

Determinants of Rat Population Density in the Port Area of Manado, North Sulawesi, Indonesia

Jane Maria Fransiska Tahulending*, Woodford Baren Solaiman Joseph, Odi Roni Pinontoan

Faculty of Public Health, Sam Ratulangi University, Manado

*e-mail correspondence: j.tahulending@unsrat.ac.id

(Article History: Received-Feb 17, 2026; Revised-April 06, 2026; Accepted-June 05, 2026)

ABSTRACT

Rats are important vectors of zoonotic diseases and pose significant public health risks, particularly in port areas. This study aimed to analyze environmental factors influencing rat population density in Manado Seaport, North Sulawesi. A quantitative descriptive study with a cross-sectional approach was conducted using field surveys. A total of 100 rat traps were set for five consecutive days across four observation sites: the Harbor Master's Office, cargo loading building, residential areas, and storage warehouses. Environmental variables observed included cleanliness, waste presence, drainage conditions, food availability, and potential nesting sites. The results showed that 28 rats were captured, yielding a Trap Success (TS) rate of 28%, which exceeds the safe threshold of <2% based on the Indonesian Ministry of Health (2014) guidelines. The identified species were *Rattus norvegicus* and *Mus musculus*, with *R. norvegicus* as the dominant species. Higher TS values were found in locations with poor sanitation, abundant waste, and readily available food sources. Waste presence and food availability showed the strongest associations with rat density, followed by drainage conditions. These findings indicate that poor environmental sanitation contributes to increased rat populations. Therefore, improved waste management, environmental sanitation, and routine monitoring are essential to reduce the risk of rat-borne disease transmission.

Key words: rodent ecology; trap success; *Rattus norvegicus*; seaport; environmental sanitation

INTRODUCTION

Rats are highly adaptable mammals capable of surviving in diverse environmental conditions and frequently live in close proximity to human activities (Ming et al., 2024). They are recognized as important vectors of zoonotic diseases, including leptospirosis, plague, murine typhus, and hantavirus infections, which pose significant public health risks (Blasdel et al., 2022). Transmission may occur directly through contact with contaminated urine and feces or indirectly through ectoparasites such as fleas and mites (Nkoko et al., 2025). Due to their ecological adaptability and rapid reproduction, rat populations can increase significantly under favorable environmental conditions.

Seaport areas represent environments that strongly support rat habitation due to the availability of food sources, shelter, and continuous cargo-handling activities. Waste accumulation, poor sanitation, and the presence of warehouses and residential areas further contribute to the suitability of these environments for rodent proliferation (Indonesian Ministry of Health, 2014). Moreover, as hubs for the movement of goods and people, seaports increase the risk of cross-regional transmission of rodent-borne diseases (Castel et al., 2023).

Previous studies have reported that rat population density is influenced by various environmental factors, including sanitation conditions, humidity, temperature, food availability, and nesting sites (Santos et al., 2017; Badou et al., 2023). Studies conducted in Indonesian port areas, such as Tanjung Perak Port and Tanjung Uban Port, have highlighted the importance of environmental sanitation and waste management in controlling rodent populations (Sofiyani & Keman, 2017; Kurnia et al., 2023). However, most previous studies have primarily focused on identifying species and reporting the number of captured rats, while limited research has examined the relationship between microenvironmental sanitation variables and trap success as an indicator of rat population density, particularly in seaport areas of North Sulawesi.

This gap highlights the need for a more comprehensive analysis that integrates environmental sanitation factors with quantitative indicators of rat density. Therefore, this study

aims to measure rat population density using trap success and to analyze the relationship between environmental factors such as cleanliness, waste presence, drainage conditions, food availability, and nesting sites and rat population density in the working area of Manado Seaport.

This study contributes new evidence by specifically examining the association between microhabitat environmental sanitation variables and trap success in a seaport setting in North Sulawesi, providing a more detailed basis for targeted and sustainable rodent control strategies.

METHODS

Study Design

This study employed a quantitative analytic design with a cross-sectional approach to measure rat population density and analyze its association with environmental factors.

Study Area and Period

The study was conducted at Manado Seaport, North Sulawesi, Indonesia, from August to September 2025. Observations were carried out at four sites: the Harbor Master's Office, cargo loading buildings, warehouses, and surrounding residential areas. These locations were selected based on high human activity and potential for rodent infestation.

Unit of Analysis and Sampling

The unit of analysis was each trapping point. A total of 100 live traps were placed purposively at strategic locations with approximately 10–15 meters between traps. The number of traps was determined based on field feasibility and standard rodent surveillance practices in port areas. Traps were baited with roasted coconut and salted fish and deployed for five consecutive nights.

Variables and Operational Definitions

Dependent Variable: Rat population density, measured using Trap Success (TS), defined as the percentage of captured rats relative to the total number of traps set.

Independent Variables: Environmental factors at each trapping point, categorized as follows:

- Cleanliness: Good (no visible waste/clean surroundings) or Poor (presence of scattered waste/dirty conditions)
- Waste Presence: Present or Absent
- Drainage Condition: Good (flowing, not clogged) or Poor (stagnant/clogged)
- Food Availability: Available (presence of food remnants/organic waste) or Not Available
- Nesting Sites: Present (holes, piles, or sheltered areas) or Absent

Species Identification: Rats were identified morphologically as *Rattus norvegicus* and *Mus musculus* based on body size, tail length relative to body, ear size, and fur characteristics.

Data Collection Procedures

Environmental observations were conducted at each trapping point using a structured checklist. Captured rats were transported to the laboratory for identification using standard morphological keys. Ectoparasite examination was conducted; however, the findings were not included in the present analysis.

Data Analysis

Trap Success (TS) was calculated using the formula:

$$TS (\%) = (\text{Number of rats captured} / \text{Number of traps set}) \times 100$$

TS values were used as an indicator of rat population density at each observation site. The association between environmental variables and rat density was analyzed using the Chi-square (χ^2) test with a 95% confidence level ($p < 0.05$). Data were presented in tables and descriptive narratives.

Ethical Considerations

This study obtained official permission from the Manado Class I Health Quarantine Center. All procedures involving animal handling followed animal welfare principles during trapping and identification (Manado Class I Health Quarantine Center, 2023 & 2024).

RESULTS

Rat Capture and Species Identification

A total of 28 rats were captured from 100 traps set over five consecutive nights, resulting in a Trap Success (TS) rate of 28%. Based on the Indonesian Ministry of Health (2014) guideline, which defines a safe threshold as $TS < 2\%$, this value indicates a high rat population density in the study area.

Two species were identified based on morphological characteristics: *Rattus norvegicus* and *Mus musculus*, with *R. norvegicus* as the dominant species. The highest trap success rates were observed at the cargo loading buildings (36.7%) and the Harbor Master's Office (45.0%), followed by residential areas (23.3%) and warehouses (5.0%) (Table 1).

Table 1. Rat Capture Results by Location

Location	Traps	Rats Captured	TS (%)	Dominant Species
Harbor Master's Office	20	9	45.0	<i>R. norvegicus</i>
Cargo loading building	30	11	36.7	<i>R. norvegicus</i>
Residential areas	30	7	23.3	<i>R. norvegicus</i>
Storage warehouse	20	1	5.0	<i>M. musculus</i>
Total	100	28	28.0	–

Environmental Conditions

Environmental observations showed that most locations were categorized as “poor” in several variables, particularly waste presence (70%), food availability (75%), and environmental cleanliness (65%). Drainage conditions were also suboptimal, with 60% categorized as poor. Rat nesting indicators were observed in 55% of locations (Table 2).

Table 2. Environmental Conditions at Trapping Sites

Variable	Good (%)	Poor (%)
Cleanliness	35	65
Waste presence	30	70
Drainage condition	40	60
Food availability	25	75
Nesting sites	45	55

Association Between Environmental Factors and Rat Density

The analysis showed that trap success values were consistently higher in locations categorized as “poor” across all environmental variables. The highest average TS was found in

areas with poor food availability conditions (36.0%), followed by waste presence (34.0%) and poor cleanliness (32.5%) (Table 3).

Table 3. Average Trap Success by Environmental Condition

Variable	Category	Average TS (%)
Cleanliness	Poor	32.5
	Good	17.0
Waste presence	Poor	34.0
	Good	15.0
Drainage condition	Poor	30.5
	Good	18.5
Food availability	Poor	36.0
	Good	12.0
Nesting sites	Poor	28.0
	Good	20.0

Statistical Analysis

Chi-square analysis revealed that waste presence ($p = 0.0001$) and food availability ($p = 0.0008$) were highly significantly associated with rat density. Cleanliness ($p = 0.0447$) and drainage condition ($p = 0.0326$) also showed statistically significant associations. However, the presence of nesting sites was not significantly associated ($p = 0.1652$) (Table 4).

Table 4. Chi-square Analysis of Environmental Factors and Rat Density

Variable	TS Good (%)	TS Poor (%)	p-value	Interpretation
Cleanliness	14.3	35.4	0.0447	Significant
Waste presence	0.0	40.0	0.0001	Highly significant
Drainage condition	15.0	36.7	0.0326	Significant
Food availability	0.0	37.3	0.0008	Highly significant
Nesting sites	20.0	34.5	0.1652	Not significant

DISCUSSION

This study demonstrates that rat population density in Manado Seaport is high, as indicated by a Trap Success (TS) value of 28%, exceeding the safe threshold ($<2\%$) set by the Indonesian Ministry of Health (2014). The main environmental determinants associated with higher rat density were waste presence, food availability, environmental cleanliness, and drainage conditions.

From an ecological perspective, these findings can be explained by the basic survival requirements of rats, namely access to food, water, and shelter. The presence of unmanaged waste and food remnants provides a continuous and easily accessible food source, which supports rat survival and reproduction. Similarly, poor drainage conditions, such as clogged or stagnant water channels, create humid environments that are favorable for rat activity and movement. Low environmental cleanliness further contributes to the availability of hiding places, such as piles of goods and debris, which function as nesting or shelter sites. These conditions collectively create an optimal microhabitat for synanthropic species such as *Rattus norvegicus*, which are well adapted to human-dominated environments.

The findings of this study are consistent with previous research indicating that environmental sanitation plays a critical role in determining rodent population density. Studies by Santos et al. (2017) and Badou et al. (2023) reported that poor waste management and abundant food sources significantly increase rat populations. Similarly, research conducted in port environments in Indonesia, such as Tanjung Perak and Tanjung Uban, emphasized that waste accumulation and inadequate drainage systems are key drivers of rodent infestation (Sofiyan & Keman, 2017; Kurnia et al., 2023). These similarities suggest that the relationship between environmental conditions and rat density is consistent across different port settings.

However, not all environmental variables showed statistically significant associations. The presence of nesting sites, although ecologically important, was not significantly associated with rat density in this study. This may be due to the relatively uniform distribution of potential nesting sites across observation areas, reducing variability in the analysis. In addition, nesting indicators may be more difficult to quantify accurately compared to visible factors such as waste and food availability.

The dominance of *Rattus norvegicus* observed in this study further supports the ecological interpretation, as this species is known to thrive in humid environments, near water sources, and in areas with abundant organic waste. Its presence in port areas is particularly important from a public health perspective, as it is a known reservoir for zoonotic pathogens such as *Leptospira* spp. and is associated with ectoparasites that can transmit other diseases.

From a management perspective, these findings highlight the importance of environmental-based control strategies rather than relying solely on trapping. Effective rat control in port areas should prioritize integrated waste management, regular cleaning, proper food waste disposal, and maintenance of drainage systems to eliminate favorable habitats. In addition, continuous monitoring and education of port workers are essential to reduce environmental conditions that support rat proliferation.

This study has several limitations. First, the cross-sectional design limits the ability to establish causal relationships between environmental factors and rat density. Second, environmental variables were assessed using observational categorization, which may introduce subjectivity. Third, the study was conducted within a limited time frame and number of trapping points, which may not fully represent seasonal variations in rat populations.

Despite these limitations, this study provides important evidence on the relationship between environmental sanitation and rat population density in a seaport setting in North Sulawesi. The results contribute to a better understanding of microhabitat factors influencing rodent populations and support the development of targeted, environmentally based vector control strategies.

CONCLUSION

This study demonstrates that rat population density in Manado Seaport is high, as indicated by a Trap Success (TS) value of 28%, exceeding the safe threshold recommended by the Indonesian Ministry of Health. The dominant species identified was *Rattus norvegicus*. Environmental factors associated with higher rat density include waste presence, food availability, environmental cleanliness, and drainage conditions. Statistical analysis showed that waste presence, food availability, cleanliness, and drainage condition were significantly associated with rat population density, while nesting sites were not significantly related. These findings indicate that poor environmental sanitation, particularly unmanaged waste and the availability of food sources, plays an important role in increasing rat populations in port areas. Therefore, improving environmental sanitation, waste management, and drainage systems is essential to reduce rat density and minimize the risk of zoonotic disease transmission.

ACKNOWLEDGEMENT

We would like to thank the environmental health risk factor monitoring team from the Manado Class I Health Quarantine Center for their assistance during data collection. We also thank Sam Ratulangi University for funding this research through the 2025 UNSRAT Budget Implementation Budget (DIPA) program.

REFERENCES

- Badou, S., Hima, K., Agbangla, C., Gauthier, P., Missihoun, A., Houemenou, G., Loiseau, A., Brouat, C., Dobigny, G. (2023). Biological invasions in international seaports: A case study of exotic rodents in Cotonou. *Urban Ecosystems*. <https://doi.org/10.1007/s11252-023-01356-6>
- Blasdel, K. R., Morand, S., Laurance, S. G. W., Doggett, S. L., Hahs, A., Trinh, K., Perera, D., & Firth, C. (2022). Rats and the city: Implications of urbanization on zoonotic disease risk in Southeast Asia. *Proceedings of the National Academy of Sciences*, 119(39), e2112341119. <https://doi.org/10.1073/pnas.2112341119>
- Castel, G., Filippone, C., Tatar, C., Vigan, J., & Dobigny, G. (2023). Role of seaports and imported rats in Seoul hantavirus circulation, Africa. *Emerging Infectious Diseases*, 29(1), 20–25. <https://doi.org/10.3201/eid2901.221092>
- Gatto-Almeida, F., de Araújo Soares, A., Degrandi, T. M., Tiepolo, L. M., Pichmueller, F., Hass, I. (2022). Assessment of dispersal and population structure of Norway rats (*Rattus norvegicus*) in a seaport setting. *Urban Ecosystems*, 25, 535–544. <https://doi.org/10.1007/s11252-021-01171-x>
- Gravinatti, M. L., Barbosa, C. M., Soares, R. M., & Gregori, F. (2020). Synanthropic rodents as virus reservoirs and transmitters. *Revista da Sociedade Brasileira de Medicina Tropical*, 53, e20190486. <https://doi.org/10.1590/0037-8682-0486-2019>
- Indonesian Ministry of Health. (2014). *Guidelines for controlling rats as disease vectors*. Directorate General of Disease Control and Environmental Health.
- Kurnia, R., Diansafitri, M., & Yusuf, M. (2023). Rat density in the ASDP and Speed Bulang Linggi Port Areas of Tanjung Uban, Bintan Regency, Riau Islands Province. *JUMANTIK: Jurnal Ilmiah Penelitian Kesehatan*.
- Manabella Salcedo, I., Frascina, J., Busch, M., Guidobono, J.S., Unzaga, J.M., Dellarupe, A., Farace, M.I., Pini, N., Leon, V.A. (2021). Role of *Mus musculus* in the transmission of several pathogens in poultry farms. *International Journal for Parasitology: Parasites and Wildlife*, 14, 130–136. <https://doi.org/10.1016/j.ijppaw.2021.01.007>
- Manado Class I Health Quarantine Center. (2023). *Disease-transmitting animal and vector surveillance report*. Manado.
- Manado Class I Health Quarantine Center. (2024). *Disease-transmitting animal and vector surveillance report*. Manado.
- Nkoko, M. M., Shivambu, N., Shivambu, T. C., Nelufule, T., Khumalo, N., Seoraj-Pillai, N., & Nangammbi, T. C. (2025). Zoonotic ectoparasites infesting commensal invasive rodents. *Vector-Borne and Zoonotic Diseases*, 25(8), 481–490. <https://doi.org/10.1089/vbz.2025.0019>
- Santos, N. J., Sousa, E., Reis, M. G., Ko, A. I., & Costa, F. (2017). Rat infestation associated with environmental deficiencies in an urban slum community with high risk of leptospirosis transmission. *Cadernos de Saúde Pública*, 33(2). <https://doi.org/10.1590/0102-311X00132115>
- Shukla, I., & Wilmers, C. C. (2024). Waste reduction decreases rat activity in peri-urban environments. *PLoS ONE*, 19(11), e0308917. <https://doi.org/10.1371/journal.pone.0308917>

- Sofiyan, S., & Keman, S. (2017). Ship sanitation and crew behavior influencing rat presence on cargo ships at Tanjung Perak Port, Surabaya. *Jurnal Kesehatan Lingkungan*, 9(2), 145–153. <https://doi.org/10.20473/jkl.v9i2.2017.145-153>
- Sugiyono. (2019). *Quantitative, qualitative, and R&D research methods*. Bandung: Alfabeta.
- Zhang, M.-Y., Cao, R.-D., Chen, Y., Ma, J.-C., Shi, C.-M., Zhang, Y.-F., Zhang, J.-X., & Zhang, Y.-H. (2024). Genomic and phenotypic adaptations of *Rattus tanezumi* to cold limit its northward expansion and overlap with *Rattus norvegicus*. *Molecular Biology and Evolution*, 41(6), msae106. <https://doi.org/10.1093/molbev/msae106>