International Journal of Mosquito Research

ISSN: **2348-5906**
CODEN: **IJMRK2**
IJMR 2022; 9(1): 18-23

www.dipterajournal.com
Received: 04-01-2021
Accepted: 12-01-2021

I Made Kardena
Laboratory of Veterinary Pathology, Department of Biopathology, Faculty of Veterinary Medicine, Udayana University, Bali, Jalan PB Sudirman, Denpasar, Bali, Indonesia

Anak Agung Ayu Mirah Adi
Laboratory of Veterinary Pathology, Department of Biopathology, Faculty of Veterinary Medicine, Udayana University, Bali, Jalan PB Sudirman, Denpasar, Bali, Indonesia

Nyoman Mantik Astawa
Laboratory of Veterinary Virology, Department of Biopathology, Faculty of Veterinary Medicine, Udayana University, Bali, Jalan PB Sudirman, Denpasar, Bali, Indonesia

Ida Bagus Made Oka
Laboratory of Veterinary Parasitology, Department of Biopathology, Faculty of Veterinary Medicine, Udayana University, Bali, Jalan PB Sudirman, Denpasar, Bali, Indonesia

I Made Dwinata
Laboratory of Veterinary Parasitology, Department of Biopathology, Faculty of Veterinary Medicine, Udayana University, Bali, Jalan PB Sudirman, Denpasar, Bali, Indonesia

Corresponding Author:
I Made Kardena
Laboratory of Veterinary Pathology, Department of Biopathology, Faculty of Veterinary Medicine, Udayana University, Bali, Jalan PB Sudirman, Denpasar, Bali, Indonesia

Mosquito diversity and abundance collected from paddy fields and animal farms in Bali province, Indonesia

I Made Kardena, Anak Agung Ayu Mirah Adi, Nyoman Mantik Astawa, Ida Bagus Made Oka and I Made Dwinata

DOI: https://doi.org/10.22271/23487941.2022.v9.i1a.573

Abstract
This study aims were to assess the genera and number of the mosquitoes collected from rice paddy fields and animal farms in Badung and Tabanan regencies, in Bali, Indonesia. A total of eight mosquito light traps were set in the sampling areas. Only the adult female mosquitoes trapped were identified and counted in this study. The results demonstrated that four mosquito genera were found, such as *Culex* spp., *Anopheles* spp., *Aedes* spp., and *Armigeres* spp. The *Culex* spp. was the highest number of the mosquito trapped with total 2899 collected along the study period. Then, it was followed by *Anopheles* spp., *Aedes* spp. with 1954 and 1229 mosquitoes collected respectively. The lowest number mosquito found was *Armigeres* spp. with 612 mosquitoes collected along the twelve weeks collection. A significant higher number of mosquitoes *Anopheles* spp., *Aedes* spp., and *Armigeres* spp. collected from paddy fields found in comparison with the number of the same mosquitoes collected from animal farms in Badung regency. However, more significant number of mosquitoes *Culex* spp., *Anopheles* spp., and *Aedes* spp. collected from animal farms found compared to the mosquitoes collected from paddy fields in Tabanan regency.

Keywords: Abundance, Bali, diversity, mosquito, vector

1. Introduction

Mosquito is an ectoparasite that can be a vector for many diseases or in more specific, mosquito borne diseases. Some infectious viruses are zoonotic and can be transmitted by the mosquito [1]. This transmission threatens not only in humans, but the livestock as well. The infections have detrimental impacts mainly on socio-economical aspects [2]. Japanese encephalitis and West Nile viruses are two examples of the fatal viral encephalitis agents that are transmitted by mosquitoes, which then transmit the pathogens and infect susceptible humans and animals [3].

Indonesia is a tropical country in Southeast Asia that is endemic for several mosquito borne viruses. Flaviviruses are the main pathogens that have been facilitated by mosquitoes. The viruses reported to cause human encephalitis in this area, such as dengue [4], Japanese encephalitis [5, 6], and Zika [7]. These disease agents are also required mosquitoes to be the vector to transmit them [8]. In fact, most of the areas in Indonesia are reported to have the diseases, including Bali [9, 10].

In tropical area where the relatively high temperature and humidity are taking part in local condition, along with other determinants may also be involved in the variation and number of the mosquito existence. Rice paddy fields and animal farms are two landscape factors that reported to take apart in the variation and density of the mosquito [11]. In Bali, these two factors are available as the local Balinese are still actively involved in agricultural and livestock activities due to their socio-cultural background [12] and a main source of local income [13]. However, limited information available in the variation of the genera and number of the mosquito in the area.

Studies on mosquitoes in Bali is also limited even though some mosquito borne diseases have been identified in this area.

However, the limitation of mosquito related studies may affect the limit knowledge of the understanding on how the disease can be happened, especially in the transmission cycle that involves mosquito as a vector. Therefore, a survey on the mosquito identification was conducted to assess the genera and density in the area where the mosquito borne viral diseases are happening in the area of Bali, Indonesia.

2. Materials and Methods

2.1 Study area

The sampling areas used in this study were Tabanan and Badung regencies as they have large areas of rice paddy fields as well as the animal farms. The animal farms used in this study were cattle and pig farms in both sampling location. The study was conducted from April to June 2021. This study only collected mosquitoes and therefore, no human or animal ethics was required.

2.1 Mosquito trap and identification

A total of eight un-baited light traps were set in paddy fields and animal farms in the regencies. The traps were installed at around 6 pm in the evening until at 6 am on the next day morning. The collection was performed once a week allowing the larva of the mosquito developed. The survey was conducted in 12 weeks. Due to their role as the vector on mosquito borne diseases, only the female adult mosquitoes trapped were collected and counted in this study. The mosquitoes trapped were stored in a freezer at -20^{0}C until the mosquito collection was finished to be performed before they were then identified for their genera and counted them for their quantity.

Identification of the trapped mosquitoes was morphologically adapted by using a pictorial identification key of important disease vectors in Southeast Asia region [14]. The identification of the collected mosquito genera was conducted by using a light microscope.

2.3 Analysis data

All of the collected mosquitoes were counted and the number of them in each genus was compared based on the study site collection in rice paddy fields and animal farms and the area regency collection. T test was performed to assess the significant different number of the mosquito collected from paddy fields and animal farms in Badung and Tabanan regencies using a significance of P value < 0.05 and 95% confidence interval (CI).

3. Results

Four genera mosquitoes found in both the rice paddy fields and animal farms from the areas of Badung and Tabanan regencies with the total number of the female adult mosquito collected were 6694. The mosquito genera were *Culex* spp., *Anopheles* spp., *Aedes* spp., and *Armigeres* spp. The *Culex* spp. was the highest number of the mosquito collected with total of 2899 mosquitoes found. Meanwhile, the total of the *Anopheles* spp. and *Aedes* spp., were 1954 and 1229 respectively. However, the *Armigeres* spp. was the genus of the mosquito trapped that had the lowest number with a total of 612 mosquitoes collected along the study period.

The number of mosquito collected from Tabanan was almost double with a total number of 4084 mosquitoes collected for all of the four mosquito genera in comparison with 2610 mosquito's trapped collection in Badung. Meanwhile, the total mosquitoes that collected from the animal farms were slightly higher with 3478 compared to the 3216 mosquitoes collected from the area of rice paddy fields for the three months period collection (Table 1).

Table 1: Quantity mosquito genera of *Culex* spp., *Anopheles* spp., *Aedes* spp., *Armigeres* spp. collected from rice paddy fields and animal farms in Badung and Tabanan regencies.

Mosquito genera	Badung		Tabanan	
	Rice paddy fields	**Animal farms**	**Rice paddy fields**	**Animal farms**
Culex spp.	604	613	757	925
Anopheles spp.	397	363	526	668
Aedes spp.	262	191	326	450
Armigeres spp.	133	47	211	221
Total	1396	1214	1820	2264

The number of weekly mosquito trapped in Badung ranged from a minimum of 81 and to a maximum of 163 with erratic trends observed in the mosquitoes collected in both areas of rice paddy fields and animal farms in the regency. More number mosquitoes collected from the areas of rice paddy fields compared to the trapped mosquitoes collected from animal farms in Badung regency although slightly more mosquitoes collected from the animal farms found in week 9 to week 11 (Figure 1).

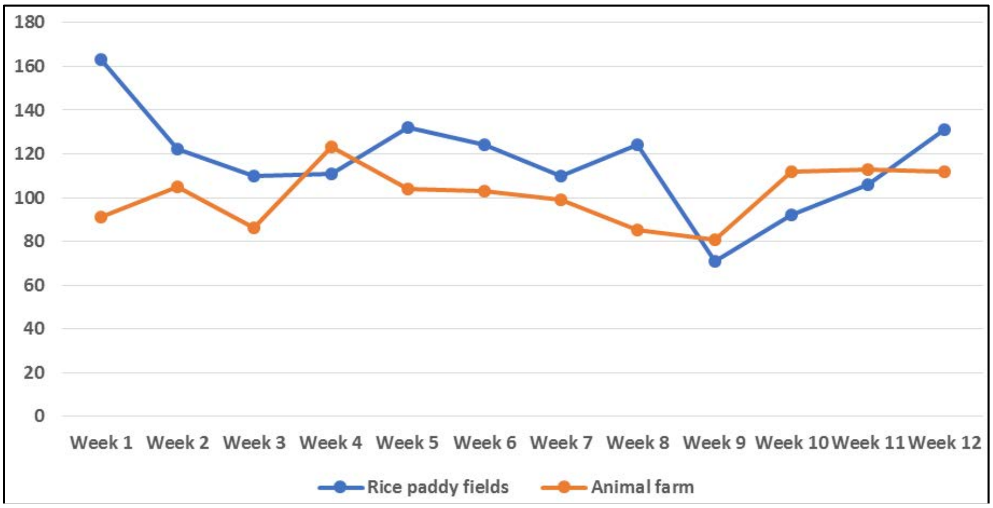

Fig 1: Weekly number of the mosquito collected from paddy fields and animal farms in Badung regency for twelve weeks of collection.

Meanwhile, in weekly based collection, the range of the mosquitoes trapped in Tabanan regency was a minimum of 141 to a maximum of 261. From week one to week eight, more mosquitoes were trapped from animal farms compared to the mosquito collected from rice paddy fields. However, in the last four weeks period of the survey collection, the number of mosquitoes trapped were almost the same (Figure 2).

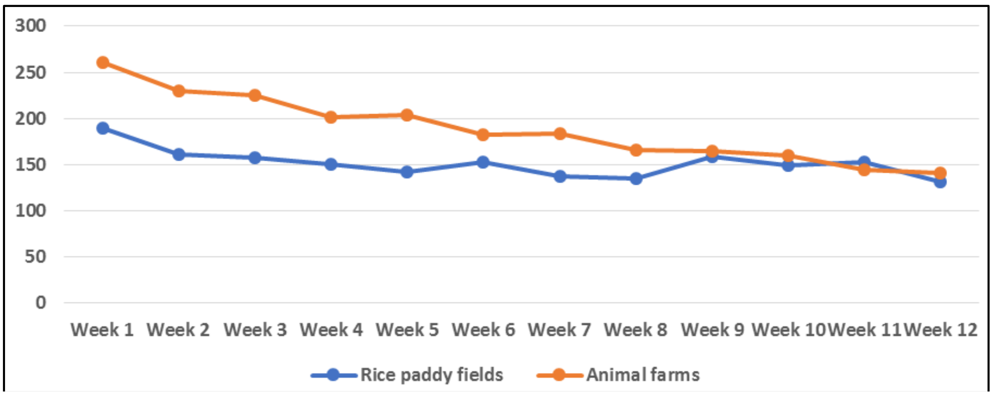

Fig 2. Weekly number of the mosquito collected from rice paddy fields and animal farms in Tabanan regency for twelve weeks period of collection.

No significant different ($p > 0.05$) found in comparison number of *Culex* spp. mosquitoes collected in paddy fields and animal farms in Badung regency. However, the number of *Anopheles* spp., *Aedes* spp., and *Armigeres* spp. that collected from paddy fields in Badung regency were significantly higher ($p < 0.05$) compared to the number of the same mosquito genera that collected from animal farms in the regency (Table 2).

Table 2: Statistical different number of each mosquito genus collected from paddy fields and animal farms in Badung regency.

Badung	Paddy fields		Animal farms		p value	95% CI	
	Mean	SD	Mean	SD		Lower	Upper
Culex spp.	50.33	11.45	51.08	5.53	$p > 0.05$	-1.76	0.26
Anopheles spp.	33.08	8.17	30.25	5.46	$p < 0.05$*	1.85	3.81
Aedes spp.	21.83	7.44	15.92	3.92	$p < 0.05$*	4.85	6.97
Armigeres spp.	11.08	3.08	3.92	2.81	$p < 0.05$*	6.89	8.13

*significant difference, SD = standard deviation, CI = confidence interval.

The number of mosquito genera of *Culex* spp., *Anopheles spp*., and *Aedes* spp. that collected from animal farms in Tabanan regency were significantly higher ($p < 0.05$) compared to the number of the same mosquito genera collected from paddy fields in the regency. The *Armigeres* spp. mosquitoes however, had no significant difference ($p > 0.05$) in the number of the mosquitoes collected from paddy fields and animal farms in the regency (Table 3).

Table 3: Statistical different number of each mosquito genus collected from paddy fields and animal farms in Tabanan regency.

Tabanan	**Paddy fields**		**Animal farms**		**p value**	**95% CI**	
	Mean	**SD**	**Mean**	**SD**		**Lower**	**Upper**
Culex spp.	63.08	8.67	77.08	11.14	$p < 0.05$*	13.05	14.95
Anopheles spp.	43.83	6.13	55.67	17.22	$p < 0.05$*	10.43	13.25
Aedes spp.	27.17	3.51	37.50	10.33	$p < 0.05$*	9.30	11.36
Armigeres spp.	17.58	3.65	18.42	3.32	$p > 0.05$	0.18	1.50

*significant difference, SD = standard deviation, CI = confidence interval.

4. Discussion

The four genera found in this study are the mosquitoes that commonly found in tropical area, including Indonesia. With the environmental temperature ranging from 22^0C – 27^0C, it is a potential condition for the mosquito to breed, lay their egg, and develop in the area [15]. Additionally, wide distribution of irrigated rice paddy fields are attracted by the mosquitoes to breed. Similarly, the availability of animals in farms to be fed their blood on by mosquitoes is the supportive situation that benefit the mosquitoes, including their role in spreading the pathogens to other susceptible hosts [16].

Culex spp. is a mosquito genus that relatively abundant in Bali. This mosquito is well-known to be a mosquito borne disease of Japanese encephalitis, especially *Cx. tritaeniorhynchus* that is the primary vector of the Japanese encephalitis virus (JEV) infection [6, 17]. It is also suspected being involved in the high seroprevalence to JEV infection in the humans and livestock of Bali [6, 12, 18]. *Culex* spp. is a nocturnal mosquito that tend to be more active at night, especially during the dusk and dawn [19].

This mosquito is also distributed in wide range areas, from rural to urban area. *Cx. tritaennirhynchus* and *Cx. bitaeniorhynchus* are more likely found in rural areas [20], whereas *Cx. quinquefasciatus* tends to be abundant in urban area [21]. Those mosquitoes were suspected to be the JEV vectors for the high seroprevalence in chickens at 97.10% (n=70, 95% CI: 90.88–99.52) and 93.05% (n=72, 95% CI: 85.28–97.41) in urban and rural areas in Bali respectively [18]. However, in peri-urban area, each of them is seemed not to be significantly different found in their total number. Peri-urban area is the area between urban and rural areas that has an increased trend for more community to reside in and performing agricultural practices to facilitate the demand for the residents in urban area [22]. In Bali, this situation may affect the risk for the residents to be contacted with the mosquitoes found, in which some of their species are potential to be the vectors of viral diseases [12].

The abundance of the *Culex* spp. mosquitoes may be related not only to the wide range of their breeding sites, such as irrigated rice paddy fields and polluted water in drainages or ditches, the mosquitoes are also attracted by the feeding sites, especially the female ones that need animals' or mammals' blood to be feed on. Therefore, these mosquitoes are reported tend to be found in animal farms [23, 24]. This situation also needs to be more concerned in regards to their potential vectors for the zoonotic borne diseases.

Other than *Culex* spp., rice paddy field is also attracted by the mosquito genus of *Armigeres* spp. to breed. The rice paddy fields in Bali tend to be planted in higher altitude where lower temperature and humidity are found for more optimal results of the paddy achieved although the conditions are likely attracted by the mosquito [25]. Additionally, this mosquito is also known to be found in the area with relatively many plans or bushes around. A study reported that *Armigeres* spp. tend to be found in water accumulation in bamboos' plantations or other vegetations that have a lot of leaf litters and rotten tree's branches [26]. Even so, both of the genera contribute to the mosquito borne diseases of Japanese encephalitis and filariasis. The species of *Ar. sulbalbatus* is reported to be the vector of zoonotic filarial infections [27]. Even, this infection is prevalent in Indonesia making this country is one out of four countries, such as India, Bangladesh, and Nigeria that categorised to have the high cases of lymphatic filariasis in the world [28].

Anopheles spp. was also found abundance in this study both in rice paddy fields and in animal farms. This finding suggests the risk of the mosquito borne diseases that facilitated by this mosquito seems not to be negligible. The *Anopheles* spp. mosquito is known to be the vector of malaria. This disease can be found in some areas of Indonesia although no case of it has been reported to occur in Bali recently. However, further studies are needed to identify the species of the *Anopheles* spp. to ensure that no species of the mosquito found in this area that is potentially being the vector of the infectious diseases, especially from pathogens that can transmit and have negative impacts on animals or humans [29]. A predictor of malaria was identified in the residents whose houses had middle size animals were 2.8 more likely to be infected with malaria compared to the residents who did not have the animals around their houses (Odd ratio 2.8, 95% CI: 2.207 - 3.575, $p< 0.001$) [30].

Aedes spp. is also another genus mosquito found in this study. Even though the mosquitoes are known to be diurnal or more active at day time [31], they can also bite the mammals' blood at night. The findings of *Aedes* spp. at night suggested that the mosquito is also nocturnal [32]. It may be related to the electrical lights on at night. In relation to be the mosquito borne diseases, this means they have longer chance to spread the pathogens into other susceptible hosts. *Aedes* spp., especially *Ae. aegypti* and *Ae. albopictus* are the vectors of the serious emerging mosquito borne diseases of Zika, dengue, chikungunya, yellow fever, and Rift Valley fever [33].

The density or variety of the mosquitoes may be also depending on the hosts availability. In the situation where mammals are around, the mosquitoes tend to be abundance. Some substances detected from humans' bodies may bring the mosquitoes to be contacted to them. The carbon dioxide (CO2) [34] and body or skin odor [35] and or sweat [36] can also be attracted by the mosquitoes.

In addition, the season can also alter the density of the mosquito. More number of mosquito can be found in wet or rainy season compared to the dry season [37]. This may be related to more availability of stagnant water on the ground. In consequence, more mosquito breeding places provided. This similar to a study that reported climate or weather is an important factor that can alter the mosquito population [38].

The close proximity of the rice paddy fields and pig farms with the local residents makes they tend to be close contacted by the mosquitoes. In consequence, those residents are also in high risk being exposed and transmitted by mosquito borne viral diseases like dengue and or Japanese encephalitis that are endemic in the study areas [39]. This results can also be an indication of some mosquitoes found that may be involved in the potential vector of other mosquito borne diseases. Alternatively, these results can be used as a reference of the diseases' risks in the study areas. Therefore, this study suggests to conduct next related studies in regard to confirm the pathogens that may be brought by the trapped mosquitoes by performing related diagnostic laboratories.

Mosquito traps used in this study were not completed with baited mosquito trap which might affect less number mosquitoes trapped. Consequently, this technique might influence the study results as well. Other related research tended to use CO_2 as the bait. the CO_2 is a compound that can be added to the trap to attract the mosquito and lead to more number of them might be trapped. However, the ultraviolet lamp installed in the light trap can also attract more mosquito to be trapped in it at night. This lights were always turned on while the traps were set from dusk until dawn on the next day of each week collection.

No mosquito trap was set at day time in this study as most of the mosquitoes are likely more active at night, especially in dusk, at night, and in dawn. Even though it would be more challenging to perform, next studies also suggest to trap mosquitoes at day time. These results may support more comprehensive data on the mosquito existence and may also predict the pattern of mosquito borne diseases in the area so that the impact of the diseases in humans as well as livestock can be minimized. In addition, this study results also suggest to identify the species mosquito in order to assess more potential specific vector that may contribute to the mosquito borne diseases occurred in the study areas or in the province of Bali in more general.

5. Conclusion

Aedes spp., *Anopheles* spp., *Armigeres* spp., and *Culex* spp. were the female mosquito genera collected and identified from rice paddy fields and animal farms in Badung and Tabanan regencies of the Bali Province. In addition, higher number of mosquitoes *Anopheles* spp., *Aedes* spp., and *Armigeres* spp. collected from paddy fields found in comparison with the number of the mosquitoes collected from animal farms in Badung regency. However in Tabanan regency, more number of mosquitoes *Culex* spp., *Anopheles* spp., and *Aedes* spp. collected from animal farms found compared to the mosquitoes collected from paddy fields.

6. Acknowledgement

This research was conducted in regard to public service on awareness of mosquito borne diseases to local community, especially the farmers around the study areas performed by staff of Department Biopathology, Faculty of Veterinary Medicine, Udayana University, Bali, Indonesia. The fieldwork, data analysis, and drafting of this manuscript were conducted by all of the authors in the same portion. The authors thank to local related authorized government in Badung and Tabanan regencies in the Province of Bali, the farmers who allowed their rice paddy fields and animal farms to be used in this study.

7. References

1. Weissenböck H, *et al*. *Zoonotic mosquito-borne flaviviruses:* worldwide presence of agents with proven pathogenicity and potential candidates of future emerging diseases. Veterinary microbiology. 2010;140(3-4):271-280.
2. Sanghi D, *et al*. Outbreaks in India: Impact on Socio-economy and Health. Journal of Communicable Diseases (E-ISSN: 2581-351X & P-ISSN: 0019-5138). 2021;53(1):35-44.
3. Auerswald H, *et al*. Serological evidence for Japanese encephalitis and West Nile virus infections in domestic birds in Cambodia. Frontiers in veterinary science. 2020;7:15.
4. Dhewantara PW, *et al*. Spatial and temporal variation of dengue incidence in the island of Bali, Indonesia: An ecological study. Travel medicine and infectious disease. 2019;32:101437.
5. Im J, *et al*. Protecting children against Japanese encephalitis in Bali, Indonesia. The Lancet. 2018;391(10139):2500-2501.
6. Kardena IM, Adi AAAM, Astawa NM. Comparison of a commercial and a manual antigen coated ELISA tests used in detecting antibodies against Japanese encephalitis virus in pig serums collected from the Province of Bali. International Journal of Veterinary Sciences and Animal Husbandry. 2021;6(4):34-39.
7. Sasmono RT, *et al*. Spatiotemporal Heterogeneity of Zika Virus Transmission in Indonesia: Serosurveillance Data from a Pediatric Population. The American Journal of Tropical Medicine and Hygiene. 2021;104(6):2220.
8. Kuwata R, *et al*. Mosquito-borne viruses, insect-specific flaviviruses (family Flaviviridae, genus Flavivirus), Banna virus (family Reoviridae, genus Seadornavirus), Bogor virus (unassigned member of family Permutotetraviridae), and alphamesoniviruses 2 and 3 (family Mesoniviridae, genus Alphamesonivirus) isolated from Indonesian mosquitoes. Journal of Veterinary Medical Science, 2020, 20-0261.
9. Leung G, *et al*. Zika virus infection in Australia following a monkey bite in Indonesia. Southeast Asian J Trop Med Public Health. 2015;46(3):460-4.
10. Yoshikawa MJ, Kusriastuti R, Surge of dengue virus infection and chikungunya Fever in bali in 2010: the burden of mosquito-borne infectious diseases in a tourist destination. Tropical medicine and health. 2013, 2011-05.
11. Le Flohic G, *et al*. Review of climate, landscape, and viral genetics as drivers of the Japanese encephalitis virus ecology. PLoS neglected tropical diseases. 2013;7(9).
12. Kardena IM, *et al*. Japanese encephalitis in Bali, Indonesia: ecological and socio-cultural perspectives. International Journal of Veterinary Science and Medicine. 2021;9(1):31-43.
13. Dane N. Analysis Of Economic, Social-Cultural Impacts, And The Environment Of Tourism Village Development In Ambengan Tourism Village, Buleleng. CULTOURE: Culture Tourism and Religion. 2020;1(1):73-82.
14. WHO. Pictorial identification key of important disease vectors in the WHO South-East Asia Region, 2020.
15. Kesetyaningsih TW, *et al*. Determination of environmental factors affecting dengue incidence in Sleman District, Yogyakarta, Indonesia. African Journal of Infectious Diseases. 2018;12(1S):13-25.
16. Damayanti PAA, *et al*. Incidence of Japanese Encephalitis Among Children is Associated with the Presence of Pigs in Bali, Indonesia. Biomedical and Pharmacology Journal. 2017;10(3).
17. Ambarawati IGAA, *et al*. Knowledge and Prevention of Farmer Household to the Japanese Encephalitis Infection in Badung Regency, Bali Province, Indonesia. Advance in Social Sciences Research Journal 2020;7(10):37-48.
18. Kardena IM, *et al*. Serosurveillance on Japanese encephalitis virus in chickens collected from two different geographycal areas in Bali, Indonesia. Bulgarian Journal of Veterinary Medicine, 2021. Online First Published.
19. Bashar K, *et al*. Host preference and nocturnal biting activity of mosquitoes collected in Dhaka, Bangladesh. 2020.
20. Di Francesco J, *et al*. Comparison of the dynamics of Japanese encephalitis virus circulation in sentinel pigs between a rural and a peri-urban setting in Cambodia. PLoS neglected tropical diseases. 2018;12(8).
21. Nguyen-Tien T, Lundkvist Å, Lindahl J. Urban transmission of mosquito-borne flaviviruses–a review of the risk for humans in Vietnam. Infection ecology & epidemiology. 2019;9(1):1660129.
22. Mwangangi JM, *et al*. Mosquito species abundance and diversity in Malindi, Kenya and their potential implication in pathogen transmission. Parasitology research. 2012;110(1):61-71.
23. Victor OA, *et al*. Influence of meteorological variables on diversity and abundance of mosquito vectors in two livestock farms in Ibadan, Nigeria: public health implications. Journal of mosquito research. 2017;7(9):70.
24. Hameed M, *et al*. A Metagenomic Analysis of Mosquito Virome Collected From Different Animal Farms at Yunnan–Myanmar Border of China. Frontiers in microbiology. 2021;11:3601.
25. Kirti JS, Kaur S. Prevalence and dıstrıbutıon of Armigeres subalbatus (Coquıllett) in Punjab. International Journal of Fauna and Biological Studies. 2015;2(3):44-47.
26. Faridah, L., R. Baizura, and S. Yusnita, *Mosquito survey in the campus area of Universitas Padjadjaran Jatinangor in September to November 2016*. GMHC, 2017. 5(3): p. 205-11.
27. Intarapuk A, Bhumiratana A. Investigation of Armigeres subalbatus, a vector of zoonotic Brugia pahangi filariasis in plantation areas in Suratthani, Southern Thailand. One Health. 2021;13:100261.
28. Ghosh SK, Ghosh C. Innovations in Vector-Borne Disease Control in India, in Public Health in Developing Countries-Challenges and Opportunities., Intech Open. 2020.
29. Asale A, *et al*. Zooprophylaxis as a control strategy for malaria caused by the vector Anopheles arabiensis (Diptera: Culicidae): a systematic review. Infectious diseases of poverty. 2017;6(1):1-14.
30. Hasyim H, *et al*. Does livestock protect from malaria or facilitate malaria prevalence? A cross-sectional study in endemic rural areas of Indonesia. Malaria journal. 2018;17(1):1-11.
31. Todorovic S, McKay T. Potential mosquito (Diptera: Culicidae) vectors of Dirofilaria immitis from residential entryways in Northeast Arkansas. Veterinary

parasitology. 2020;282:109105.
32. Kusariana N, *et al*. Nocturnal Activity of Aedes spp. in the Filariasis Endemic Area in Central Java. ASPIRATOR-Journal of Vector-borne Disease Studies. 2021;13(1):47-54.
33. Leta S, *et al*. Global risk mapping for major diseases transmitted by Aedes aegypti and Aedes albopictus. International Journal of Infectious Diseases. 2018;67:25-35.
34. Sukumaran D, *et al*. Application of biogenic carbon dioxide produced by yeast with different carbon sources for attraction of mosquitoes towards adult mosquito traps. Parasitology research. 2016;115(4):1453-1462.
35. Takken W, Verhulst NO, Chemical signaling in mosquito–host interactions: the role of human skin microbiota. Current opinion in insect science. 2017;20:68-74.
36. Wondwosen B, *et al*. Sweet attraction: sugarcane pollen-associated volatiles attract gravid Anopheles arabiensis. Malaria journal. 2018;17(1):1-9.
37. Rose NH, *et al*. Climate and urbanization drive mosquito preference for humans. Current Biology. 2020;30(18):3570-3579.e6.
38. Polgreen PM, Polgreen EL. Infectious diseases, weather, and climate. Clinical Infectious Diseases. 2018;66(6):815-817.
39. Ma'roef CN, *et al*. Japanese encephalitis virus infection in non-encephalitic acute febrile illness patients. PLoS neglected tropical diseases. 2020;14(7):e0008454.