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SHORT COMMUNICATION

Distribution areas of quarantine plant pest organisms of the fruit fly *Bactrocera musae* (Diptera: Tephritidae) in South Sulawesi, Indonesia

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ABSTRACT

Bactrocera musae is one of the most damaging fruit fly species affecting tropical fruit crops, particularly bananas. In Indonesia, this species is classified as an A2 Quarantine Plant Pest due to its economic impact and potential to spread into key production and export regions. However, updated information on its spatial distribution in South Sulawesi remains limited. This study aimed to map the occurrence and distribution of *B. musae* through field surveillance. Fruit fly specimens were collected using traps baited with methyl eugenol and installed across selected survey locations representing fruit-producing areas. Morphological identification was performed using standard taxonomic keys for *Bactrocera* species. The survey results confirmed that the distribution of *B. musae* in South Sulawesi is relatively extensive. The pest was detected in Makassar City and the regencies of Gowa, Takalar, Jeneponto, Bulukumba, Bantaeng, Sinjai, and Bone. These areas are characterized by the presence of tropical fruit crops, including banana, mango, guava, and papaya, which may serve as suitable host plants and support population establishment. The confirmed presence of *B. musae* in multiple regions indicates the need for strengthened surveillance, early detection programs, and quarantine measures. The findings of this research provide important baseline data for future pest risk analysis and policy development, particularly regarding pest status determination and preventive actions in South Sulawesi and other vulnerable regions. Further studies on population ecology, host interactions, and management strategies are recommended to support more effective control efforts.

Keywords: *Bacrocera musae*, banana, methyl eguenol, quarantine pest, survey

INTRODUCTION

Bactrocera musae, commonly known as the banana fruit fly, is categorized as an A2 Quarantine Plant Pest Organisms and is considered highly detrimental to the agricultural sector in Indonesia. This species belongs to the *Bactrocera* group, which is widely recognized as a major pest of fruit crops, particularly bananas and other tropical fruit commodities. Several studies have reported its broad geographical distribution and significant economic impact (Schutze et al., 2014; Oliveira et al., 2014). *B. musae* attacks tropical fruits such as banana, mango, guava, and papaya—crops widely cultivated in Australia, Papua New Guinea, Indonesia, including regions of South Sulawesi. The rapid spread of this species poses serious challenges to agricultural trade at both domestic and international scales (Vargas et al., 2015).

Recently, thirteen Indonesian agricultural commodities were reported to be at risk of rejection by the Taiwanese government following the detection of nine fruit fly species on exported products. Indonesia is suspected to harbor three fruit fly species not yet recorded in Taiwan, namely *B. papayae*, *B. zonata*, and *B. musae* (Daud et al., 2020).

According to the Decree of the Head of the Indonesian Agricultural Quarantine Agency No. 571/2025 concerning the determination of quarantine plant pest species, the distribution of *B. musae* has been confirmed in several regions, including West Java, Kalimantan, Maluku, Lombok, Sulawesi, and Papua. Internationally, its presence has also been documented in the Philippines, Australia, Papua New Guinea, and the Solomon Islands.

Bactrocera musae is known to occupy a wide range of habitats, particularly tropical environments. Although its presence in Indonesia has been confirmed,

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available reports remain limited. Hudiwaku et al. (2021) described *B. musae* is a polyphagous species capable of infesting multiple host plants, with bananas serving as its primary host. Similarly, Sari et al. (2022) documented its occurrence in banana cultivation areas, emphasizing the need for continuous surveillance.

The continued spread of *B. musae* presents major challenges for quarantine enforcement and pest management efforts. Findings by Arma et al. (2018) indicate that infestations are frequently recorded in chili cultivation areas, potentially due to the proximity of banana plants, as observed in South Sulawesi. These findings highlight the importance of spatial mapping to identify vulnerable locations and support effective pest management strategies.

Methyl eugenol (ME) is widely used as a pheromone attractant for several *Bactrocera* species, including *B. musae.* ME is particularly effective in male annihilation programs for monitoring and control (Shelly, 2010). Post-control monitoring using pheromone-baited traps is critical to assess treatment success and facilitate adjustments in integrated pest management (Shelly, 2010). Pujiastuti et al (2020). further demonstrated that monitoring using traps containing cue-lure (CL) and ME can effectively detect the presence of fruit flies during early infestation stages, enabling timely quarantine action.

Mapping the distribution of *B. musae* is essential to generate updated information on its spread, contributing to a better understanding of spatial patterns and ecological factors influencing Tephritidae dispersal, including this species (Shi et al., 2012). Such data are necessary to prevent economic losses and strengthen quarantine preparedness. Therefore, this study aims to map the distribution of *B. musae* in selected agricultural centers known for tropical fruit production.

MATERIALS AND METHODS

Research Site. The survey was conducted in eight regencies of South Sulawesi, namely Makassar, Gowa, Takalar, Jeneponto, Bantaeng, Bulukumba, Sinjai, and Bone. Sampling was carried out from July to December 2024. Morphological identification of collected specimens was performed at the Laboratory of the South Sulawesi Animal, Fish, and Plant Quarantine Center.

Field Survey. A field survey approach twas implemented to determine and map the distribution of *B. musae* in South Sulawesi. Sampling sites were selected based on major tropical fruit production areas, including banana, mango, and papaya cultivation zones. All selected locations exhibited high availability of host plants known to support fruit fly development.

Trap Design and Installation. The fruit fly trap used in this study was constructed from a 600 mL plastic mineral water bottle (Figure 1). Two holes (1 cm diameter) were made on opposite sides of the bottle body to allow fruit fly entry. The bottle cap was perforated to attach a string for hanging on tree branches.

A cotton wick (2 cm diameter) was soaked with 0.2 mL of methyl eugenol (ME) serving as the male attractant. The trap reservoir was filled with 100 mL of 70% ethanol, functioning as a killing and preserving solution. Traps were hung on sturdy mango tree branches at approximately 1.5 m above ground level.

Traps were deployed at multiple points in each regency and inspected weekly. Captured flies were collected and stored for further laboratory analysis (Figure 2).

Figure 1. A simple pheromone-based trap designed for capturing adult male *Bactrocera musae.*

Identification of *B. musae*. Specimens retrieved from traps were preserved and subsequently identified morphologically under a stereoscopic microscope. Observed diagnostic characters included body coloration, body and head shape, wing venation patterns, abdominal line patterns, and ovipositor morphology.

Species determination was performed by comparing observed morphological characteristics with published identification keys, including the dichotomous key by Suputa et al. (2006), Drew & Romig (2016), and species descriptions of Plant Health Australia (2018).

RESULTS AND DISCUSSION

The survey results confirmed the presence of *B. musae* in all surveyed locations (Table 1; Table 2). The distribution pattern appears strongly influenced by environmental conditions, particularly temperature and humidity. Higher fruit fly populations were recorded in humid regions such as Gowa, Bantaeng, Bulukumba, Sinjai, and Bone, suggesting a positive correlation between humidity and population abundance. During trap installation, temperature ranged from 19–33 ºC, falling within the optimal thermal range required for adult activity and mating behavior. Since the traps used methyl eugenol (ME), which attracts males mimicking female-emitted pheromones, the captured specimens were predominantly male adults.

B. musae is recognized as an important pest species capable of infesting bananas and other tropical fruits. Findings by Doorenweerd et al. (2020) and Sulaeha et al. (2020) indicated that fruit fly diversity in Sulawesi, including *B. musae*, aligns with the Lydekker line, reinforcing the classification of this region as part of the Wallacea biogeographic zone. This geographic context may contribute to the species' successful establishment and spread, further supported by the movement of infested host fruits through trade and transportation.

In terms of control strategies, pheromone-based trapping—particularly using methyl eugenol—has demonstrated effectiveness for monitoring and suppressing species within the *Bactrocera dorsalis* complex, including *B. musae* (Ono et al., 2021; Sulaeha et. al., 2020). ME-based traps can therefore serve as both monitoring tools and components of integrated pest control programs such as male annihilation techniques.

Morphological identification of trapped specimens was conducted in the South Sulawesi Animal, Fish, and Plant Quarantine Center Laboratory (Figure 3). *B. musae* belongs to the family Tephritidae

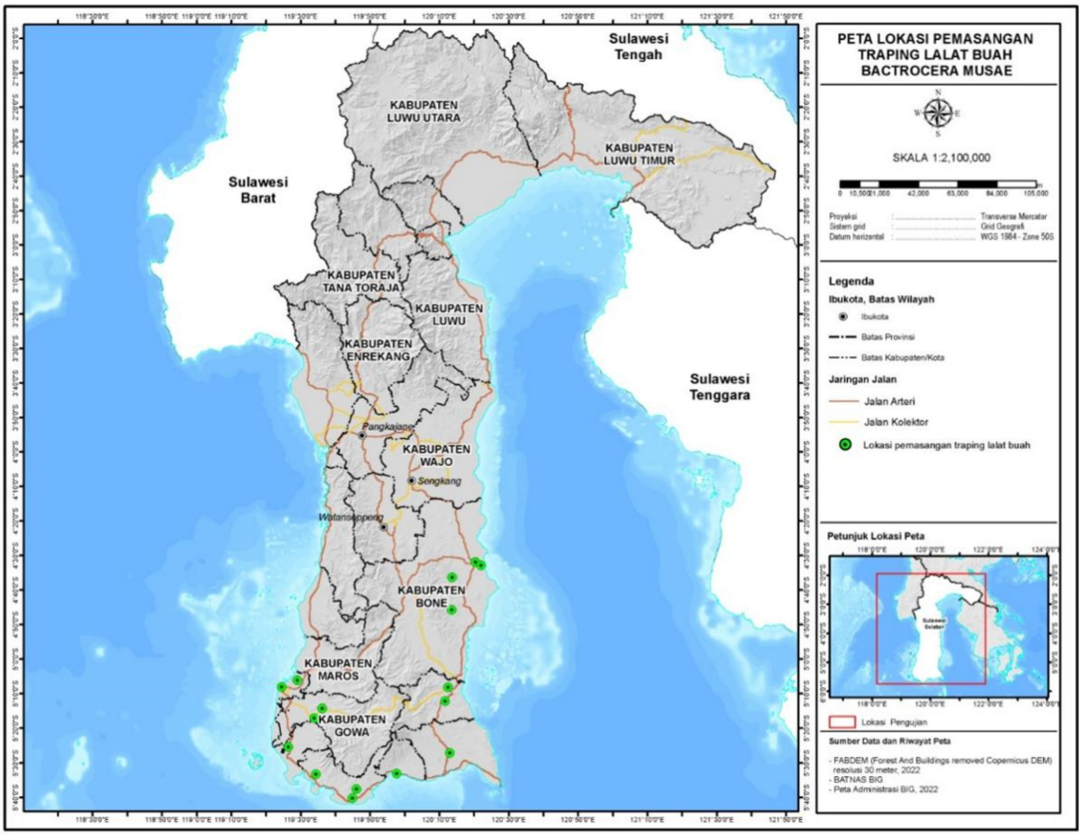

Figure 2. Map showing the distribution of *B. musae* across surveyed locations in South Sulawesi.

Table 1. Locations of *B.musae* trapping sites in South Sulawesi

No.	Regency	District	Village	Latitude	Longitude
1	Makassar	Tamalanrea	Kapasa	05°6'7,12811"	119°29'1,15668"
2	Makassar	Ujung Pandang	Tamalanrea	05°8'6,60264"	119°24'29,01067"
3	Gowa	Bontomarannu	Bili-bili	-5°17'6,218"	199°33'53.50749"
4	Gowa	Parangloe	Balapunranga	-5°14'a16,4311"	119°36'8,085552"
5	Takalar	Pattalassang	Kallabirang	5°25'26"	119°26'25"
6	Jeneponto	Binamo	Balantoa	5°40'15"	119o44'51"
7	Jeneponto	Bangkala	Palangtikang	5°57'37.533"	119o56'2.2863"
8	Jeneponto	Turatea	Kayuloe Timur	5°37'41.196"	119o46"3.984"
9	Bantaeng	Bantaeng	Lembang	05°33'8.2162'	119°57'39.33403'
10	Bulukumba	Rilau Ale	Topanda	05°479 152'	120°205 267'
11	Sinjai	Sinjai Selatan	Palae	-5°17'830" 6572'	120°21'58"4149'
12	Sinjai	Sinjai Timur	Bongki Lengkese	-5°14'83"	120°22"30'
13	Bone	Tanete Riattang	Desa Ta	-4°31'55,5641"	120°20'20,86807'
14	Bone	Tanete Riattang Timur	Cellu	-4°32'52,50228"	120°22'1,74072"
15	Bone	Cina	Jampulu	-4°36'22,50328"	120°13'38,20692"
16	Bone	Tanah Batu	Libureng	-4°45'48,48887"	120°13'31,99632"

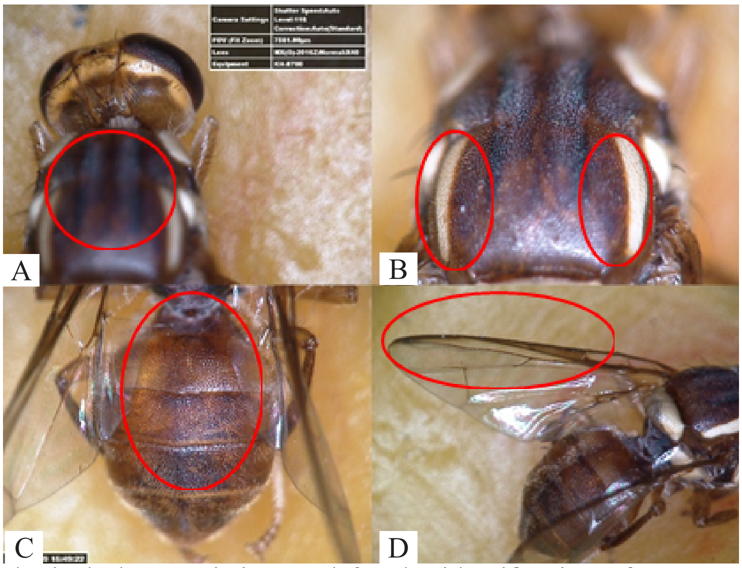

Figure 3. Key morphological characteristics used for the identification of *B. musae*. A. Black scutum on the thorax; B. Tapering lateral vittae on the thorax; C. Absence of a T-shaped abdominal pattern; D. Dark costal band overlapping vein R2+R3. Identification follows the Keys to the Tropical Fruit Flies of South-East Asia.

and exhibits distinct taxonomic characteristics useful for species confirmation. Morphological traits observed include:

1) Size and shape: Adults measure approximately 5–10 mm in length with a cylindrical, slender body structure characteristic of the *Bactrocera* genus (Larasati et al. 2016);

2) Coloration: The body typically exhibits yellow to brown coloration with darker patterning on specific regions. Wings are transparent with distinct banding, serving as an important diagnostic feature (Lengkong & Rante, 2019);

3) Head structure: The head contains large bluish-green compound eyes and yellow segmented antennae, which assist in differentiating *B. musae* from closely related species (Lengkong & Rante, 2019);

4) Abdominal Pattern: The abdomen displays a characteristic T-shaped marking on the tergites,

Table 2. Abundance of fruit flies (Genus *Bactrocera*) in selected regencies of South Sulawesi, 2019–2024

No.	Distric species of *Bactrocera*		Year						Crop Vegetation
			2019	2020	2021	2022	2023	2024	
1	Gowa	*B. musae*	2	3	2	2	4	2	*Mangifera indica, Musa* spp., *Carica papaya, Psidium guajava, Nephelium appaceum, Averrhoa carambola*
		B. umbrosa	4	6	5	9	7	5	
		B. papayae	12	16	20	17	20	49	
		B. carambolae	3	2	4	3	2	5	
2	Takalar	*B. musae*	3	2	2	3	2	1	*Mangifera indica, Artocarpus heterophyllus, Manilkara zapota, Syzygium samarangense Musa* spp., *Carica papaya Artocarpus heterophyllus, Manilkara zapota, Syzygium samarangense*
		B. umbrosa	9	7	5	8	7	4	
		B. papayae	12	9	7	5	8	23	
		B. carambolae						8	
3	Jeneponto	*B. musae*	2	1	2	1	2	1	*Mangifera indica, Musa* spp., *Carica papaya, Artocarpus heterophyllus, Capsicum* spp., *Syzygium samarangense*
		B. umbrosa	6	9	12	9	7	3	
		B. papayae	12	9	10	8	12	18	
		B. carambolae	2	4	2	3	3	6	
4	Bantaeng	*B. musae*	1	3	2	1	2	1	*Mangifera indica, Musa* spp. *Carica papaya, Artocarpus heterophyllus, Passiflora edulis, Solanum lycopersicum*
		B. umbrosa	7	6	9	12	9	7	
		B. papayae	12	15	9	8	7	25	
		B. carambolae	2	3	1	2	2	3	
5	Bulukumba	*B. musae*	1	1	2	2	3	2	*Mangifera indica, Musa* spp., *Carica papaya, Garcinia mangostana*
		B. umbrosa	3	5	4	7	5	6	
		B. papayae	8	7	6	9	12	10	
		B. carambolae	2	2	3	4	3	2	
6	Bone	*B. musae*	3	4	2	5	4	3	*Hylocereus undatus, Musa* spp. *Carica papaya, Psidium guajava, Capsicum* spp., *Cocos nucifera, Artocarpus heterophyllus, Averrhoa carambola, Artocarpus altilis*
		B. umbrosa	15	20	15	17	10	9	
		B. papayae	8	6	9	10	15	10	
		B. carambolae	2	3	2	2	4	2	
7	Sinjai	*B. musae*	1	1	2	1	2	1	*Musa* spp., *Carica papaya, Artocarpus heterophyllus, Psidium guajava, Persea americana, Capsicum* spp.
		B. umbrosa	5	3	2	3	1	7	
		B. papayae	9	7	5	8	5	6	
		B. carambolae	2	3	2	2	2	2	

although slight variations may occur among individuals (Prambudi et al., 2013);

5) Ovipositor: Females possess a long, slender ovipositor used for penetrating host fruit tissue during egg-laying. This feature is essential for distinguishing between sexes (Lengkong & Rante, 2019).

In addition to *B. musae,* morphological evaluation of trap captures revealed the presence of three additional *Bactrocera* species—*B. carambolae, B. papayae*, and *B. umbrosa*—as shown in Figures 4, 5, and 6. The detection of these species indicates that the surveyed landscape supports a diverse assemblage of Tephritidae and underscores the complexity of fruit fly communities in South Sulawesi.

Figure 4 illustrates *Bactrocera carambolae*, distinguished by a predominantly black scutum, two sharply defined yellow longitudinal vittae, and a prominent dark costal band extending distally beyond veins R2+R3 and R4+R5. The tergite IV displays a rectangular T-shaped marking, a key diagnostic character separating this species from other members of the *B. dorsalis* complex. These morphological traits correspond closely with the identification keys of Drew and Romig (2016) and the diagnostic guidelines issued by Plant Health Australia (2018). The species' presence aligns with patterns in Table 2, which show routine co-occurrence of *B. carambolae* with *B. musae* in mixed horticultural landscapes dominated by mango, papaya, guava, and starfruit.

Figure 5 depicts *Bactrocera papayae*, characterized by a pair of parallel post-sutural lateral vittae, a costal band confluent at vein R2+R3, and a triangular to T-shaped marking on tergite IV. These features are consistent with the species' description in Schutze et al. (2014), who integrated *B. papayae* within the broader *B. dorsalis* complex based on extensive morphological, genetic, and behavioral evidence. Although its primary hosts include papaya and guava, its attraction to methyl eugenol explains its presence in the ME-baited traps used in this study. The detection of *B. papayae* highlights the taxonomic and ecological overlap among members of the *B. dorsalis* complex in the region.

Figure 6 represents *Bactrocera umbrosa,* a species readily distinguished by its dark scutum, broad and nearly parallel lateral vittae, and the presence of three distinct transverse wing bands. It is typically associated with *Artocarpus* species such as jackfruit and cempedak. Its presence across several regencies aligns with previous regional reports (Daud et al., 2020) and reflects the availability of suitable host plants within the surveyed localities. Although not a primary pest of bananas, *B. umbrosa* poses diagnostic challenges because of its superficial similarity to other *Bactrocera* species encountered in the same traps.

As a follow-up action, the findings of this study highlight the need to strengthen pest management strategies through more intensive monitoring, particularly in areas with high population densities. Additionally, the development and application of more effective and environmentally friendly trapping technologies should be prioritized to support sustainable control efforts.

The detection of *B. musae* across multiple

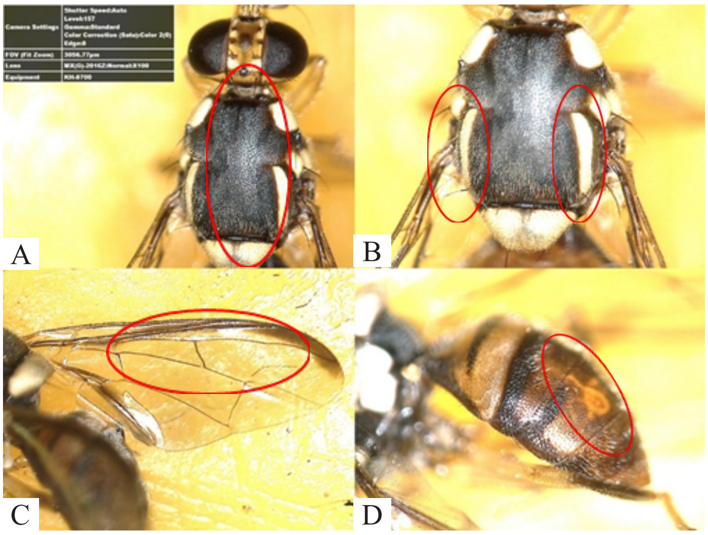

Figure 4. Identification of *Bactrocera carambolae*. A. Thorax predominantly black; B. Two yellow longitudinal stripes on the thorax; C. Wing pattern showing a dark costal band overlapping vein R2+R3, extending beyond the tips of R2+R3 and R4+R5, and widening toward the wing apex; D. Abdomen exhibiting a distinct black "T-shaped" pattern, with a more pronounced rectangular black marking on the lateral region of tergite IV.

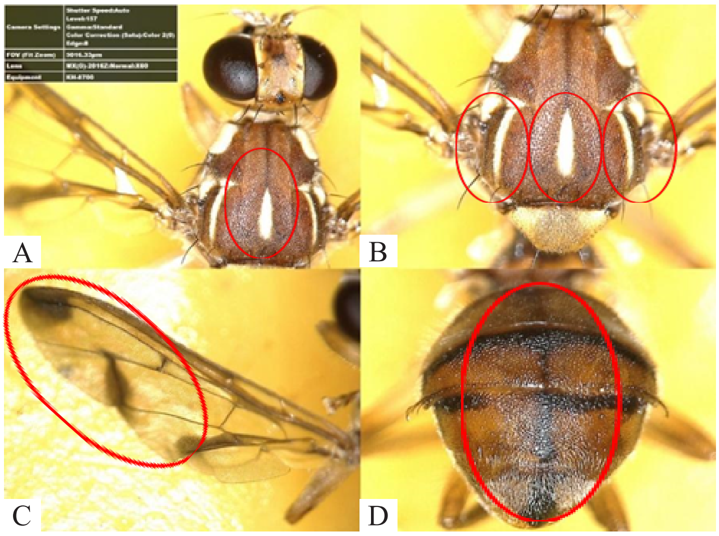

Figure 5. Identification of *Bactrocera cucurbitae.* A. Scutum with a reddish-brown coloration; B. Scutum predominantly red-brown with distinct medial and lateral yellow post-sutural vittae; C. Wings measuring approximately 6–7 mm in length, with a distinctive pattern: a continuous and deep costal band extending below vein R2+R3 or to vein R4+R5 before the apex, expanding apically into a spot reaching the mid-depth of cell r4+5; a cross-band present at cross-vein dm–cu; and an anal band nearly reaching the wing margin along the extension of cell cup; D. Abdomen with tergites I–V separated or detached, featuring a visible medial T-shaped marking.

Figure 6. Identification of *Bactrocera umbrosa*. A. Scutum with a black coloration; B. Lateral vittae broad/large subparallel; C. On the wings there are 3 transverse bands.

regencies in South Sulawesi indicates a significant threat to the agricultural sector, especially horticultural crops. The confirmed spread of this pest in key agricultural production zones suggests that preventative measures are urgently needed. Mitigation strategies such as the application of pheromone-based trapping systems, implementation of crop rotation, and adoption of modern agricultural technologies are essential to reduce potential losses (Santoso, 2021). Strengthening human resource capacity in pest identification, including the use of more advanced diagnostic techniques, is also required to support long-term management.

Quarantine measures play a critical role in preventing the further spread of quarantine pest organisms such as *B. musae*, particularly in South Sulawesi. Beyond the direct impact on crop production, the presence of this species poses a serious risk to export activities due to pest-free compliance requirements in international markets (Santoso, 2021). Therefore, a strict and well-implemented quarantine system must be integrated into the broader pest management framework.

Quarantine protocols include inspection, monitoring, and regulation of plant material movement across regions to prevent pest introduction into pest-free zones and contain spread within affected areas. The use of pheromone-based traps in this study demonstrates their value as a frontline monitoring tool in high-risk locations. Furthermore, quarantine inspections at ports, checkpoints, and distribution hubs are essential to minimize the movement of potentially infested produce. Without rigorous oversight of inter-island trade and horticultural commodity transport, the risk of *B. musae* dispersal remains high (Ministry of Agriculture, 2020).

CONCLUSION

This study successfully identified the distribution of the fruit fly *Bactrocera musae* across several regencies in South Sulawesi. Morphological identification confirmed the presence of *B. musae* in Makassar City and the regencies of Gowa, Takalar, Jeneponto, Bantaeng, Bulukumba, Sinjai, and Bone. The traps baited with methyl eugenol effectively captured specimens, demonstrating the usefulness of pheromone-based surveillance for monitoring population presence. The surveyed regions are known production centers for tropical fruits such as mango, banana, papaya, and guava, which serve as host plants for *B. musae*. The distribution data generated from this study provide valuable baseline information to support quarantine actions and pest management strategies. These findings may contribute to preventing further spread of *B. musae* into other regions of Indonesia.

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AUTHORS' CONTRIBUTIONS

J caried out the field activities, performed laboratory analysis, and analyzed the data. J and R drafted the manuscript. BP and AG designed the study and contributed to manuscript revision and final approval.

COMPETING INTEREST

The authors declare no competing interests.

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