parasitism in survey locations is relatively similar. The percentage of fruit flies infected by *Biosteres* sp. is relatively high, around 25-35 % in mango, guava, rose apple, and star fruit that were found in all survey location. In the same way, the percentage of infected fruit flies by *Fopius* sp. is also high including in sapodilla fruit, especially in Pamekasan. Both parasitoids were no found in certain fruits, such as jackfruit, bird's eye chili, and ketepeng. It is possibly associated with the tendency of fruit flies to be attracted to certain fruit. The factors that related to this condition is not revealed yet in this study.

The effectiveness of both parasitoids in fruit flies infection is shown in Figure 7. It is noticeable that *Biosteres* sp. has higher parasitism level than *Fopius* sp. in all fruit hosts except in jackfruit, chili, and ketepeng, which the data were absent. This may indicate that these parasitoids are competitor to each other in infecting fruit flies cocoon. Further observation will be needed to reveal this.

DISCUSSION

There were six species fruit flies identified in this study. It has also been revealed that every fruit fly was attracted to one attractant. The fruit hosts of fruit flies that were attracted to cue lure and methyl eugenol have not been known yet due to harvest time was over. In spite of this, fruit hosts of several identified fruit flies have been known including *Bactrocera carambolae* Drew & Hancock, *Bactrocera papayae* Drew & Hancock, and *Bactrocera umbrosa* (Fabricius).

Only several obtained fruits were infected by fruit flies were also containing parasitoids such as *Biosteres* and *Fopius* (Hymenoptera: Braconidae). Corresponding to this, research by Dewi et al (2007) shows that seven fruit samples from fruit gardens in Garut regency was infected by parasitoid *Biosteres vandenboschi* (Hymenoptera: Braconidae). Data shows that the highest parasitism level is found with total density of 6-7 female fruit flies in a fruit. Other relevant research conducted by Artayasa (2007) suggests the potential of *Biosteres.*

If all factors are analyzed in integrated manner, it indicates temperature and humidity are correlated and influencing fruit flies population. Temperature shows direct effect on the reduction of fruit flies population in certain condition (r= -0.7997). It can be noticed that the -

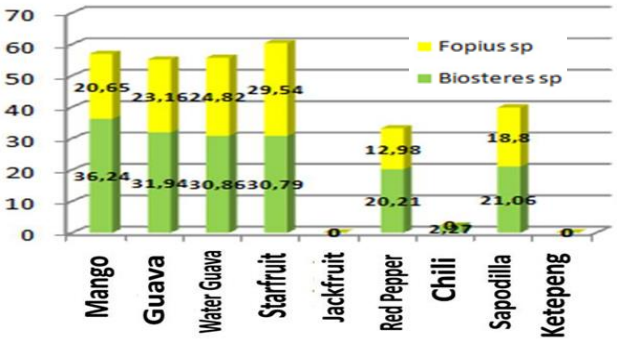

Figure 7. The comparison of parasitism of *Biosteres sp.* and *Fopius sp.* in the fruits collected from several survey locations in Madura Island.

Table 1. Result of path analysis over the relation between the number of fruit flies captured in survey location and the several supporting factors.

Effect of X_1 on Y	Correlation
Direct Effect of X_1 on Y	= 0.0595
Effect of X_1 through X_2 on Y	= -0.0388
Effect of X_1 through X_3 on Y	= 0.0387
Effect of X_1 through X_4 on Y	= 0.0041
Effect of X_1 through X_5 on Y	= 0.0229
Total Effect of X_1 on Y	= 0.0863
Effect of X_2 on Y	
Effect of X_2 through X_1 on Y	= 0.0029
Direct Effect of X_2 on Y	= -0.7997
Effect of X_2 through X_3 on Y	= 0.8141
Effect of X_2 through X_4 on Y	= 0.2589
Effect of X_2 through X_5 on Y	= 0.1061
Total Effect of X_2 on Y	= 0.3823
Effect of X_3 on Y	
Effect of X_3 through X_1 on Y	= 0.0025
Effect of X_3 through X_2 on Y	= -0.7152
Direct Effect of X_3 on Y	= 0.9103
Effect of X_3 through X_4 on Y	= 0.1247
Effect of X_3 through X_5 on Y	= 0.0597
Total Effect of X_3 on Y	= 0.3820
Effect of X_4 on Y	
Effect of X_4 through X_1 on Y	= 0.0005
Effect of X_4 through X_2 on Y	= 0.4354
Effect of X_4 through X_3 on Y	= -0.2386
Direct Effect of X_4 on Y	= -0.4756
Effect of X_4 through X_5 on Y	= -0.1693
Total Effect of X_4 on Y	= -0.4486
Effect of X_5 on Y	
Effect of X_5 through X_1 on Y	= 0.0069
Effect of X_5 through X_2 on Y	= -0.4285
Effect of X_5 through X_3 on Y	= 0.2745
Effect of X_5 through X_4 on Y	= 0.4066
Direct Effect of X_5 on Y	= 0.1980
Total Effect of X_5 on Y	0.4575

Note: X_1 = parasitoid rate, X_2 = air temperature (^{0}C), X_3 = relative humidity (%), X_4 = wind speed, X_5 = place height (meter of altitude), Y = fruit flies population.

influence of temperature through humidity is positive, by means it can increase the population (r=0.8141). In the same way, the increase of humidity will directly increase the number of fruit flies population (r=0.9103). On the contrary, if it is correlated to the increase of temperature it will inhibit the growth of fruit flies (r= -0.7152).

By all means, it can be say that weather factors, especially air temperature and humidity are closely related I determination of fruit flies population number. Other factors, such as parasitoid, wind speed, and altitudes have no significant effect to the fruit flies population. In addition, the parasitoids influence might be not significant because the population number of parasitoids itself were limited due to the other weather factors or the abundance of fruit hosts.

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