The existence and characteristics of rats and shrews in endemic leptospirosis areas and types of ectoparasites: a case study of West Jakarta, Indonesia [version 1; peer review: 2 approved, 1 not approved]

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Abstract

Background: This study aimed to determine the presence and species of the rats and shrews that can potentially cause leptospirosis in West Jakarta, Indonesia, and the species of ectoparasites found in them.

Methods: The research was a descriptive study employing a cross-sectional approach. The study population was all species of rats and shrews in the region and the sample collection technique used was purposive sampling. The traps were installed in the homes of respondents who had suffered from leptospirosis and their closest neighbors, with a total of 521 traps. Leptospirosis data based on secondary data was obtained from West Jakarta Health Office (2016-August 2019). The technique for catching rats involved using humane live traps, while the identification of the rats and ectoparasites was done in the laboratory.

Results: It was found that more rats were caught in Cengkareng Timur sub-district, Cengkareng District, with a percentage of 14.8%, while the least in Duri Kepa, Kapuk, Kedaung Kali Angke and Kedoya Utara with a percentage of 3.7%. The rats were mostly found in East Cengkareng Sub-District, with the most common type being Rattus rattus (74.1 %) and the least Suncus murinus (11.1%); more male rats were caught (66.7%) than female (33.3%). The type of ectoparasite found in the rats was fleas. Xenopsylla cheopis was the most common type, at 83.3% and more fleas were male, at 66.7%. The most common rat species was Rattus rattus. The ectoparasite most commonly found in them was the female flea Xenopsylla cheopis.

Conclusions: Rattus rattus and Xenopsylla cheopis were found in an East Cengkareng sub-district. Surveys, monitoring, and control of rats and ectoparasites are essential for the preparedness and development of an early warning system of possible diseases that they can cause.
Keywords
species, rats, ectoparasite, shrew

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Introduction
Rodents such as rats and shrews can carry various bacteria and viruses that can cause infections in humans. They are thought to be a reservoir of 30% of zoonotic pathogens, including several viruses, bacteria, and parasites. Rats are one of the most important components of an ecosystem. Their presence is very widespread, representing 40% of all mammal species (Churakov et al., 2010). They can be useful as food for some mammals and predatory birds (Tobin & Fall, n.d.), but their presence in the ecosystem can cause various losses in sectors such as agriculture and health (Tobin & Fall, n.d.). Rats are a reservoir of various diseases, and as animals that cannot be separated from human life, they can cause various health problems in humans and pets and other wildlife (Tobin & Fall, n.d.). They are also an important host for ectoparasites and have a close relationship, such as lice, fleas, and mites (Kiffler, Vor, Hagedorn, Niedrig, & Rühe, 2011). They can produce a variety of associations influenced by the host and parasite species and the biotic and abiotic environment (Buchholz & Dick, 2017). The rate of rat ectoparasite infestation can reach 66.6%, and ectoparasites are vectors for various diseases which can cause health problems (Zendehfili, Zahirnia, Maghsood, Khanjani, & Fallah, 2015).

Leptospirosis can cause death, with the case fatality rate in humans of 5-30% (CDC, 2018). It is a disease caused by Leptospira bacteria (World Health Organization, 2003). Leptospira interrogans and Leptospira borgpetersenni are present in many populations of rats and have been confirmed to cause leptospirosis in humans (Cosson et al., 2014). The disease can be transmitted through water or soil contaminated by the urine of rats infected with Leptospira bacteria and direct contact with infected animals (Centers for Disease Control and Prevention, 2018; Haddis, 2004; World Health Organization, 2003). Leptospira bacteria can enter the human body through mucous membranes, wounds, or blisters on the skin (Centers for Disease Control and Prevention, 2018; Haddis, 2004; World Health Organization, 2003). In several previous studies, it has been found that Rattus norvegicus is the rat species that is the main reservoir of Leptospira bacteria (Marcos Tucunduva de Faria et al., 2013; Pui, Bilung, Apun, & Su’ut, 2017).

Environmental conditions and their habitat greatly influence the presence of rats; each species has a different habitat. Mus musculus is a rat species that like to live in homes, outbuildings, and shops (Global Invasive Species Database, 2015). Rattus rattus is spread in forests and can also live in and around buildings, both underground and above ground (Csurhes, 2012). Rattus norvegicus is a species that is widespread in places such as sewers, agricultural and horticultural land, grasslands, and the interior part of the region (Hauser & de Roguin, 1995). The rat population will continue to increase to the level of capacity accommodated by their habitat (Jackson, 1972). Moreover, the rat population will also greatly depend on the availability of food and predators' presence in their habitat.

West Jakarta is one of the five administrative cities in the Special Capital Region of Jakarta, Indonesia; its center is in Kembangan. West Jakarta has an area of 129.54 km² and eight subdistricts, namely Taman Sari, Tambora, Kembangan, Kalideres, Cengkareng, Palmerah, Kebun Jeruk, and Groglot Petamburan Districts (Badan Pusat Statistik Administrasi Jakarta Barat, 2019). West Jakarta is one of the areas with 70 cases from January 2016 to August 2019 (Suku Dinas Kesehatan Jakarta Barat, 2019). The population density in West Jakarta in 2018 was 19,757 inhabitants/km², with an average population per household of four (Badan Pusat Statistik Administrasi Jakarta Barat, 2019). This means that West Jakarta is a densely populated area, one of the conditions that rats highly favor. This research aims to establish the presence and species of the rats and shrews that can potentially cause leptospirosis in West Jakarta and the species of ectoparasite found in them. The research could be used as the basis for an early alert system for various diseases that rats can carry, and also as a preliminary study to ascertain which rat species are the main reservoirs of leptospirosis in West Jakarta.

Methods
Study site
This research describes the presence and species of the rats and shrews in an endemic leptospirosis area in West Jakarta, employing a cross-sectional approach. The study population comprised all species of rats and shrews in the region. The research was conducted in December 2019 and consisted of all people diagnosed with leptospirosis, which referred to the doctor’s diagnosis results through clinical reports and laboratory tests that were reported and recorded in the West’s work area Jakarta Health Office from January 2016 to August 2019. The sample collection technique used was purposive sampling, involving the installation of rat traps at the homes of participants who had suffered from leptospirosis and their closest neighbors.

Rat catching
The rodents were caught using a live trap. This live trap has no brand made from wire 34 cm length, 20 width, and 15 heights. Each house had two live traps installed over two consecutive days with a total of 128 houses (16 houses in Kembangan District, 10 houses in Groglot Petamburan District, 24 houses in Cengkareng District, 18 houses in Kebun
in the West Jakarta area. The rat species most commonly found in the West Jakarta area was \textit{Rattus norvegicus} (74.1%), followed by \textit{Xenopsylla cheopis} (14.8), \textit{Suncus murinus} (11.1%), and more male rats were caught, equal to 66.7% (female 33.3%) (Table 2). The only type of ectoparasite found in the rats in the West Jakarta area was the flea (Table 3). \textit{Xenopshilla cheopis} was the most common type (83.3%) and \textit{Xenopsylla astia} (16.7%). More fleas were male (66.7%) than female (33.3%).

Discussion

Cengkareng district is the administrative area of West Jakarta with the highest population, comprising 514,416 people (Badan Pusat Statistik Kota Jakarta Barat, 2019). It has 26.54 km² and includes six sub-Districts; Cengkareng Timur sub-District is one of the densely populated areas in Cengkareng district (Badan Pusat Statistik Kota Jakarta Barat, 2019). Based on the research results, rats are most commonly found in the East Cengkareng sub-District. This study found different results to previous studies, which found that rats were more commonly found in agricultural areas (58.0%) (Munòè-Zanzi, Mason, Encina, Gonzalez, & Berg, 2014). These different results could be caused by regional differences
and the categories of the research areas. Previous studies [25] have researched three locations, namely agricultural areas, rural areas, and slums, while this study was only conducted in West Jakarta, without categorizing the area.

The presence of rats in an area depends on ecology, vegetation, food availability, and predators’ presence. Also, the presence of rats also correlates with the number of tree species; their number will tend to increase in areas with high tree diversity (Madden et al., 2019). However, in this study, the level of tree diversity did not affect rats’ presence, as the habitat of those caught was in homes and gutters. Moreover, Cengkareng Timur sub-district is not an area that has a diversity of trees. Seasons also have an important influence on rats’ presence; house or commensal rats will be more common in the dry season (Panti-May, Hernández-Betancourt, Ruiz-Piña, & Medina-Peralta, 2012). In this study, the rats were found in densely populated areas, and the process of catching them took place in the dry season so that more would be caught. In the dry season, the availability of rat food is higher, especially leftovers from processed household products, as well as from some home industries in the Eastern Cengkareng sub-district.

In this study, the rat species most commonly found was *Rattus rattus* (black rats). This species was commonly found because catching the rats and setting traps was commonly found in participants’ homes. *Rattus rattus* is a species whose habitat is forests and homes (Csurhes, 2012). The species can also be found in natural and semi-natural habitats (The ICUN Red List, 2017). It is an arboreal animal that can climb. *Rattus rattus* favors lowlands that are less than 250 meters above sea level (Isnaini, 2008). The environmental conditions greatly affect the presence of *Rattus rattus* in the ecosystem, for example, the availability of food sources. Food, organic waste that is not stored or properly disposed of, gardens that are not well managed; and the presence of pets and livestock can affect the number of rats, including the *Rattus rattus* species (Feng & Himsworth, 2014).

The presence of rats in the community environment can cause various health problems, one of which is leptospirosis, a disease caused by Leptospira bacteria (Centers for Disease Control and Prevention, 2018; Haake, David A, & Levett, 2015; World Health Organization, 2003). Rats are the most important reservoir of Leptospira bacteria. Previous studies have found a similarity between the PFGE pattern and gyrB sequence in Leptospira bacteria isolated from humans and rats in Luzon, Philippines (Villanueva et al., 2014). This indicates that rats infected with Leptospira bacteria can cause leptospirosis in humans (Villanueva et al., 2014). The prevalence rate of Leptospira bacteria in each rat species is different. Based on the results of previous studies, it is known that Leptospira spp positively infects up to 17.8% of the *Rattus rattus* species, 30.3% of the *Rattus norvegicus* species, 10.9% of the *Rattus exulans* species, 19.3% of the *Rattus argentiventer* species, and 3.4% of the *Rattus tanezumi* species (Id, Shiokawa, & Id, 2019; Koizumi et al., 2009). From these results, it is clear that *Rattus norvegicus* is the most infected species with the Leptospira bacteria, which causes leptospirosis in humans. However, to establish which species of rats are most responsible for carrying Leptospira bacteria and causing leptospirosis, further research is needed.

### Table 1. Frequency distribution of rats and shrews caught in the West Jakarta area, November 2019.

| Region                          | Number of rats caught | Percentage (%) |
|--------------------------------|-----------------------|----------------|
| West Cengkareng sub-district    | 2                     | 7.4            |
| East Cengkareng sub-district*   | 4                     | 14.8           |
| Duri Kepa sub-district          | 1                     | 3.7            |
| Kamal sub-district              | 3                     | 11.1           |
| Kapuk sub-district              | 1                     | 3.7            |
| Kedaung Kali Angke sub-district | 1                     | 3.7            |
| Nort Kedoya sub-district        | 1                     | 3.7            |
| Nort Kembangan sub-district     | 3                     | 11.1           |
| South Meruya sub-district       | 2                     | 7.4            |
| Rawa Buaya sub-district         | 2                     | 7.4            |
| Semanan sub-district            | 2                     | 7.4            |
| South Tanjung Duren sub-district| 2                     | 7.4            |
| Tegal Alur sub-district         | 3                     | 11.1           |
| Total                          | 27                    | 100.0          |

*The region was found more rats and Shrews.*
In addition to the presence of rats, ectoparasites can also cause other health problems for humans. One disease that can be caused by rat ectoparasites (fleas) is pes (plague) (Illinois Department of Public Health, n.d.; Nurisa, 2005). Based on the study findings, out of the 27 rats caught, some had ectoparasites such as fleas. The most common type of flea was *Xenopsylla cheopis* (male). The results of this study are in line with those of previous study by Maulana et al., which also found that several species of rats carried ectoparasites, with the most commonly found type being *Xenopsylla cheopis* (81.1%) (D, 2012). In another study by Kia et al, it was also found that one of several fleas found in *Rattus ratus* and

Table 2. Characteristics of rats and shrews caught in West Jakarta, November 2019.

| Species        | Gender | Body length (mm) | Tail length (mm) | Rear feet length (mm) | Earlobe length (mm) | Head length (mm) | Mammae | Weight (Grams) |
|----------------|--------|------------------|------------------|-----------------------|---------------------|------------------|--------|----------------|
| *Rattus rattus*| Male   | 70               | 110              | 10                    | 10                  | 30               | 0      | 31             |
| *Rattus rattus*| Male   | 75               | 110              | 15                    | 15                  | 20               | 0      | 33             |
| *Rattus rattus*| Male   | 180              | 185              | 25                    | 20                  | 40               | 0      | 324            |
| *Rattus rattus*| Male   | 70               | 115              | 10                    | 15                  | 40               | 0      | 26             |
| *Rattus rattus*| Female | 130              | 155              | 20                    | 15                  | 50               | 6      | 85             |
| *Rattus rattus*| Male   | 120              | 150              | 15                    | 10                  | 35               | 0      | 89             |
| *Rattus rattus*| Male   | 130              | 140              | 15                    | 15                  | 30               | 0      | 89             |
| *Rattus rattus*| Male   | 120              | 160              | 20                    | 20                  | 40               | 0      | 103            |
| *Rattus rattus*| Female | 130              | 180              | 15                    | 20                  | 30               | 8      | 121            |
| *Rattus rattus*| Male   | 90               | 130              | 10                    | 10                  | 30               | 0      | 45             |
| *Rattus rattus*| Male   | 90               | 150              | 10                    | 10                  | 30               | 0      | 46             |
| *Rattus rattus*| Male   | 180              | 145              | 20                    | 20                  | 55               | 0      | 210            |
| *Rattus rattus*| Male   | 130              | 140              | 15                    | 20                  | 35               | 0      | 81             |
| *Rattus rattus*| Male   | 130              | 165              | 20                    | 35                  | 20               | 0      | 188            |
| *Rattus rattus*| Female | 130              | 180              | 20                    | 30                  | 20               | 10     | 145            |
| *Rattus rattus*| Female | 100              | 150              | 15                    | 15                  | 25               | 10     | 71             |
| *Rattus rattus*| Male   | 110              | 170              | 15                    | 15                  | 25               | 0      | 68             |
| *Rattus rattus*| Male   | 120              | 170              | 20                    | 15                  | 35               | 0      | 86             |
| *Rattus rattus*| Female | 130              | 160              | 15                    | 15                  | 40               | 12     | 122            |
| *Rattus rattus*| Male   | 85               | 110              | 15                    | 15                  | 35               | 0      | 49             |
| *Rattus norvegicus*| Female | 170           | 165              | 25                    | 20                  | 50               | 14     | 287            |
| *Rattus norvegicus*| Female | 190           | 180              | 30                    | 25                  | 50               | 12     | 429            |
| *Rattus norvegicus*| Male   | 160              | 200              | 35                    | 20                  | 55               | 0      | 245            |
| *Rattus norvegicus*| Male   | 180              | 170              | 30                    | 25                  | 50               | 0      | 231            |
| *Suncus murinus*| Male   | 70               | 65               | 10                    | 50                  | 30               | 0      | 38             |
| *Suncus murinus*| Female | 90               | 65               | 15                    | 10                  | 40               | 6      | 50             |
| *Suncus murinus*| Female | 70               | 55               | 10                    | 5                   | 30               | 0      | 25             |

Table 3. Frequency distribution of ectoparasites in rats caught in West Jakarta, November 2019.

| Ectoparasite     | Number | Percentage (%) |
|------------------|--------|----------------|
| Fleas            |        |                |
| *Xenopsylla astia*| 3      | 16.7           |
| *Xenopsylla cheopis*| 15    | 83.3           |
| Total            | 18     | 100.0          |
**Rattus norvegicus** was related to the transmission of plague. The most abundant ectoparasite (88.7%) in Bandar Abbas, Southern Iran, was Xenopsylla, found in **Rattus norvegicus** (Kia et al., 2009).

A previous study by Ristiyanto et al. had also found that female **Rattus tanezumi** had more ectoparasites than males, while more ectoparasites were in male Rattus exulans rats than in female ones (Ristiyanto, Mulyono, Agustina, Yuliadi, & Muhidin, 2011). Riyanto also found that the most common type of flea found in house rats was *Xenopsylla cheopis*. This suggests the potential for disease caused by rats and their ectoparasites (Riyanto, 2019). However, not all rats will have ectoparasites, as many aspects can influence their presence. One aspect that can affect the presence of ectoparasites in rats is the season. In the summer, due to dry and hot weather, rats and ectoparasites' presence is low (Alahmed & Al-Dawood, 2001). The presence of rat ectoparasites that can potentially cause health problems leading to high mortality and morbidity must be controlled properly.

**Conclusion**

Rats were mostly found in Cengkareng district, specifically in the East Cengkareng Sub-District, one of the districts with a high incidence of leptospirosis in West Jakarta. The most common rat species is **Rattus rattus**. The ectoparasite most commonly found in rats is the male flea *Xenopsylla cheopis*. Surveys, monitoring, and control of rats and ectoparasites are essential for the preparedness and development of an early warning system of possible diseases that they can cause. Future research should include data about the relative abundance index of trapping, a map of the trapped area, and information about the house/region.

**Data availability**

**Underlying data**

Dryad: Ectoparasites in rats and shrews data related to leptospirosis in West Jakarta. https://doi.org/10.5061/dryad.t4b8gtj18 (Susanna, Nova & Rozek, 2021).

This project contains the following underlying data:

- Data 1. sav (dataset containing the region, name of species Rattus, gender, body length, tail length, rear length, feet length, earlobe length, head length, mammae, and weight.)
- Data 2. sav (dataset containing species of ectoparasite and gender)

Data are available under the terms of the Creative Commons Zero “No rights reserved” data waiver (CC0 1.0 Public domain dedication).

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This research has complete data and methods that can be carried out elsewhere. This is very beneficial for the community and it is necessary to increase early awareness of vector-borne diseases by rats and ectoparasites so that public health prevention efforts can be carried out early on, because the rat population is always present in the human population, especially in densely populated environments.

“The type of ectoparasite found in the rats was fleas. *Xenopsylla cheopis* was the most common type, at 83.3% and more fleas were male, at 66.7%. The most common rat species was *Rattus rattus*. The ectoparasite most commonly found in them was the female flea *Xenopsylla cheopis*.”

- This is an important finding because it is known that the types of ectoparasites found in rats are fleas, especially *Xenopsylla cheopis*, so early awareness of zoonotic diseases, especially bubonic plague, needs to be carried out in the community.

“The technique for catching rats involved using humane live traps, while the identification of the rats and ectoparasites was done in the laboratory.”

- This study follows ethical rules in animals.

- In the method of catching rats, it is stated that the traps are set in the afternoon between 15.00 and 17.00 WIB, and the rats are collected in the morning between 07.00 and 09.00. Within 14 hours, if the rat dies and is surrounded by ants because of the smell, will it still be examined as a research sample?

**Is the work clearly and accurately presented and does it cite the current literature?**
Yes

**Is the study design appropriate and is the work technically sound?**
Yes
Are sufficient details of methods and analysis provided to allow replication by others? Yes

If applicable, is the statistical analysis and its interpretation appropriate? Yes

Are all the source data underlying the results available to ensure full reproducibility? Yes

Are the conclusions drawn adequately supported by the results? Yes

**Competing Interests:** No competing interests were disclosed.

**Reviewer Expertise:** Epidemiology, infectious disease, HIV/AIDS

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Reviewer Report 06 September 2021

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Philip Samuel Paulraj
ICMR-Vector Control Research Centre, Puducherry, India

This article is a good paper and approved for indexing. This publication has good epidemiological significance correlating the presence of ectoparasites found on rats with the prevalence of leptospirosis.

A similar study of mine conducted in scrub typhus endemic areas in India showed higher numbers of ectoparasites belonging to mites, fleas, and ticks. Since this study showed very few ectoparasites only belonging to fleas, an extensive study should be planned to be undertaken in these areas to collect/record more ectoparasites. This study can be taken up as a pilot study for future in-depth studies (P. Philip Samuel, R. Govindarajan, R. Krishnamoorthi, and V. Rajamannar A study on ectoparasites with special reference to chigger mites on rodents/shrews in scrub typhus endemic areas of Kerala, India Entomon, 45: 4; 2020)

You could also mention this reference of mine under ectoparasites identification: “Philip Samuel P., Govindarajan R., Krishnamoorthi R., Venkatesh A. (2021). A rapid protocol for clearing, staining, and mounting of Arthropoda: Trombiculidae, Pediculidae, and Pulicidae. North-western Journal of Zoology,17(1):1-5 Article No. e201104”.
After a scientific name is written in full in a publication, it is acceptable or customary to abbreviate the genus name by just using the first initial (or as recommended) and then full stop to represent the genus. These changes can be made in the entire manuscript.

Please mention the rat identification method.

References
1. Samuel P, Govindarajan R, Krishnamoorthi R, Rajamannar V: A study on ectoparasites with special reference to chigger mites on rodents/shrews in scrub typhus endemic areas of Kerala, India. *ENTOMON*. 2020; **45** (4): 285-294 [Publisher Full Text]
2. Philip Samuel P, Govindarajan R, Krishnamoorthi R, Venkatesh A: A rapid protocol for clearing, staining, and mounting of Arthropoda: Trombiculidae, Pediculidae, and Pulicidae. *North-western Journal of Zoology*. 2021; **17** (1): 1-5

Is the work clearly and accurately presented and does it cite the current literature? Yes

Is the study design appropriate and is the work technically sound? Yes

Are sufficient details of methods and analysis provided to allow replication by others? Yes

If applicable, is the statistical analysis and its interpretation appropriate? Yes

Are all the source data underlying the results available to ensure full reproducibility? Yes

Are the conclusions drawn adequately supported by the results? Yes

*Competing Interests:* No competing interests were disclosed.

*Reviewer Expertise:* Medical Entomology

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

[Reviewer Report 11 June 2021](https://doi.org/10.5256/f1000research.50145.r84286)

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Malina Binti Osman
Department of Medical Microbiology and Parasitology, Faculty of Medicine, Universiti Putra Malaysia, Serdang, Malaysia

The study provided information on known reservoirs which are linked to leptospirosis. Even though the areas has been said to be endemic with leptospirosis, none of the epidemiological data is presented. It has been mentioned in the abstract that data on leptospirosis was retrieved from West Jakarta Health Office, but there is no data on leptospirosis in this study.

In my opinion, some statistics work should be inserted to allow any determination on correlation between number of the reservoirs with the number of cases reported.

I would suggest molecular work on determining the presence of the bacteria in the reservoirs should be done as well.

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Partly

Are sufficient details of methods and analysis provided to allow replication by others?
Partly

If applicable, is the statistical analysis and its interpretation appropriate?
No

Are all the source data underlying the results available to ensure full reproducibility?
Partly

Are the conclusions drawn adequately supported by the results?
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Epidemiology, biostatistics, tropical health

I confirm that I have read this submission and believe that I have an appropriate level of expertise to state that I do not consider it to be of an acceptable scientific standard, for reasons outlined above.
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