International Journal of Entomology Research
www.entomologyjournals.com
ISSN: 2455-4758
Received: 16-01-2022, Accepted: 31-01-2022, Published: 16-02-2022
Volume 7, Issue 2, 2022, Page No. 84-87

Morphological characters of fruit fly *Bactrocera dorsalis* complex on oranges plantation at Karo district, North Sumatera, Indonesia

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Abstract
The aim of this research is to know the fruit fly species and fruit fly morphometric that infested the two oranges plantations at Karo district, North Sumatera province. This study aims also in understanding the relationship among body length of obtained fruit flies and its other morphological characters. This investigation also has goal to comprehend the differences of fruit flies body size that be found at two oranges crops that diffrent in Karo district. The sampling of fruit flies has been done on the oranges crops that located in Rumanis and Garingging villages. The fruit flies were collected by using steiner traps that be given with methyl eugenol lure on cotton. The identification of fruit flies was carried out by classical approach, namely based on morphology features. The morphological characters that be observed and measured were body length (Y), wing length (X_1), wing width (X_2), hind leg length (X_3) and tibia length (X_4). The morphometric features measuring of fruit flies was undertaken under Stereo Zeiss-Stemi 2000-C microscope. Morphometric traits was analyzed descriptively. Meanwhile, the relationship among body length and other morphological traits and also significantly differences of fruit flies body size between Rumanis and Garingging villages analyzed by helping of software IBM SPSS Statistics 22. The result of investigation showed that the fuit flies that be collected from Karo distric citrus crops based on morphology belong to *Bactrocera dorsalis* Hendel species. The mean of the body length, wing length, wing width, hind leg length and tibia length of obtained fruit flies (n=60) were 6.85, 5.90, 2.35, 5.75 and 2.25 mm, respectively. There is no significantly differences of fruit flies body size between Rumaris and Garingging oranges crops, except in wing width (U=308.000, P=0.03). The morphological trait that has highest contribution regarding body length prediction was wing length with determinat coefficient 56.8%. The multiple regression equation among body length of fruit fly (n=60) toward its other morphological traits (X_1-X_2) was displayed by equation $Y = 1.54 + 0.67X_1 + 0.57X_2$ (r^2=59.6%).

Keywords: morphometric traits, *Bactrocera dorsalis* complex, Karo district

Introduction
Karo district is known as the center of fruit and vegetables production in North Sumatera. The crops production from this region are not just for Sumatera but also for other island in Indonesia as Java and also for other country like Malaysia and Singapore. Regarding fruit production increasing, especially oranges production, one as important problem that be faced by farmers is due to fruit fly infestation. The fruit fly infestation on oranges or citrus fruit has caused yield losses. It has been reported that fruit fly infestation in Karo district has destroyed 17.000 ha citrus crops and therefore caused the decreasing of oranges production, in this case, at that moment became just 20 ton ha^{-1} prior to 60 ton ha^{-1} [1].
The fruit fly that infested fruit crops in Indonesia and caused yield losses mainly belong to *Bactrocera* spp. [2,3,4]. This female fruit flies puncture the soft fruits (near ripening) with help of its ovipositor and lay the eggs under the fruit skin. Furthermore, the maggots which hatch from these eggs bore further into the fruit causing rotting and fruit fall [5]. The fruit flies *Bactrocera spp*. belong to the family Tephritidae of the order Diptera [6].
In order to control and monitoring of insect pest including fruit flies *Bactrocera* spp in oranges crops, the understanding of their biological characteristics is very needed. These knowledges are important due to support the fruit flies management in the field, especially in integrated pest management action.
Studies on fruit flies *Bactrocera* spp that could be found on some crops in Indonesia both based on morphology and molecular markers has been done by some experts [2,3,4,7,8,9]. The diversity of fruit flies that infested oranges or citrus plantation in highland Karo district in North Sumatera by a preliminary research has been reported as *B.dorsalis*, *B.umbrosa* and *B.caudatus* [7]. Furthermore, Manurung *et al*. (2020) [10] have reported the present of *B.umbrosa* Fabricus on star fruit plantation at Namoriam village, Deliserdang district in North Sumatera.
This research aim is to find out the biological characters of fruit flies species that infested oranges crops in Karo district , North Sumatera based on its morphology characters. The other goals of this investigation is to know the morphometric data of obtained fruit flies and also in understanding the relationship among morphometric traits of obtained fruit flies toward its body length that until this study has never been attemped.

Materials and Methods

Study area

Fruit flies sampling was undertaken in oranges plantations that be found in Rumamis Barus Jahe vilage (N: 03°02'11.6"; E: 098°33'52.1", 1324 m above sea level) and in Garingging village (N: 02°58'28.1"; E: 098°32'01.0", 1399 m above sea level) at Karo district, North Sumatera, Indonesia. The fruit flies catching took place in June 2021.

Collecting, morphologycally identification and morphometric features assesment

In order to collect the fruit flies, the Steiner traps (modification) that be given with methyl eugenol lure on cotton have been used.[1,7]. Fruit flies samples were preserved in alcohol, labeled and transported to the laboratory for curation and identification. Species identification based on morphology features were carried out under stereo binocular microscope SZ 51 in taxonomy laboratory of Biology Department of Universitas Negeri Medan and be consulted on Siwi *et al*. (2006) [6]. The method for morphometric traits assesment was based on Manurung *et al*. (2020) [10] and Manurung *et al.* (2019) [11] The observation and measurements were done under Stereo Zeiss-Stemi 2000-C microscope by using sofware Carl Zeiss Imaging System Axio Vision LE Release 4.8.2. Morphometric measurement was carried out on 60 individuals of male fruit flies (30 individual from Rumamis orangen plantation and 30 individual from Garingging orangen plantation). The measurement of morphometry traits were undertaken on body length, wing length or wing expanse, wing width, hind leg length and tibia length. Data analysis included mean and deviation standard of body length, wing length, wing width, hind leg length and tibia length. The morphometric traits differences between two fruit fly populations (Rumamis vs Garingging) were analyzed by using non parametric statistic. In order to understand the relationship among body length toward other morphometric traits, its analysis was done by using stepwise multiple regression method. All of data analysis was carried out by the helping of Software IBM SPSS Statistics 23.

Results and Discussion

Fruit flies *Bactrocera dorsalis* Hendel traits based on morphology markers

Based on observation results on morphological characteristics of obtained fruit flies, the fruit flies species that be collected on oranges fruits crops in Rumamis and Garingging villages were *Bactrocera dorsalis* Hendel species. The validation of this fruit fly species was based on its colour, head, thorax, wing and abdomen features. In this case, on the face of fruit fly there was a dark spot in each antennal furrow. Its scutum colour is predominant black, meanwhile its lateral is yellow. Its abdominal tergites has a distinct black T shaped mark. The head and thorax are with reduced chaetotaxy. The scutum with anterior supra-alar setae and prescutellar acrostichal setae. The vein Sc of wing is abruptly bent forward at nearly 90^{o}, weakened beyond this bend and ending at subcostal break. All tergites of abdomen are separate. On the tergit of male, there is the row of setae or pecten. All these characteristics pointed out that fruit flies species is *Bactrocera dorsalis* Complex [6].

Morphometric traits of *Bactrocera dorsalis* complex

The research result due to five morphometric features of obtained fruit flies *Bactrocera dorsalis* originated from Karo district in North Sumatera, Indonesia was displayed in Table 1.

Table 1: Morphometric of *B. dorsalis* originated from Karo district in North Sumatera, Indonesia

No	Morphological traits	Mean ± SD (mm) (n=60)	Min.-Max. (mm)
1	Body length-BL (Y)	6.85 ± 0.61	5.3-7.8
2	Wing length-WL (X_1)	5.90 ± 0.60	4.3-6.7
3	Wing width-WW (X_2)	2.35 ± 0.20	2.1-2.7
4	Hind Leg length-HLL (X_3)	5.75 ± 0.50	4.5-6.5
5	Tibia length-TL(X_4)	2.25 ± 0.20	1.8-2.1

Table 1 shows that the average of body length, wing length, wing width, hind leg length and tibia length of obtained fruit fly *B.dorsalis* were 6.85, 5.90, 2.35, 5.75 and 2.25 mm, respectively. In comparison to morphometric characteristic of fruit fly *B.umbrosa* that originated from Namo Riam village, Deliserdang district, North Sumatera, the body length, wing length and wing width of *B. dorsalis* in this research finding were shorter and narrower, whereas its leg length (hind leg and tibia) was longer (Manurung *et al*. 2020). The morphometry comparison of *B. dorsalis* between Rumamis and Garingging populations are presented in Table 2. Finding of this study revealed that the body length, wing length and wing width of Rumamis population were longer in comparison to Garingging, whereas in hind leg length and tibia length, Garingging fruit fly population were longer than Rumamis.

Table 2: Statistical analysis of *B.dorsalis* morphometry from Rumamis and Garingging villages

No	Morphological traits (n=30)	Rumamis (n=30)	Garingging (n=30)	Mann-Whitney (U)	Wilcoxon (W)	Z	Asymp.sig
		Mean ± SD (mm)	Mean ± SD (mm)				

1	Body length-BL (Y)	6.9 ± 0.69	6.8 ± 0.56	394.500	859.500	-824	0.41
2	Wing length-WL (X_1)	5.9 ± 0.68	5.9 ± 0.58	428.000	893.000	-327	0.74
3	Wing width-WW (X_2)	2.4 ± 0,21	2.3 ± 0.15	308.000	773.000	-2.140	0.03 *
4	Hind leg length-HLL (X_3)	5.7 ± 0.54	5.8 ± 0.51	441.000	906.000	-134	0.89
5	Tibia length-TL(X_4)	2.2 ± 0.20	2.3 ± 0.20	427.000	892.000	-347	0.72

Notes: Morphological feature is significant diffrent when Asymp. Sig. value smaller than 0.05 (*)

The statistical test result, furthermore showed, that there was no significantly differences beween body length, wing length, hind leg length and tibia length of Rumamis and Garingging fruit fly populations, except in wing width, in this case, there was significantly differences (U=308.000; P=0.03).

In comparison to the body size of *B. dorsalis* Hendel male adults that originated from mango, guava and peach fruits in India as reported by Sharma & Gupta (2018) [5] and Singh & Sharma (2013) [12], the finding of *B. dorsalis* body size in this study was shorter and smaller, India *Bactrocera dorsalis* population has body length 7.12-8.18 mm and wing span 11.81-12.40 mm.

Due to differences of fruit flies body size on diffrenf fruit host, Sharma and Gupta (2018) [5] have reported that the body size of *B. dorsalis* that infested mango was biggest and longest compared to guava and peach fruit fly populations. Singh and Sharma (2013) [12] have stated that *B.dorsalis* that infested guava has biggest and longest body size compared to pear, kinnow and peach. Furthermore, the body size of *B.dorsalis* that infested mango, guava and peach was bigger and longer than fruit flies *B. zonata* that infested on the same fruits [5]. Lihou *et al* (2020) [13] stated that sucrosa content of diets influenced on adult fecundity and larval development of *B. dorsalis* fruit fly.

The relationship among *B. dorsalis* body length toward other morphometric traits

The regression equation that revealed relationship among body length (Y) and other morphological traits (X_1 to X_4) of *B.dorsalis* fruit fly is displayed in Table 3. Based on equation, it could be stated that there were two from four morphological atributes that contributed on the determination of fruit fly body length. The first trait was wing length and the second was wing width. The relation among body length (Y) with wing length (X_1) and wing width (X_2) be stated in regression equation $Y=1.54+0.67X_1+0.57X_2$. The contribution of wing length on body length of *B.dorsalis* fruit fly and act as a dominant determinator was 56.80%. This finding was diffrent compared to *B.umbrosa*. In this case, Manurung *et al.* (2020) have reported that the significant morphometric trait that contributed on *B.umbrosa* body length determination was tibia length (36.30%). Meanwhile, abdomen and head length variables were two morphomemetric feature that has highhest contribution in prediction of male body length of insect *Cofana spectra* [11].

Table 3: Regression equation and determinant coefficient of some morphological traits in determination of fruit flies *B. dorsalis* body length

No	Regression equation	Determinant coefficient (R^2)
1	$Y = 2.44 + 0.75X_1$	56.80%
2	$Y = 1.54 + 0.67X_1 + 0.57X_2$	59.60%

Conclusion

The fruit flies that be found and infested the oranges fruit in two citrus plantations at Karo district based on morphology traits belong to *Bactrocera dorsalis* Hendel species. The body length, wing length, wing width, hind leg length and tibia length of obtained fruit fly were 6.85, 5.90, 2.35, 5.75 and 2.25 mm, respectively. The wing length was the character that has the highest contribution on fruit fly body length determination.

Acknowledgement

This research doing was funded by "Dana PNBP Universitas Negeri Medan" under the research grant "Penelitian Dasar" (Fundamental Research) with grant number SK Ketua LPPM Unimed No. 124/UN33.8/KEP/PPKM/2021. Authors are thankful to the staffs and management of biology laboratory of FMIPA-Universitas Negeri Medan for providing laboratory facility.

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