



The Occurrence and Diversity of Flies Related to the Bali Cattle Breeding System in Badung Regency, Bali Province, Indonesia

I Made Dwinata¹ and Ida Bagus Made Oka²

^{1,2} Department of Parasitology, Faculty of Veterinary Medicine, Udayana University, Denpasar, Bali, Indonesia

*Corresponding author: made_dwinata@unud.ac.id; okaibm@unud.ac.id

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ABSTRACT

This study aimed to determine the occurrence and diversity of flies species in an intensive and extensive farming system. The flies were collected from October to December 2019 by sweeping net in two cowsheds (intensive and extensive farming system) on a private Bali cattle farm in Badung regency, Bali province, Indonesia. A total of 4125 flies belonging to 4 species (*Stomoxys calcitrans*, *Musca domestica*, *Haematobia irritans*, and *Hippobosca* sp.) were obtained. At the intensive breeding system, the most collected flies were *Stomoxys calcitrans* (42.58%) and the rare ones were *Hippobosca* sp. (3.25%). At the extensive breeding system, the most collected flies were *Stomoxys calcitrans* (33.86%) and *Haematobia irritans* were the least abundant (11.36%). *Stomoxys calcitrans* were observed abundance in Mengwi district, whereas *Musca domestica* were highest in South Kuta district. It was concluded that the abundance of flies during the study period was affected by farming system, temperature, humidity, and rainfall.

Key words: Diversity, Extensive farm, Flies, Intensive farm, Bali cattle

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INTRODUCTION

Insects are unique in their way and contribute all types of services to the ecosystem. Their diversity is indeed an intrinsic part of the earth's ecosystem (Adelusi et al. 2018). Insects are important because of their diversity, ecological role, and influence on agriculture, human health, and natural resources (Premalatha et al. 2011; Halsch et al. 2020). They are one of the most diverse organisms (Skevington and Dang 2002) and are reported to be home to more than 58% of the global biodiversity on earth (Emmanuel and Anuoluwa 2019).

Over the last decade, insects have been managed to take a significant position in the feed and food chain. Insects can be used to feed fish, swine, poultry, and pets, (van Huis et al. 2020), also might help to reduce environmental pollution and increase animal welfare (Menozzi et al. 2021). However, they might carry biological and chemical contaminants as well as physical hazards that can be detrimental to the health. Insect also act as mechanical vectors of several bacterial, viral and protozoal diseases of livestock (Patra et al. 2018).

Insects, particularly flies, are also vectors of many pathogens. Flies can cause a decrease in livestock production and act as important vectors of infectious diseases, both directly and indirectly (Lucas et al. 2020);

Perez de Leon et al. 2020). Flies contribute to the spread of many pathogenic microorganisms and parasites. The direct impact of dipterans on livestock includes causing anxiety and stress in the animals, which results in reduced feeding, as well as skin lesions, facultative and accidental myiasis (Nosal et al. 2019), and potentially could disturb the health of many livestock. Flies also result in a significant economic loss to animal production because animals can get sick and spend a lot of energy avoiding the nuisance of fly bites (Taylor et al. 2012; Narladkar 2018).

Environmental conditions with favorable temperatures and poor enclosure sanitation conditions can be a very potent factor for an increase in the fly population (Collinet-Adler et al. 2015). In general, flies show an increase in population during the rainy season and a decrease in the dry season. The reproduction of flies depends on temperature. The optimal temperature for rapid reproduction appears between an average temperature of 22.8-24°C.

Climatic factors may however vary from one habitat to another and this may affect the population trends of insects differently not only during some parts of the year but also different in different agroecological zones. This underscores the critical necessity of this work to evaluate the effect of climatic factors such as temperature, humidity, and rainfall on the population trends of insects associated with citrus orchards in two different agro-ecological zones in Ghana.

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Raising cattle is associated with the accumulation of large amounts of manure. Manure plays an important role in the development and spreading of insects (Nosal et al. 2019). Each member of an insect responds differently to environmental changes. These different responses allow us to understand the important role of livestock grazing systems on biodiversity (Clement et al. 2018).

The Bali cattle rearing system is categorized in three ways, namely the extensive, semi-intensive, and intensive system (Sari et al. 2016). In an extensive breeding system, the cattle are released in the grazing field, allowed to feed. In the intensive breeding system, farmers kept their cattle in a paddock. Farmers bring and provide water and chopped or cut grass to their cattle in a pen. Intensive cattle farming, along with its dense population, is a rich source of manure, and increasing available manure. This situation provides an attractive environment for synanthropic insects and can increase flies diversity by adding new niches. Commonly, it is believed that the cattle production environment predominantly attracts by blood-sucking flies from the *Muscidae* family (Soviana et al. 2019). The occurrence and diversity of flies related to ruminant farming were reported the largest abundance of Diptera from the *Drosophilidae* family and dominating *Muscidae* species (Nosal et al. 2019).

The study is designed to document the diversity and infestation prevalence of flies in Badung, Bali Indonesia. In this study, the emphasis is on evaluating the breeding system, as well as the effect of temperature, humidity, and rainfall. This information is useful for agricultural, medical and veterinary purposes.

MATERIALS AND METHODS

Study Area

This research was conducted from October to December 2019 in the District of South Kuta and the district of Mengwi, Badung Regency of Bali Province. District of South Kuta covers 101.13 km², a harsh, scrubby limestone plateau off the south side of Bali, which lies between latitude -8.785502° and longitude 115.199806°. The District of South Kuta is only 108m/354.33 feet above sea level. The relative humidity is 82%, from October to December the temperature is 26.3-26.9°C. The rainfall throughout the year is 68-260 mm. District of Mengwi covers an area of 82.0 km², which lies between latitude -8.543465° and longitude 115.171579°. The District of Mengwi is only 125m/410feet feet above sea level. The relative humidity is 76%, from October to December the temperature is 28°C. The rainfall throughout the year is 0.8 mm.

Sample Collection

The flies were caught in a total of 107 private Bali cattle farms during a planned survey using a sweeping net. All flies were collected from an intensive (Fig. 1) and extensive farming system (Fig. 2). In the intensive breeding system, cattle are stall-fed year-round in the paddock. The farmers bring and provide water and feed in a paddock. In extensive farming, cattle move around freely in cowherd land, do not need extra feed. Caught flies were enumerated and all flies collected were preserved in 70% alcohol. The specimens were brought to the Parasitology Laboratory,

Faculty of Veterinary Medicine, Udayana University and identified using morphological differences described by Alikhan et al. (2016) and Phasuk et al. (2013).



Fig. 1: Intensive breeding system.

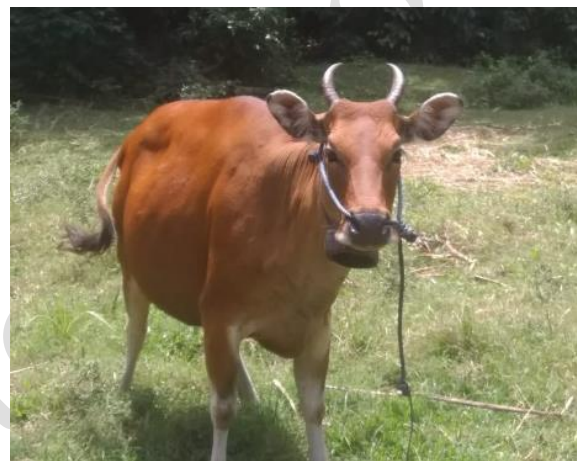


Fig. 2: Extensive breeding system.

Data Analysis

Data were analyzed using SPSS software (version 21) to determine the relationship between the farming system, temperature, humidity, and rainfall factors, and flies abundance during these months (Szyniszewska et al. 2016). The differences between the number of flies and the farming system and the area were analyzed using the Student T-test ($P < 0.01$).

RESULTS

A total of 4125 flies from 107 farms were sampled and only 105 flies could not be identified due to the damage of sample. A total of 2832 flies were collected in 147 cattle from the intensive farming system and 1188 flies in 153 cattle from the extensive farming system. A total of 4 species (*Stomoxys calcitrans* (Fig. 3), *Musca domestica* (Fig. 4), *Haematobia irritans* (Fig. 5), and *Hippobosca* sp. (Fig. 6) were identified in this research (Table 1). At the intensive farming system, the most collected flies were *Stomoxys calcitrans* (42.58%) and the rare ones were *Hippobosca* sp. (3.25%). The highest prevalence of the flies species in the intensive farming system were *Stomoxys calcitrans* with the prevalence of 42.58%, followed by *Musca domestica* (40.61%), *Haematobia irritans* (13.56%), and *Hippobosca* sp. (3.25%). However, in an



Fig. 3: *Stomoxys calcitrans* (left: head, right: wing vein).



Fig. 4: *Musca domestica* (left: head; right: wing vein).

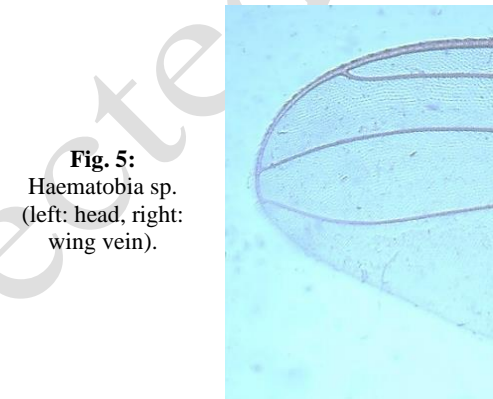


Fig. 5: *Haematobia* sp. (left: head, right: wing vein).

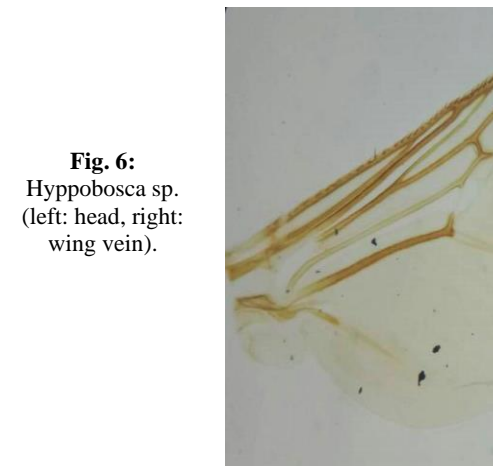


Fig. 6: *Hypobosca* sp. (left: head, right: wing vein).

extensive farming system, *Haematobia irritans* were the least abundant (11.36%) (Table 1). Average overall flies abundance was significantly greater ($P < 0.05$) at intensive farming system with extensive farming. The infestation of

Hypobosca sp. in the extensive farming system (25.42%) was higher when compared to the intensive farming system (3.25%).

Table 1: Total number and proportion (%) of individual flies species captured in the survey at the intensive and extensive farming system

No	Species	Intensive farming system	Extensive farming system
1	<i>Stomoxys calcitrans</i>	1206 (42.58)	426 (35.86)
2	<i>Musca domestica</i>	1150 (40.61)	325 (27.36)
3	<i>Haematobia irritans</i>	384 (13.56)	135 (11.36)
4	<i>Hyppobosca</i> sp.	92 (3.25)	302 (25.42)

Values in parenthesis indicate percentage.

Based on the area, species diversity is presented in Table 2. The result on four species was collected, frequency of occurrence for distribution of *Stomoxys* sp. was higher in the district of Mengwi than in South Kuta district. In contrast, *Musca* sp. were significantly higher collected in South Kuta district. Focusing on four species, *Musca* sp. was observed to increase with increasing humidity and rainfall, whereas *Stomoxys* sp. was found to be increased with decreasing rainfall and humidity.

Table 2: Total number of flies collected in at South Kuta and Mengwi District

Species of flies	Regions	
	South Kuta (n=2108)	Mengwi (n=1912)
<i>Stomoxys calcitrans</i>	669 (31.74)	963 (50.4)
<i>Musca domestica</i>	1018 (48.29)	457 (23.90)
<i>Haematobia irritans</i>	244 (11.57)	275 (14.35)
<i>Hippobosca</i> sp.	177 (8.40)	217 (11.35)

Values in parenthesis indicate percentage.

DISCUSSION

The flies collected in this study differed in numbers between the farms examined, however, the farming system has the same distribution in species composition of insects. The fly species abundance and diversity was observed and the differences were significant between the intensive and extensive farming system. It is an indication that the sites of the farm occupy a different management system. The diversity of flies in cattle depends on differences in region, season, and management breeding system. The overall most abundant insect in the intensive farming system was *Stomoxys calcitrans* followed by *Musca domestica*, *Haematobia irritans*, and *Hippobosca* sp. were rarely found in the intensive farming system.

This research shows most abundant flies were the *Stomoxys calcitrans* and it occurred abundantly in an intensive and extensive farming system than the other detected flies. The abundant population of *Stomoxys calcitrans* is probably because this location is good habitat as well as the suitable environmental conditions for *Stomoxys calcitrans* larvae that complete their life cycle. Rainfall fluctuations may be the main climatic factor correlated with population changes of the most abundant species (Phasuk et al. 2013). *Stomoxys calcitrans* is, is a cosmopolitan haematophagous fly that frequently attacks livestock in farmyards (Murchie et al. 2018) and considered a major pest of livestock worldwide (Shukri Sharif et al. 2020). *Stomoxys calcitrans* is a species considered to be one of the most harmful in livestock breeding and raising around the world (Nosal et al. 2019). The research in Minahasa, Indonesia reported that *Stomoxys calcitrans* was a relatively high population than other flies such as

Stomoxys sp., *Haematobia* sp. and *Musca* sp. (Djenaar et al. 2019).

Besides *Stomoxys* sp. during this research, *Musca* sp. was the most common flies on this farm. *Musca* sp. tends to be most abundant than *Hippobosca* sp. and *Haematobia* sp. This study showed the two farming systems had an equal number of *Musca* sp. In another study, Djenaar et al. (2019) showed that *Haematobia* sp. was the most common flies on the cattle farm. This may be because of the difference in location. *Musca* sp. can breed in cattle dung, and the adult stage feeds on secretions from cattle (Soviana et al. 2019). Some species of *Musca* flies can be a biological vector of *Thelazia* eyeworm disease that occurs when flies feed on cattle's tear secretions (Canie and Bogale 2014). Habits of *Musca* sp. which easily alighted then flew around the body of livestock, can become one of the potential disease vectors.

Our study also revealed that the *Hippobosca* sp. are rare species in the extensive farming system compared to the extensive farming system. The relatively high population of *Hippobosca* sp. at the extensive farming system is likely due to the environmental conditions suitable for *Hippobosca* sp. larvae completing their life cycle. In the extensive farming system, cattle move around freely on cowherd land. The cows will pass their feces in a variety of different places and this will prevent the accumulation of feces in one place. The manure spill around the farm is excellent for scrub and tree growth. Scrub and trees around the farm are a good location for *Hippobosca* sp. put their pupae (Soviana et al. 2019).

In this study, infestation of *Haematobia* sp. in extensive farming system was the lowest when compared to others flies. These species were present at 11.3%. *Haematobia* sp. is a bloodsucking fly in the form of the same palpus and proboscis, and the palpus was a sturdy type (Soviana et al. 2019). A different prevalence was observed in California. *Haematobia* sp. was the most common fly observed in cattle breeding areas in California is an obligate parasite that is always present on a cattle's body and can potentially be a mechanical vector for surra caused by *Trypanosoma evansi* (Desquesnes et al. 2013).

Climate changes have significant impacts directly on insects. Direct impacts are on insect reproduction, development, survival and dispersal. Insects are poikilothermic organisms; the temperature of their body depends on the temperature of the environment. Thus, the temperature maybe the most important factor affecting insect distribution, development, and reproduction. Since temperature is the most important environmental factor affecting insect population dynamics (Skendžić et al. 2021).

Stomoxys sp. were considered a major pest of livestock in Badung Bali. The abundance of these flies is observed in the Mengwi district and low in the South Kuta district. The differences could be due to temperature, humidity, and rainfall in the two district areas. The temperature was reported to affect the population peak of *Stomoxys* sp. (Semelbauer et al. 2018). Humidity was observed to have a significant effect in increasing the number of larva pupated (Issimov et al. 2020). Rainfall has also been reported to affect *Stomoxys* activity. The increase in rainfall causes a critical factor for eggs to hatch and the

larvae to survive and successfully develop into pupae (Lendzele et al. 2019). The low number of flies trapped in the South Kuta district may be caused by increase rainfall in these months.

Musca domestica (known as the common housefly) numbers were highest during this study in South Kuta district compared in Mengwi district. In the South Kuta district, the relative humidity and rainfall were highest compared to the Mengwi district. The differences in *Musca domestica* population could be due to differences in temperature, humidity and rainfall. The temperature and relative humidity affect the *Musca domestica* development and prevalence (Jiménez et al. 2019). *Musca domestica* have favourable production performances at higher temperature (Francuski et al. 2020). It was evident that the abundance of flies during the study period was affected by farming system, temperature, humidity and rainfall in Badung regency.

Conclusion

Among captured samples, the most abundant species were *Stomoxys* sp. and the rare species were *Hyppobosca* sp. in intensive farming systems, and *Haematobia irritans* in the extensive farming system. *Stomoxys calcitrans* were observed abundant in Mengwi district, whereas *Musca domestica* were highest in South Kuta district. This information could deepen the knowledge of the ecology of flies in Bali cattle. Further research is needed to expand using other sampling techniques and seasonal variation effect on flies abundance in Bali.

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Authors Contribution

All the authors contributed significantly to the paper.

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