The spatial distribution of *Bactrocera dorsalis* after 15 years of the 2004 Indian Ocean tsunami in Banda Aceh, Indonesia

C Januarita¹, A Rahman², S Rasnovi¹ and Suwarno¹,³
¹Department of Master Program in Biology, Faculty of Mathematics and Natural Sciences, Universitas Syiah Kuala, Banda Aceh, Indonesia
²Tsunami and Disaster Mitigation Research Center (TDMRC), Universitas Syiah Kuala, Banda Aceh, Indonesia
E-mail: suwarno@unsyiah.ac.id

**Abstract.** *Bactrocera dorsalis* is one of fruit fly species that caused to the decreasing of fruits qualities. The 2004 Indian Ocean tsunami impacted more than 60% Banda Aceh city’s areas and changed the Banda Aceh city’s landscape. The purpose of this study is to analyze the special distribution of *B. dorsalis* after 15 y of the 2004 Indian Ocean tsunami in Banda Aceh tsunami-affected and non-affected areas. The data was collected from December 2018 to January 2019. The *B. dorsalis* was trapped by using the Modified Steiner Trap method in four villages, which selected randomly in nine sub-districts in the tsunami-affected and non-affected areas of Banda Aceh. The host plants were selected such as mangos, star fruits, guavas, and jackfruits, which commonly recognized in Banda Aceh. Data was analyzed and presented by using the GIS. After 15 years of the 2004 Indian Ocean tsunami the land and fruits plants have recovered. *Bactrocera dorsalis* were found in tsunami-affected and non-affected areas with total 2510 of *B. dorsalis*. There is no significant difference of the spatial distribution of *B. dorsalis* in both areas.

1. Introduction

The 2004 Indian Ocean destroyed and affected the Banda Aceh city. More than 60 % of Banda Aceh destroyed with significant impact, with numerous lives lost as well as serious damage to infrastructure, the economy, livelihoods [1]. The 2004 Indian Ocean tsunami has also impacted the changing of the landscape. The previous studies on the impact of the 2004 Indian Ocean tsunami tended to focus on the technical issues such as the impact of the tsunami to the human and infrastructure or how society changed and adapted to the disaster. But, it has also been realized that disaster studies should also consider another factor such as how the disaster could impact of the most specific environment condition including the changes in species distribution.

For decade researches seem not much focused their attention on the relationship of the existence of fruit flies (e.g. Diptera: Tephritidae) to the quality of fruits after the disaster. The main reason for the researcher's attention on this matter is due to it impacted the economic sectors. At least 4,000 fruit fly species around the world have been identified which more than 35% caused negative impacts on fruit quality [2,3]. The species of fruit fly that harm on the quality of fruit is the family Tephritidae. The fruit fly is mainly attacked near-ripe of fruit and damage caused by fruit fly larvae causes the fruit to rot and fall before reaching the maturity. We could distinguish the attacked fruit by identifying the appearances of dark spots (stains) on the surface of the fruit skin. The fruit flies put their eggs into

³ To whom any correspondence should be addressed.
flesh, and then the fruit fly eggs turn into larvae. Fruit fly larvae eat the flesh of the fruit, which can be markedly marked with rotten fruit and color [4]. More than 75% of fruit plants in Indonesia are affected by fruit fly attacks. The estimated losses can reach 30 - 60% of production [4]. This situation should be pointed in order to handle the fruit fly attacks on the production. In Banda Aceh city, every yard of fruit the inhabitants has garden including the small number of fruit trees. The most common fruit than commonly finds is mango (*Mangifera indica* L.), star fruit (*Averrhoa carambola* L.), water guava (*Syzygium aqueum* L.), and jackfruit (*Artocarpus heterophyllus* L.) [5]. In Indonesia, the fruit fly survey was first carried out by Hardy in 1985 and found 66 species. In 1992 to 1994, the National Agricultural Quarantine Center conducted a survey and found about 47 species, 20 of which were *B. dorsalis* complex [6].

According to Siwi & Hidayat (2006), 89 types of fruit flies could be found scattered in Indonesia, especially in the western part [7]. Eight out of 89 species belong to important pests. The eight types of fruit flies are *B. albistrigata*, *B. dorsalis*, *B. carambolae*, *B. papayae*, *B. umbrosa*, *B. caudate*, *B. cucurbitae*, and *Dacus longicornis*. Each type of fruit fly prefers (preferably) to certain plants, but generally can attack more than one type of fruit. According to Syahfari and Mujiyanto (2013) the main targets of fruit flies are star fruit, water guava, guava, mango, jackfruit, melon and chilli [8]. This study is a preliminary research to identify the existence of fruit fly and its relationship to the 2004 Indian Ocean tsunami in Banda Aceh city.

The purpose of this study is to analyze the majority species of fruit fly and spatial distribution of fruit fly in the tsunami-affected and non-affected areas of post the 2004 Indian Ocean tsunami in Banda Aceh.

2. Methods

This study was quantitative research. Banda Aceh city was chosen as the research location due to the city represent both of situation (affected and non-affected areas of the 2004 Indian Ocean tsunami could be identified) (Figure 1). The field research was conducted from December 2018 to January 2019. In this study, the fruit fly trap was modified from the Steiner modification trap method [9]. Males of many fruit fly species (Diptera: Tephritidae) are attracted to Methyl Eugenol in modified Steiner traps for the regular monitoring of populations of fruit flies [9].

![map](image_url)

**Figure 1.** Location of research area in Banda Aceh City. Source: Rahman *et al.*, (2018) [1].
A total of 144 sampling points fruit flies traps were installed in four villages and the nine sub-districts randomly (see Figure 2 and Figure 3). While the identification of samples from the results of field research was conducted at the Zoological Laboratory of the Faculty of Mathematics and Natural Sciences (FMIPA), Universitas Syiah Kuala (Unsyiah) Banda Aceh, Indonesia. The fruit flies Steiner trap was modified from 144 cylindrical water bottles of 1500 ml size (Figure 2). As attractant place, small cotton installed by hanging it with small and lid there is a hole that has a diameter of 3 cm as the entrance gate for fruit fly. At the top of the plastic container is equipped with a hook. The hook was modified from the rope to make it easier for the trap device to be installed on the branch of the host tree.

Small holes are settled at the bottom of the fruit fly trap which functioned as a place to drain water that could probably be entered the traps. Each modified traps were labeled with identities; trap numbers, research locations, the date for trap setting, trapped fruit flies cultivating and also a warning signs of being "toxic" on each trap. Three drops of insecticide were also added in preventing the escape of fruit flies that already trapped [10], the small cotton which was placed and settled inside the trap. The 3-5 drops of Methyl Eugenol (ME) were using and setting inside of traps as an attractant. In every four days since the first installing time, the fruit fly traps were cleaning and also dropping new ME and insecticide. The cultivating of fruit flies was done in every four days for three times.

3. Results and discussion

The total amount of fruit flies trapped in the installed traps was 2516 individuals that distributed in the tsunami-affected and non-affected area (see Figure 3). Two species were found, which are 2510 individuals of *B. dorsalis* and six individuals of *B. umbrosus*. The relative density and frequency of *B. dorsalis* in Banda Aceh City are higher than *B. umbrosus*. The number of fruit flies trapped in the modified fruit fly traps for each sub-district were; Meuraxa Sub-district (171 individuals), Jaya Baru Sub-district (220 individuals), Banda Raya Sub-district (342 individuals), Baiturrahman Sub-district (65 individuals), Lueng Bata Sub-district (304 individuals), Kuta Alam Sub-district (340 individuals), Kuta Raja Sub-district (46 individuals), Syiah Kuala Sub-district (475 individuals), and Ulee Kareng Sub-district (553 individuals). For more detail could be seen in Figure 4.

*Bactrocera dorsalis* was found in all districts (2510). Whereas *B. umbrosus* was found only in four districts namely Meuraxa (1 individual), Banda Raya (3 individuals), Lueng Bata (1 individual), and Kuta Alam (1 individual). The distribution of the existence of fruit flies could be seen in Figure 3. *Bactrocera dorsalis* is a fruit fly that has a wide distribution of hosts and includes polyphagous insects. *Bactrocera dorsalis* attack mangoes. This is consistent with the statement from Nismah and Susilo (2008) that *B. dorsalis* has many hosts including mango, star fruit, chili, guava and so on. This is in accordance with the research of Yuniar (2013) and Wandira (2014) that the plants attacked by *B. 
The fruit fly of the genus *Bactrocera* is a species of fruit fly originating from the tropic area [11], but it also could probably become from the Asia Pacific [4].

![Figure 3](image1.png)

**Figure 3.** The sampling points of study where the *B. dorsalis* and *B. umbrosus* identified.

![Figure 4](image2.png)

**Figure 4.** The frequency distribution of *B. dorsalis* and *B. umbrosus* in sub-district of Banda Aceh city, Indonesia.
Figure 5. Spatial distribution (frequency distribution) of B. dorsalis in affected and non-affected areas in Banda Aceh, Indonesia.

The result shows that B. dorsalis could be found in all the host plants (2509 individuals), except for one female androgynous found in the Lamteh, Ulee Kareng sub-district. Specific factors could probably cause it. For example, when male fruit flies chase their partners, female fruit fly was also following the male fruit fly through the trap. Or it also could be presented of hormones in the body of female fruit flies because the ME chemical is a female sex pheromone to attract male fruit flies. The distribution of B. dorsalis in the tsunami non-affected area is higher than in the tsunami-affected area. After the 15 years of the 2004 Indian Ocean tsunami, the land and the plant host of fruit fly is still recovering (see Figure 5), but the differences are not significant.

After the 15 years of the 2004 Indian Ocean tsunami, Banda Aceh city recovered in the term of the landscape where the new fruit tree as host plants for the fruit flies replanted. Even though the frequency of B. dorsalis in tsunami-affected area is lower than the frequency in the tsunami non-affected area. It should be better for further research need to analyze the interrelationship the spatial distribution of fruit fly after the disasters and the changes of environment.

4. Conclusion
The conclusions that can be drawn from this study are the dominant of fruit flies species in Banda Aceh of post 15 years of the 2004 Indian Ocean tsunami is B. dorsalis. There the difference spatial distribution of B. dorsalis between the tsunami-affected area and non-affected area in Banda Aceh city. It could probably be the tsunami inundation areas still need time to recover where the host plants of fruit flies could replant and grow appropriately. The existence of B. dorsalis is still the main problem in keeping the quality of fruits for the local fruit trees plantation in Banda Aceh city.

References
[1] Rahman A, Iwasaki S, Sutton A S and Sakurai A 2004 Parmakope Urban Water Management Issues and Challenges of Post The 2004 Indian Ocean Tsunami Recovery: Lessons Learned from Banda Aceh City, Indonesia Urban Drought: Emerging Water Challenges in Asia ed. B Ray and R Shaw (Springer)
[2] Indrawan M, Primack R B and Supriatna J 2012 *Biologi Konservasi: Biologi Konservasi* (Yayasan Pustaka Obor Indonesia)

[3] Tjahjadi I N 1991 *Bertanam cabai* (Kanisius)

[4] Suputa, Cahyanti, A K, M R, Issusilaningtyas and A T 2006 *Pedoman Identifikasi Lalat Buah (Diptera: Tephritidae).* (Yogyakarta: UGM)

[5] Wandira A 2014 *Jenis Lalat Buah (Diptera: Tephritidae dan Preferensinya Terhadap Tanaman Buah Pekarangan di Kota Banda Aceh* (Syiah Kuala Press)

[6] Drew R A I and Hancock D L 1994 The Bactrocera dorsalis complex of fruit flies (Diptera: Tephritidae: Dacinae) in Asia *Bull. Entomol. Res. Suppl. Ser.* 1 1–68

[7] Siwi S S and Hidayat P 2006 *Taksonomi dan bioekologi lalat buah penting di Indonesia (Diptera: Tephritidae)* (Kerjasama Balai Besar Penelitian dan Pengembangan Bioteknologi dan Sumberdaya Genetik Pertanian dengan Departement of Agriculture, Fisheries and Forestry Australia)

[8] Syahfari H 2013 *Identifikasi Hama Lalat Buah (Diptera: Tephritidae) pada Berbagai Macam Buah-buahan Ziraa’ah Majalah Ilmu Pertanian* 36 32–9

[9] Raghu S, Hulsman K, Clarke A R and Drew R 2000 A rapid method of estimating catches of abundant fruit fly species (Diptera: Tephritidae) in modified Steiner traps *Aust. J. Entomol.* 39 15–9

[10] Ginting R 2009 Keanekaragaman lalat buah (Diptera: Tephritidae) di Jakarta, Depok, dan Bogor sebagai bahan kajian penyusunan analisis risiko hama

[11] Yuniar 2013 *Identifikasi Lalat Buah (Bactrocera spp.) di Kabupaten Enrekeng* (Universitas Hasanuddin)

[12] Bangun D A 2009 *Kajian Beberapa Metode Perangkap Lalat Buah (Diptera: Tephritidae) Pada Pertanaman Jeruk Manis (Citrus spp.) di Desa Sukanaulu Kabupaten Karo* (USU)