*Research Article*

# Nocturnal Activity of *Aedes* spp. in the Filariasis Endemic Area in Central Java

## *Aktivitas Nokturnal* Aedes *spp. di Wilayah Endemis Filariasis di Jawa Tengah*

**Nissa Kusariana[1*], Praba Ginandjar[1], Vivi Septi Ariyani[1], Moh Arie Wurjanto[1]**

[1]Department of Epidemiology and Tropical Disease, Public Health Faculty, Universitas Diponegoro, Semarang City, 50275, Indonesia

**Citation:** Kusariana N, Ginanjar P, Ariyani VS, Wurjanto MA. Nocturnal Activity of *Aedes* spp. in the Filariasis Endemic Area in Central Java. ASP. Juni 2021:13(1): 47–54

Editor: Heni Prasetyowati
Recieved: 18 December 2020
Revised: 10 March 2021
Accepted: 09 June 2021

**Publisher's Note:** Aspirator stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.



**Abstrak.** *Program eliminasi filariasis belum menunjukkan hasil maksimal di Provinsi Jawa Tengah. Perubahan perilaku vektor nyamuk terutama waktu aktif menghisap darah sangat mempengaruhi penularan penyakit filariasis. Salah satu perubahan perilaku vektor tersebut adalah aktivitas nyamuk* Aedes *spp. yang aktif di pagi hari menjadi aktif di malam hari. Tujuan penelitian ini adalah untuk mendeskripsikan aktivitas nokturnal nyamuk* Aedes *spp. di daerah endemis filariasis di Jawa Tengah. Penelitian ini merupakan penelitian observasional dengan desain* cross-sectional *yang dilakukan di dua desa endemis filariasis yaitu Desa Tegal Dowo, Kecamatan Tirto, Kabupaten Pekalongan dan Desa Ujung-Ujung, Kecamatan Pabelan, Kabupaten Semarang. Penangkapan nyamuk dilakukan selama 2 malam di rumah penderita filariasis atau rumah di sekitar rumah kasus (Jarak ± 200 meter) dengan menggunakan teknik* purposive sampling. *Penangkapan nyamuk berlangsung pada pukul 18.00 - 24.00 WIB dengan jumlah penangkap nyamuk 3 orang di dalam dan 3 orang di luar rumah. Pengumpulan nyamuk dilakukan dengan metode* Human Landing Collection *(HLC) dan* resting collection. *Hasil penelitian menunjukkan peningkatan aktivitas nokturnal* Aedes aegypti *dan* Aedes albopictus *di daerah endemis filariasis di Jawa Tengah. Total nyamuk* Aedes *spp. yang ditemukan yaitu sebanyak 124 nyamuk, dengan 121* Ae. aegypti *ditemukan di dalam rumah dan 2 nyamuk diluar rumah. Di dua wilayah penelitian ditemukan waktu aktif* Ae. aegypti *berada pada pukul 18.00-19.00 WIB. Hasil penelitian ini menunjukkan adanya aktivitas nokturnal dari* Aedes *spp. di wilayah endemis Filariasis di Provinsi Jawa Tengah.*

**Kata Kunci:** *Aktivitas Nokturnal,* Aedes *spp., Filariasis, Jawa Tengah*

**Abstract.** The elimination filariasis program has not been successful in the province of Central Java. The Changes in mosquito vector behavior, especially their active time in blood feeding, greatly affect the transmission of filariasis. One of the behavioral changes is the shifting of mosquito activity from morning to night, such as the *Aedes* spp. This study aims to describe the nocturnal activity of the *Aedes* spp. mosquito in the filariasis endemic area in Central Java. This research is an observational study with a cross-sectional design, carried out in two endemic filariasis villages, Tegal Dowo Village, Tirto Sub-District, Pekalongan Regency and Ujung-Ujung Village, Pabelan District, Semarang Regency. Mosquito catching was conducted in 2 nights from 06.00 pm to 12.00 am, with three mosquito catchers inside and three outside of each patient's house that was positive for filariasis from 2018-2019 or the house around the Filariasis cases house (± 200 meters distance) using a purposive sampling technique. The mosquito collections were carried out using the Human Landing Collection (HLC) method and resting collection. The results showed the nocturnal activity of *Aedes aegypti* and *Aedes albopictus* in the Filariasis endemic area. A total of 124 mosquitoes with 121 *Ae. aegypti* were found at night inside the house and 2 in Tegal Dowo Village, while in Ujung-ujung Village there are only 2 *Ae. aegypti* were found outdoor at night. In the two research areas, it was found that the highest active time of *Ae. aegypti* mosquitoes were at 06.00-07.00 pm. Our study concludes that there is evidence of nocturnal activity of Aedes mosquitoes at night in filariasis endemic areas in Central Java.

**Keywords:** Nocturnal behaviour, *Aedes* spp, Filariasis, Central Java

*Corresponding Author.
Email: nissakusariana@gmail.com

## BACKGROUND

Filariasis is an infectious disease that still becoming a concern in Indonesia. The adverse impact of filariasis is causing lifelong disability in patients. In 2014, there were more than 14,000 chronic clinical cases of filariasis suffering elephantiasis across all provinces in Indonesia. In 2014, there were also 235 regencies/cities as endemic areas in Indonesia. In 2019 it was found that 236 districts/cities, and 118 regencies/cities had completed POPM filariasis and entered the post-POPM surveillance stage. Meanwhile, 118 other districts/cities will still implement POPM for filariasis and 38 districts/cities have been declared filariasis eliminated.[1,2] Filariasis was caused by filarial nematodes *Wuchereria bancrofti* (Wb), *Brugia malayi* (Bm), or *Brugia timori* (Bt). A filarial worm is transmitted by various mosquito species. Twenty-three mosquito species that had been confirmed as filariasis vectors in Indonesia, such as Anopheles, Culex, Mansonia, and Armigeres genus.[1,3] Based on the type of vector, filariasis is divided into rural and urban types. The urban filariasis vector is *Culex quinquefasciatus* mosquito, while the rural includes Anopheles, Culex, and Aedes mosquitoes.[4]

In Central Java, there were 439 chronic cases of filariasis in 2018 and it was ranked 6$^{th}$ as the province with the highest number of filariasis cases in Indonesia.[1] Efforts to eliminate filariasis are in line with the strategy formulated by the World Health Organization, which is based on large-scale treatment activities to suppress the spread of the disease and reduce the disability impact caused by filariasis. Weak monitoring of filariasis in the breeding environment of mosquitoes, and the low quality of community hygiene that supports the increase of breeding sites, will have an impact on the increase in the spread of filariasis in this area. If the area has a favorable environment and climate for vector reproduction, filariasis seems most likely to occur.[5,6]

After mass drug administration (MDA), the global Filariasis Lymphatic control plan initiated by the WHO also used heterogeneous surveillance to investigate mosquitoes. A biomolecular examination is performed to determine whether the mosquitoes still contain the microfilaria parasite. However, the Minister of Health Republic Indonesia Regulation No. 94, 2014 does not provide a foundation for heterogeneous monitoring activities through laboratory inspections. The results of the study in Pekalongan Regency stated that vector control is an important element and should run simultaneously with MDA. Surveillance is not only carried out in humans but also comprehensively carried out against vectors. After MDA, a heterogeneous surveillance laboratory study must be conducted to detect elephantiasis based on microscopic images.[3]

Although many efforts to eliminate filariasis have been carried out, several areas are still filariasis endemic areas. Data in 2018 shows that out of nine districts/cities for endemic filariasis in Central Java, no region has succeeded in reducing the number of microfilaria rate to <1% and there are also five districts/cities that are still implementing POPM filariasis in 2018.[1,3] This showed that the elimination filariasis program has not been successful in the province of Central Java.

There are filariasis endemic areas in Central Java, Pekalongan Regency, and Semarang Regency. One of the elimination filariasis programs is mosquito vector control in the Endemic areas. In Central Java Province, there are nine places/cities where filariasis is endemic, Pekalongan City, Pekalongan Regency, Brebes, Wonosobo, Semarang, Grobogan, Blora, Pati, and Demak. A cumulative number of filariasis (chronic) cases in Central Java is 501, distributed in 34 regions/cities. Only Magelang has never reported cases of chronic filariasis. Cases of chronic filariasis are found every year. There were 34 newly discovered cases of filariasis in 2016, of which Demak accounted

for 10 cases, followed by Semarang City with 5 cases, Boyolali with 4 cases, Purbalingga with 2 cases, Semarang with 2 cases, and Pakalongan 2 cases. Brebes has 2 cases, the other one happened in Banjarnegara, Sukoharjo, Wonogiri, Grobogan, Blora, Batang, and Tegal.[7] According to the data there are 9 LF endemic areas/cities among 35 regency/cities in Central Java. Wonosobo Regency, Semarang Regency, Grobogen Regency, Blora Regency, Pati Regency, and Demak Regency.[3]

The Ministry of Health has declared the Semarang Regency as an endemic area for filariasis. In 2014, there were 6 cases of filariasis in Semarang, all of which were old cases. In the past two years, there were no other cases. The incidence of filariasis in 2014 was 0.61 per 100,000 population. From 2016 to the present, there has been an increase in filariasis cases, which were nine cases, including 6 old cases and 3 new cases, distributed in 7 districts in Pabelan, Ambarawa, Suruh, Banyubiru, Bandungan, Kaliwungu and Bringin. From 2016 to January 2019, the incidence of filariasis did not decrease.[8,9]

Filariasis transmission was caused by the similarity between the active time of the vector and the periodicity of microfilaria worms. *Wuchereria bancrofti, Brugia timori*, and *Brugia Malayi,* have different periodicity. The periodicity of microfilariae and the active time of mosquitoes's blood feeding correlate with the spread and transmission of filariasis. A study in Jambi shows that *Brugia malayi* have day and night periodicity (periodicity of microfilariae in the blood). The circadian cycle of microfilaria is closely related to the activity of the host. Changes in host activity also affect the circadian cycle and periodicity.[1,10–12]

Parasite transmission does not only depend on vector survival but also on the ability of the vector to find a host and blood-feeding activity. Infection from microfilariae can affect the behavior and fecundity of the *Aedes aegypti*.[13] *Aedes aegypti* is known to carry the microfilaria *Brugia malayi*. Species of *Aedes* spp. especially *Aedes aegypti* is also known to have the competence as a vector of filarial worms based on laboratory test, this species is capable of carrying agents (microfilaria) up to the infective stage (L3) and transmits microfilaria to the host (humans).[14–16]

The changes in mosquito vector behavior, especially their active time in sucking blood, greatly affect the transmission of filariasis. One of the behavioral changes was the shifting of mosquito activity from morning to night, such as the *Aedes* spp. Several studies showed changes in the activity of the *Aedes* spp. mosquito as a vector of dengue fever in Indonesia[1,4,12], but there are not many studies related to changes in the behavior of the *Aedes* spp. as a vector of filariasis. Study about mosquito vectors in filariasis endemic areas is very important, especially to find out about the spread of mosquitoes and population dynamics so that the risk of transmission can be identified to be used for effective and efficient vector control program. Based on the facts above, this study aims to describe the nocturnal activity of the *Aedes* spp. mosquito in the filariasis endemic area in Central Java.

## METHODS

This research is an observational study with a cross-sectional design, carried out in two endemic filariasis villages, Tegal Dowo Village, Tirto Sub-District, Pekalongan Regency and Ujung-Ujung Village, Pabelan Sub-District, Semarang Regency from April to September 2019. The research has received ethical clearance from the Health Research Ethics Commission of the Faculty of Public Health, Diponegoro University number 266 / EA / KEPK-FKM / 2019. The population was all types of mosquitoes in the research location, while the samples were *Aedes* spp. caught when the research was

carried out. Mosquito collected for 2 nights at 06.00 pm to 12.00 am, with three mosquito collectors inside and three outside of each patient's house that was positive for filariasis from 2018-2019 or the house around the patient's house (± 200 meters distance) using purposive sampling technique. The mosquito collections were carried out using the Human Landing Collection (HLC) method and resting collection. Each hour of collection consists of 50 minutes of HLC, 10 minutes were used to catch mosquitoes resting on the walls and surroundings. The mosquitoes that were caught were put in paper cups and divided by the hour.[17,18] The mosquitoes that were caught were identified using the identification key for larvae and *Aedes* spp. (Ministry of Health Republic of Indonesia in 2013) and dissecting microscope to determine the species of mosquitoes.[19] Results of mosquito collection are written in the form of types, number ,and time of capture and it is recorded in table form.

## RESULT

The results showed the nocturnal activity of *Ae. aegypti* and *Ae. albopictus* in the Filariasis endemic area. 124 *Aedes* spp. were found. at night in both study sites. A total of 91 mosquitoes were found indoors through the HLC method, 31 resting mosquitoes were found indoors and 2 resting mosquitoes were found outdoor.

Most of the mosquitoes collected are *Ae. aegypti*. The number of mosquitoes found in Tegal Village is more than in Ujung-Ujung Village. In Tegal Dowo Village, 117 *Ae. aegypti* and 1 *Ae. albopictus* were found, both species of mosquitoes are found indoors. Whereas in Ujung-ujung Village only *Ae. aegypti* were found. Four *Ae. aegypti* were found indoor and 2 mosquitoes found outdoor (see Table 1).

In those two research areas, it was found that the highest active time of *Ae. aegypti* was at 06.00-07.00 pm which was shown by 34 mosquitoes in Tegal Dowo Village (see Figure 1) and four in Ujung-ujung Village (see Figure 2). *Aedes albopictus* was only found in Tegal Dowo Village, Pekalongan Regency from 08.00-09.00 pm in the house (see Table 1).

Tabel 1. Number of *Aedes aegypti* and *Aedes albopictus* by Period of Collection in Tegal Dowo Village, Pekalongan Regency and Ujung-ujung Village, Semarang Regency

| Location | Time | Number of *Ae. aegypti* | | | | Number of *Ae. albopictus* | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| | | HLC | | Resting | | HLC | | Resting | | |
| | | In | Out | In | Out | In | Out | In | Out | |
| Tegal Dowo Village, Tirto Sub-District, Pekalongan Regency | 18.00–19.00 | 22 | 0 | 14 | 0 | 0 | 0 | 0 | 0 | 36 |
| | 19.00–20.00 | 20 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 28 |
| | 20.00–21.00 | 20 | 0 | 9 | 0 | 1 | 0 | 0 | 0 | 30 |
| | 21.00–22.00 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 |
| | 22.00–23.00 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 |
| | 23.00–24.00 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 |
| Ujung-ujung Village, Pabelan District, Semarang Regency | 18.00–19.00 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
| | 19.00–20.00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 20.00–21.00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 21.00–22.00 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 2 |
| | 22.00–23.00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 23.00–24.00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | | 90 | 0 | 31 | 2 | 1 | 0 | 0 | 0 | 124 |

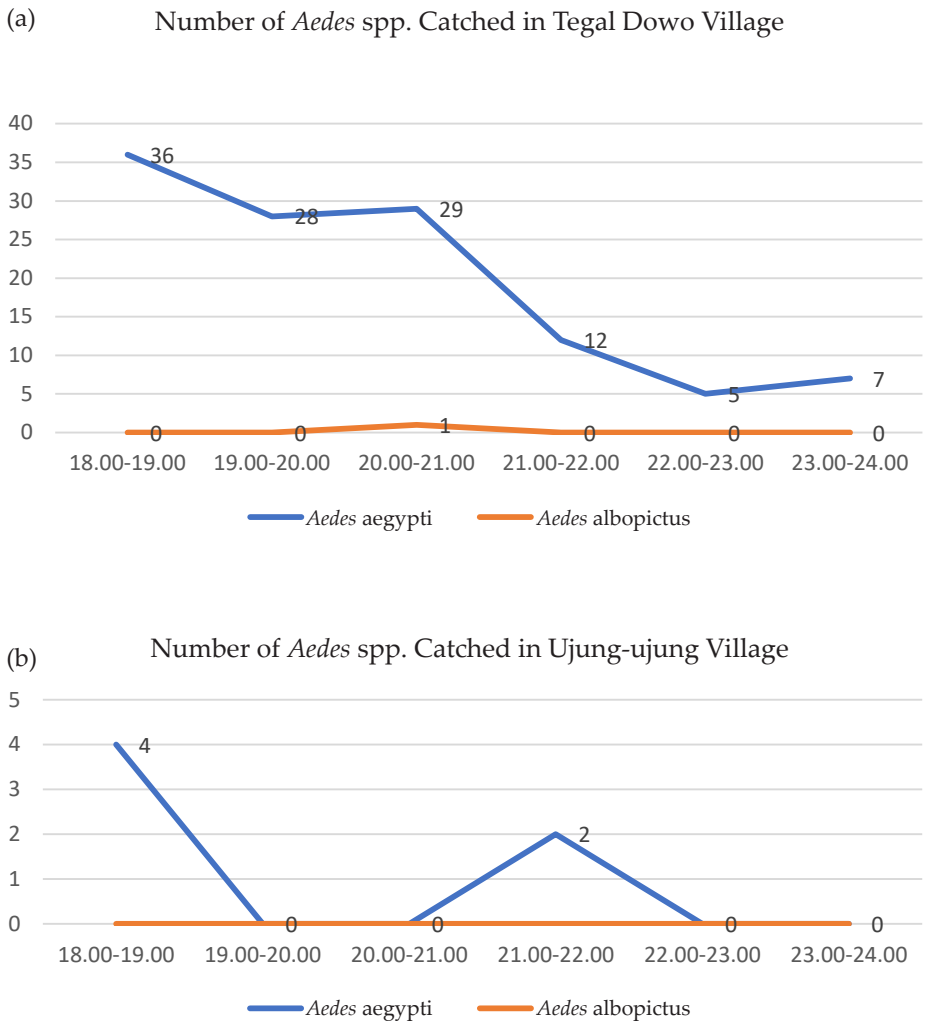


Figure 1. Number of *Aedes* spp. and periodicity in a) Tegal Dowo Village and b) Ujung-ujung Village

## DISCUSSION

The transmission of filariasis in an area is related to the presence of agents and also the presence of potential vector mosquitoes in the region. The results of this study indicate increased activity in *Ae. aegypti* and *Ae. albopictus* mosquito at night (nocturnal). The active behavior of *Ae. aegypti* and *Ae. albopictus* mosquitoes at night are also found in various endemic filariasis areas in Indonesia such as in Panumbangan village, Ciamis district, Jalaksana village, Kuningan regency, Batukuwung village, Serang regency, and also in Banyuasin regency.[20–22]

Epidemiologically, filariasis can be influenced by several complex factors: the presence of filarial worms as disease agents, the presence of mosquitoes as vectors, humans as hosts as well as physical, biological, and socio-economic factors. In this study, it was found that most of the mosquitoes were found indoors (inside the house) and *Ae. aegypti* was the largest population. *Ae. aegypti* is known to have a high vector capacity because of its anthropophilic nature, well domestication, and high adaptability to survive in various geographic areas including Africa, America, Asia, and Europe. Generally, *Ae. aegypti* prefer to bite mammals and humans for blood-feeding activity

(anthropophilic). This behavior can make *Ae. aegypti* as an efficient vector. The active time of mosquitoes for blood-feeding greatly affects the transmission of filariasis. The research on filariasis in Bogor Regency is thought to be caused because vector behavior in parts of the Bogor area are anthropophilic, endophagic, biting humans indoors at night. The spread of filariasis in the Bogor area is greater in rural areas.[23] Therefore, *Ae. aegypti* has the potential to transmit filariasis in Pekalongan Regency and Semarang Regency.

Mosquito biting activity patterns vary widely. This pattern is caused because the level of adaptation of each mosquito species is different in every different environment.[24] The behavior of mosquitoes in finding hosts at night (nocturnal) is associated with increased light intensity, especially in *Ae. albopictus* which is sensitive to dim light.[14,25] The activity to finding the host will stop completely in total darkness, besides that, the flight behavior of mosquitoes is influenced by the circadian rhythm in the mosquito's body. The presence of light may have a direct influence in determining the amount of mosquito activity at night and also an indirect effect through the regulatory phase of endogenous rhythms in the mosquito's body. The nocturnal activity of the *Aedes* spp. rather caused by the intrinsic reaction of mosquitoes to light, so this behavior can increase disease transmission both in urban and rural areas.[14,26,27]

This study found that the highest density of *Ae. aegypti* in both study areas was found at 06.00-07.00 pm. This result is also similar to the research conducted in Samborejo Village, Tirto Sub-District, Pekalongan Regency.[28] *Aedes aegypti* and *Ae. albopictus* are diurnal mosquito species that actively blood-feed during the day, at 08.00-09.00 am and 04.00-05.00 pm. The transmission of filariasis to humans is influenced by the relationship between the vector and the microfilaria worms which it's transmitting. Based on the behavior of microfilariae, lymphatic filarial can be divided into various intra-specific variants: periodic nocturnal, subperiodic noctural, subperiodic diurnal, and non-periodic. In nocturnal microfilariae, the stage of microfilariae is found in peripheral blood, especially at night and peaks at 10.00 pm–01.00 am, while microfilariae, which are subperiodic nocturnal, are in the peripheral blood for 24 hours but peak at 18.00-22.00 pm. Microfilariae which are non-periodic can be found in the peripheral blood all the time and there is no peak density.[4] Some molecular studies show that *Ae. aegypti* and *B. malayi* are used as vector and parasite relationship models due to the adaptability of *Ae. aegypti* and its easy maintenance in the laboratory.[29] The estimation of vector capacity is influenced by the relationship between the vector and the pathogen that will be transmitted. There is a correlation between the behavior of filarial worms which are nocturnal and subperiodic diurnal, and increased nocturnal activity in the *Aedes* spp. *Aedes aegypti* and *Ae. albopictus* can increase the potential of filariasis transmission in Pekalongan and Semarang regency. The findings of this *Aedes* spp. nocturnal activity need further research, especially the one that related to the examination of filariasis agents in mosquitoes, therefore, it can strengthen knowledge about the role of *Aedes* spp. as a vector for filariasis.

## CONCLUSION

This study showed the nocturnal activity of the *Aedes aegypti* and *Aedes albopictus*, in the Filariasis Endemic area in Central Java, with peak blood-feed activity at 06.00-07.00 pm. The results of this study indicate increased activity in *Ae. aegypti* and *Ae. albopictus* mosquito at night (nocturnal behaviour).

## ACKNOWLEDGMENTS

Our sincere gratitude for the Faculty of Public Health, Diponegoro University, who funded this research through "Lecturer Research Grant (Non-APBN)", Local Government and Tegal dowo village community, Pekalongan Regency and Ujung-ujung villages, Semarang Regency.

## AUTHORS CONTRIBUTIONS

The role of the author's contributors in writing this article, namely Nissa Kusariana as main contributors, while Praba Ginandjar, Vivi Septi Ariyani, and Moh Arie Wurjanto as member contributors. The role details of the authors are as follows.

| | | |
|---|---|---|
| Conceptualization; Project Administration; Validation; Writing - Original Draft Preparation: Writing - Review & Editing | : | NK, PG |
| Formal Analysis | : | PG |
| Investigation; Resource; Supervision | : | NK, PG, VSA, MAW |
| Methology | : | NK, PG, MAW |
| Visualization | : | NK, VSA |

## REFERENCES

1. Kemenkes RI. Infodatin: Pusat data dan informasi Kementrian Kesehatan RI, Situasi filariasis di Indonesia. 2019. p. 1–10.
2. Kementerian Kesehatan Republik Indonesia. Kaki gajah penyebab kecacatan [Internet]. Biro Komunikasi dan Pelayanan Masyarakat, Kementerian Kesehatan R. 2019. Available from: https://www.kemkes.go.id/article/view/19100700004/elephantiasis-causes-disability.html
3. Irawan AS, Boesri H, Nugroho SS. Program nasional untuk eliminasi filariasis limfatik: Studi kasus di Kabupaten Pekalongan, Jawa Tengah. Vektora J Vektor dan Reserv Penyakit. 2018;10(2):95–102.
4. Ramadhani T, Hadi UK, Soviana S, Irawati Z. Transmisi strain Wuchereria bancrofti periodik nokturnal oleh Culex quinquefasciatus di Kota Pekalongan. Acta Vet Indones. 2019;7(2):1–8.
5. Muhimmah I, Fata SN, Lusiyana N. Segmentasi Mikrofilaria untuk diagnosis penyakit kaki gajah berbasis citra mikroskopis. Teknoin. 2016;22(10):744–51.
6. Meliyanie G, Andiarsa D. Program eliminasi lymphatic filariasis di Indonesia. J Heal Epidemiol Commun Dis. 2019;3(2):63–70.
7. Dinas Kesehatan Provinsi Jawa Tengah. Profil Kesehatan Provinsi Jawa Tengah Tahun 2016. 2016.
8. Dinas Kesehatan Kabupaten Semarang. Profil Kesehatan Kabupaten Semarang Tahun 2016. Kabupaten Semarang; 2016.
9. Dinas Kesehatan Kabupaten Semarang. Profil Kesehatan Kabupaten Semarang Tahun 2018. Kabupaten Semarang; 2018.
10. Kemenkes RI. Info data dan informasi filariasis. 2016.
11. Supranelfy Y, Ritawati, Oktarina R. Periodisitas mikrofilaria Brugia malayi dalam darah di Kabupaten Muaro Jambi. Spirakel. 2019;11(1):17–23.
12. World Health Organization. Lymphatic filariasis [Internet]. 2020. Available from: https://www.who.int/lymphatic_filariasis/epidemiology/en/

13. Gleave K, Cook D, Taylor MJ, Reimer LJ. Filarial infection influences mosquito behaviour and fecundity. Sci Rep. 2016;6(October):1–8.
14. Marcondes CB. Arthropod Borne Diseases. Marcondes CB, editor. Brazil: Springer International Publishing; 2017. 23–28 p.
15. Pan J. Filariasis. Vol. 2, Radiology of Infectious Diseases. 2015. p. 307–14.
16. Cebri S. A Literature review of host feeding patterns of invasive aedes mosquitoes in Europe. Insects. 2020;11(12):1–16.
17. Juhairiyah J, Hidayat S, Hairani B, Fakhrizal D, Setyaningtyas DE. Keanekaragaman jenis dan perilaku nyamuk pada daerah endemis filariasis di Kabupaten Barito Kuala, Provinsi Kalimantan Selatan. Balaba J Litbang Pengendali Penyakit Bersumber Binatang Banjarnegara. 2018;31–42.
18. Hadi UK, Soviana S, Gunandini DD. Nocturnal biting activity of dengue vectors in several areas of Indonesia. Indones J Entomol [Internet]. 2013;9(1):1–6. Available from: http://pei-pusat.org/jurnal/index.php/jei/article/view/73
19. Direktorat Jenderal Pengendalian Penyakit dan Penyehatan Lingkungan. Kunci Identifikasi Nyamuk Aedes. Jakarta: Kemenkes; 2013.
20. Astuti EP, Ipa M, Wahono T, Riandi U. Kepadatan nyamuk tersangka vektor Filariasis di Desa Panumbangan Kabupaten Ciamis, Desa Jalaksana Kabupaten Kuningan dan Desa Batukuwung Kabupaten Serang. J Ekol Kesehat. 2012;11(4):342–52.
21. Sitorus H, Budiyanto A, Ambarita LP, Hapsari N, Taviv Y. Keanekaragaman spesies nyamuk di wilayah endemis filariasis di Kabupaten Banyuasin dan endemis malaria di Oku Selatan. Balaba. 2015;11(Des 2015):97–104.
22. Ridha MR, Fadilly A, Rosvita NA. Aktivitas nokturnal Aedes (Stegomyia) aegypti dan Ae. (Stg) albopictus (Diptera : Culicidae) di berbagai daerah di Kalimantan. J Heal Epidemiol Commun Dis. 2017;3(2):50–5.
23. Nirwan M, Hadi UK, Soviana S, Setyaningsih S, Satrija F. Studi epidemiologi dan gambaran program eliminasi filariasis limfatik di Kabupaten Bogor. ASPIRATOR - J Vector-borne Dis Stud. 2020;12(2):93–104.
24. Chen CD, Wan-Norafikah O, Nurin-Zulkifli IM, Lee HL, Faezah K, Izzul AA, et al. Biting behaviour of medically important mosquitoes (Diptera: Culicidae) in Peninsular Malaysia. Trop Biomed. 2017;34(1):199–211.
25. Camargo C, Braimah YHA, Amaro IA, Harrington LC, Wolfner MF, Avila FW. Mating and blood - feeding induce transcriptome changes in the spermathecae of the yellow fever mosquito Aedes aegypti. Sci Rep [Internet]. 2020;1–13. Available from: https://doi.org/10.1038/s41598-020-71904-z
26. Muhammad NAF, Kassim NFA, Ab Majid AH, Rahman AA, Dieng H, Avicor SW. Biting rhythm and demographic attributes of Aedes albopictus (Skuse) females from different urbanized settings in Penang Island, Malaysia under uncontrolled laboratory conditions. PLoS One [Internet]. 2020;15(11 November):1–12. Available from: http://dx.doi.org/10.1371/journal.pone.0241688
27. Kawada H, Takemura SY, Arikawa K, Takagi M. Comparative study on nocturnal behavior of Aedes aegypti and Aedes albopictus. Vol. 42, Journal of Medical Entomology. 2005. 312–318 p.
28. Wibawaning Astuti RRUN, Mulyaningsih B, Nurcahyo RW, Soesilohadi RH, Hadisusanto S. Diversity, dominancy, and periodicity of mosquitoes in filariasis endemic areas in Samborejo Village Tirto District Pekalongan Regency. Indones J Trop Infect Dis. 2019;7(6):131.
29. Famakinde D. Mosquitoes and the lymphatic filarial parasites: Research trends and budding roadmaps to future disease eradication. Trop Med Infect Dis. 2018;3(1):4.