SPECIES

Autecology of Termite species in Barangay Pinatilan, Valencia City, Bukidnon, Philippines

Milven V Orevillo[1], **Alma B Mohagan**[2]

To Cite:
Orevillo MV, Mohagan AB. Autecology of Termite species in Barangay Pinatilan, Valencia City, Bukidnon, Philippines. *Species* 2023; 24: e72s1578
doi: https://doi.org/10.54905/disssi.v24i74.e72s1578

Author Affiliation:
[1]Department of Animal Biology, Undergraduate Student, Central Mindanao University, Maramag, Bukidnon, Philippines
[2]Department of Animal Biology, Faculty and University Museum Zoological Section, Central Mindanao University, Maramag, Bukidnon, Philippines

Contact List
Milven V Orevillo milvenorevillo2023@gmail.com
Alma B Mohagan almamohagan@gmail.com

Peer-Review History
Received: 04 June 2023
Reviewed & Revised: 08/June/2023 to 18/August/2023
Accepted: 22 August 2023
Published: 27 August 2023

Peer-Review Model
External peer-review was done through double-blind method.

Species
pISSN 2319–5746; eISSN 2319–5754

DISCOVERY SCIENTIFIC SOCIETY

ABSTRACT

Termite mounds have long captivated human interest, yet the underlying reasons for developing mound-building characteristics in termites remain elusive. Termites represent eusocial insects that fall under the taxonomic category Isoptera, where in a caste system divides them into three significant castes: workers, soldiers, and reproductive. Termites are renowned for their remarkable ability to digest cellulose, the primary component of wood and plant materials. Some termite species even rely on consuming fungus to break down cellulose effectively. Termites are commonly recognized as structural and agricultural pests. Many often overlook their crucial role in maintaining soil balance and nutrient levels in our ecosystem. Though termite is not new to science, few of us can tell of their ecological importance, behavior, and diet. The study centered on termite autecology, and there have yet to be published data on the types of termite species found in Pinatilan, Valencia City. The study used the active collecting technique (visual searching) and the passive collecting method (opportunistic) sampling to gather the required data for analysis. The study found that the Macrotermes gilvus with complex soil nest found in Stations 1 and 3 are more prominent in body size (0.7 cm) with bilateral homing as compared to Schedorhinotermes intermedius (0.5 cm) with timber nest found in Station 2. Also, termite species in Pinatilan, Valencia City, had different body coloration and preferred habitats. The knowledge acquired in performing this study is essential to understand its foraging behavior, ecology, and morphology fully.

Keywords: Termites, Termites Mounds, Fungus comb, Autecology, Mindanao, Philippines

1. INTRODUCTION

Termites are eusocial insects living in organized colonies with specialized roles for efficient cooperation and survival. It specializes in defense, foraging, construction, or nurturing the young through behavioral and morphological adaptations, (Bignell, 2006). Termites are found in many habitats, spanning from arid deserts, steppes, prairies, and Mediterranean shrublands to the wettest and most dense tropical forests. Termites feed on a wide range of cellulose-rich resources, and their diet is highly diverse, encompassing a variety of food sources, much like their relatives in the dictyopteran family, (Traniello and Leuthold, 2000). In a study by Schmidt et al., (2022), fungus farming in termites originated approximately 30 million years ago in the African rainforest within the subfamily Macrotermitinae. Termites play a crucial role in ecosystems by decomposing organic matter and facilitating the processes of humification and mineralization of leftover materials, as stated by (Bignell and Eggleton, 2000).

Although termite mounds have captivated human interest for a considerable period, the reasons behind the development of mound-building behavior in termites have received limited research attention. According to Korb, (2011), the primary purpose of termite mounds is undoubtedly to serve as a residence for large termite colonies. The study of Bignell, (2019) highlighted the significance of termite mound and runway construction in processes such as pedogenesis and nutrient recycling. The structure of bumps that appear suited to local temperatures does not indicate a deliberate design of the mounds, with all termites having a predetermined blueprint of the nest ingrained in their nervous system, (Korb, 2003). Termites build bi-layered mounds with a solid core and a porous outer layer, providing exceptional strength, stability, and ventilation, (Zachariah et al., 2020).

Termite mounds harbor bacteria that decompose lignin and cellulose, fix nitrogen, solubilize phosphate, and suppress plant soil pathogens. These make them valuable as biofertilizers and biocontrol agents (Enagbonma and Babalola, 2019). With the rapid development of education and the advancement of technology, a series of necessary research initiatives have been undertaken. New projects, particularly those involving previously overlooked and new termite species, are receiving increased attention. Currently, no termite species are listed as threatened or near extinction. However, further exploration of their autecological characteristics and autecological status is required. This study aims to investigate and provide comprehensive information on termite ecology, offering valuable insights for our economy, the environment, and future researchers, specifically in Research Methods.

2. MATERIALS AND METHODS

Sampling Sites

Barangay Pinatilan, Valencia City, was surveyed from the 25th of June, 2023, until the 28th day of the same month. Primarily it is a rural area somewhere in the Province of Bukidnon. The specimens were collected from Purok-1Pinatilan in Valencia, Province of Bukidnon, Philippines (Figure 1). This area was surveyed due to insufficient data regarding termite species that inhabit this place. Though the area is accessible, no published data would tell us what type of termite species can be explored in the said place. Barangay Pinatilan is on the southeastern side of Valencia City, about 1.0-1.4 kilometers from the national highway road (7° 53 '50.1"N 125° 06' 15.5"E). The area is considered a residential area surrounded by paddy fields and some crops such as corn and bananas. The area is dominated by rice crops (*Oryza sativa*) and the slightly invasive perennial ryegrass (*Lolium perenne*). The researcher established three sampling stations to work on. Station 1 was located at Orevillo's Residence, Purok-1. Station 2 at Babaran's Residence, Purok-7, and finally, Station 3 was conducted at Mutia Residence, Purok-12.

Collection of Termites

The visual searching and active collecting (by hand) methods were used to gather the necessary data that needs to be collected. This approach allows researchers to observe and collect samples of different species subject to ex-situ conservation, enabling the study of their ecological behaviors and drawing conclusions based on their similarities and differences. The student researcher, an incoming 4th-year Animal Biology student at Central Mindanao University, collected the data. A few specimens obtained from the sampling site will be subject to preservation, and preservation techniques were applied (Figure 2). A transparent plastic container filled with 96% of ethyl alcohol solution will be utilized to preserve these specimens.

Photography and measurements

The Smartphone Camera (SC) was used to capture images of the Termites. Various morphometric measurements were recorded, including the total body length (from head to the end of the abdomen), body length excluding the head, head length, and abdomen length. All measurements are presented in centimeters. Hygrometers are employed to measure humidity levels, whereas thermometers gauge temperature levels. The specimens analyzed in this research are stored at the University Museum, specifically the Zoological Section of Central Mindanao University.

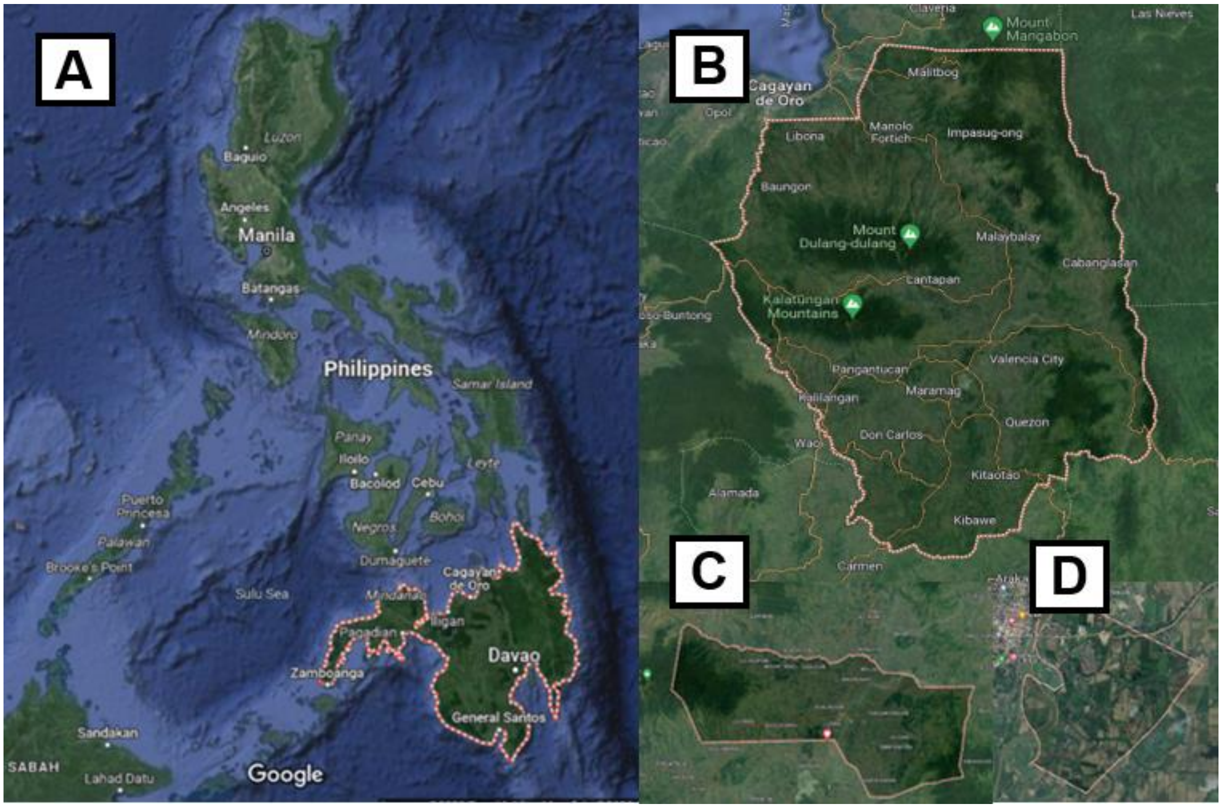


Figure 1 Geographical Location of the study sites: Map of the Philippines and Mindanao Island, Bukidnon, Valencia City, and Barangay Pinatilan. Showing the location and grid coordinates of the study station are as follows: Station 1 (7°53'50.2"N 125°06'15.3" E), Station 2 (7°53'49.9"N 125°06'16.3" E), and Station 3 (7°53'49.4"N 125°06'16.4" E) (Photo courtesy: Google map).

Figure 2 Actual photo of field sampling and collecting specimen (Pinatilan, Valencia City)

3. RESULTS AND DISCUSSION

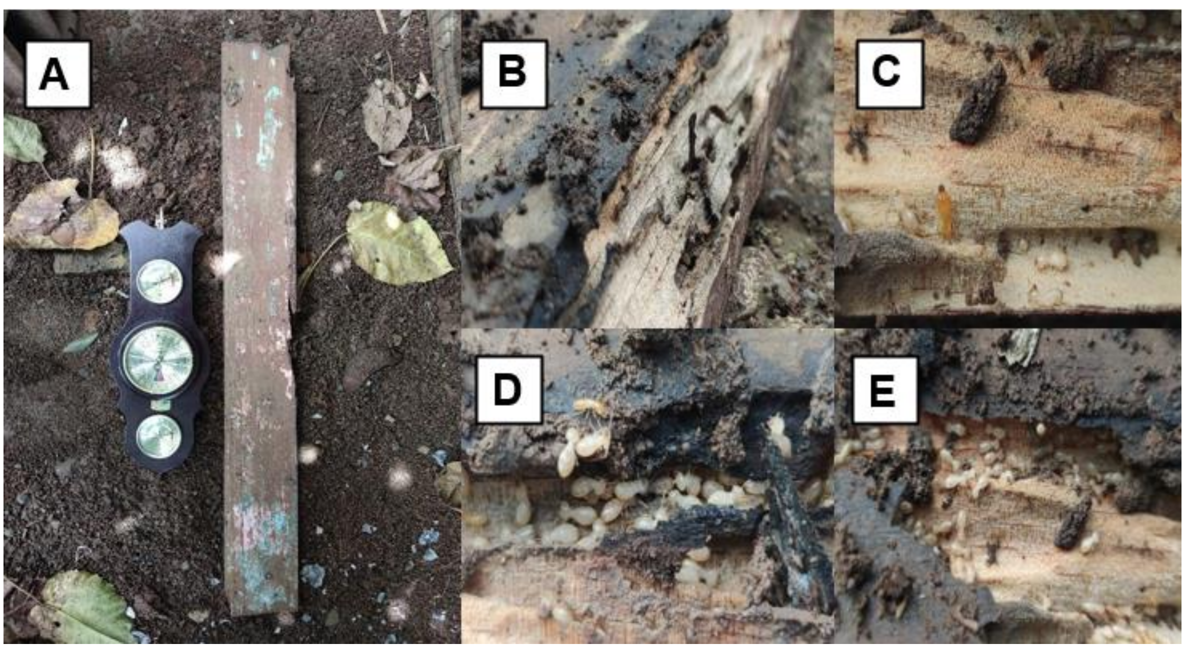
The information provided in (Table 1) suggests that the three termite species observed in the established stations can survive and thrive within specific ecological conditions, as indicated by the numerical values presented. When comparing the three stations, distinct variations become apparent. Station 1, located in Purok-1 Pinatilan, Valencia City, recorded a temperature of 33 degrees Celsius and a humidity level of 80 percent. It was inhabited by Macrotermes gilvus termites that primarily feed on fungus, dwelling in mounds within piles of dry wood.

Station 1 Plate A) Measuring of Temperature and Humidity using a Hygrometer and Thermometer, B) Close-up shot of *Macrotermes gilvus* microhabitat, C) Mud chamber connected to their Mound D) A pile of infested wood, E) Mushrooms sprouted in their nest.

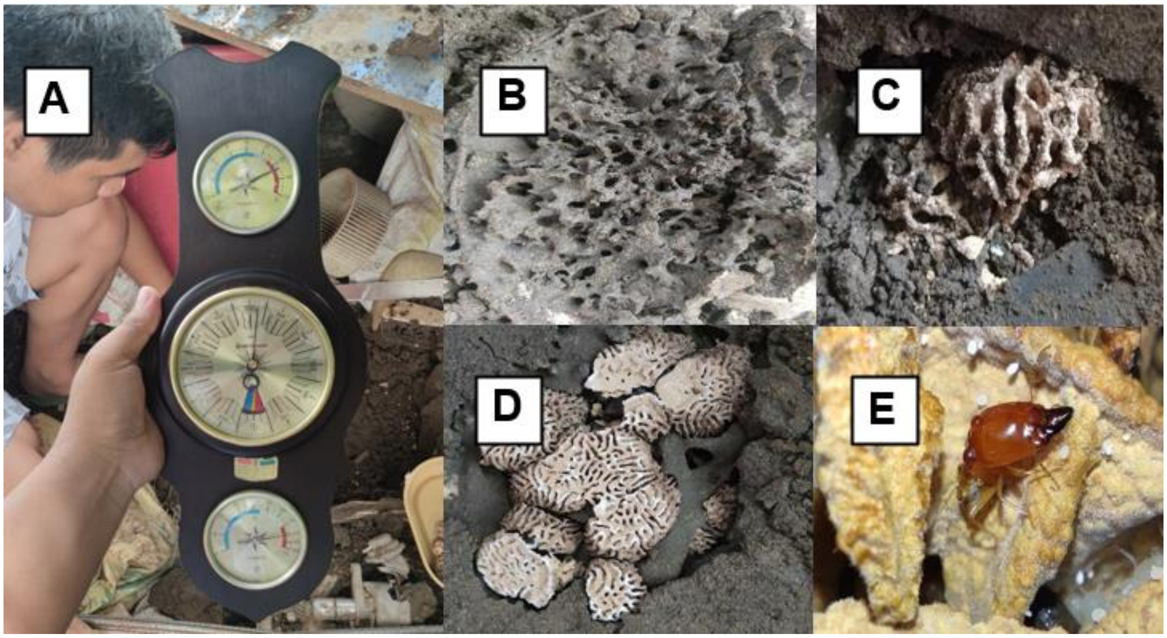
Table 1 Ecological parameters per station of collected termite species in Pinatilan, Valencia City.

	Station 1 Purok-1	Station 2 Purok-7	Station 3 Purok-12
	Macrotermes gilvus	*Schedorhinotermes intermedius*	*Macrotermes gilvus*
Temperature	33 ℃	30℃	35℃
Humidity	80%	94 %	78%
Food source	Fungus	Cellulose in woods	Fungus
Habitat	Mound within the pile of dry wood	Secondary nest in timber	Household junk materials surround the mound.

Also, Station 2, situated in Purok-7 Pinatilan, Valencia City, experienced a slightly lower temperature of 30 degrees Celsius and a humidity level of 94 percent. *Schedorhinotermes intermedius* termites occupied this station, feeding on cellulose from woods and residing in its secondary nest in timber. Further, Station 3, found in Purok-12 Pinatilan, Valencia City, exhibited a higher temperature of 35 degrees Celsius and a humidity level of 78 percent. Macrotermes gilvus termites, like those in Station 1, fed on fungus; however, their habitat consisted of mounds surrounded by household junk materials. These observations highlight variations in temperature, humidity, termite species, feeding behavior, and habitat, signifying the diverse ecological dynamics across the three stations.



Station 2 Plates: A) Measuring of Temperature and Humidity using Hygrometer and Thermometer, B) Secondary nest of *Schedorhinotermes intermedius*, C) Foraging termite worker guarded by a termite soldier, D) Close-up shot of infested timber, E) The foraging scenario of *Schedorhinotermes intermedius* termite.



Station 3 Plates A) Measuring of Temperature and Humidity using Hygrometer and Thermometer, B) Termite mound, C) Fungus comb, D) Fungus comb and its chamber, E) Close-up shot of *Macrotermes gilvus* soldier inside the Fungus comb.

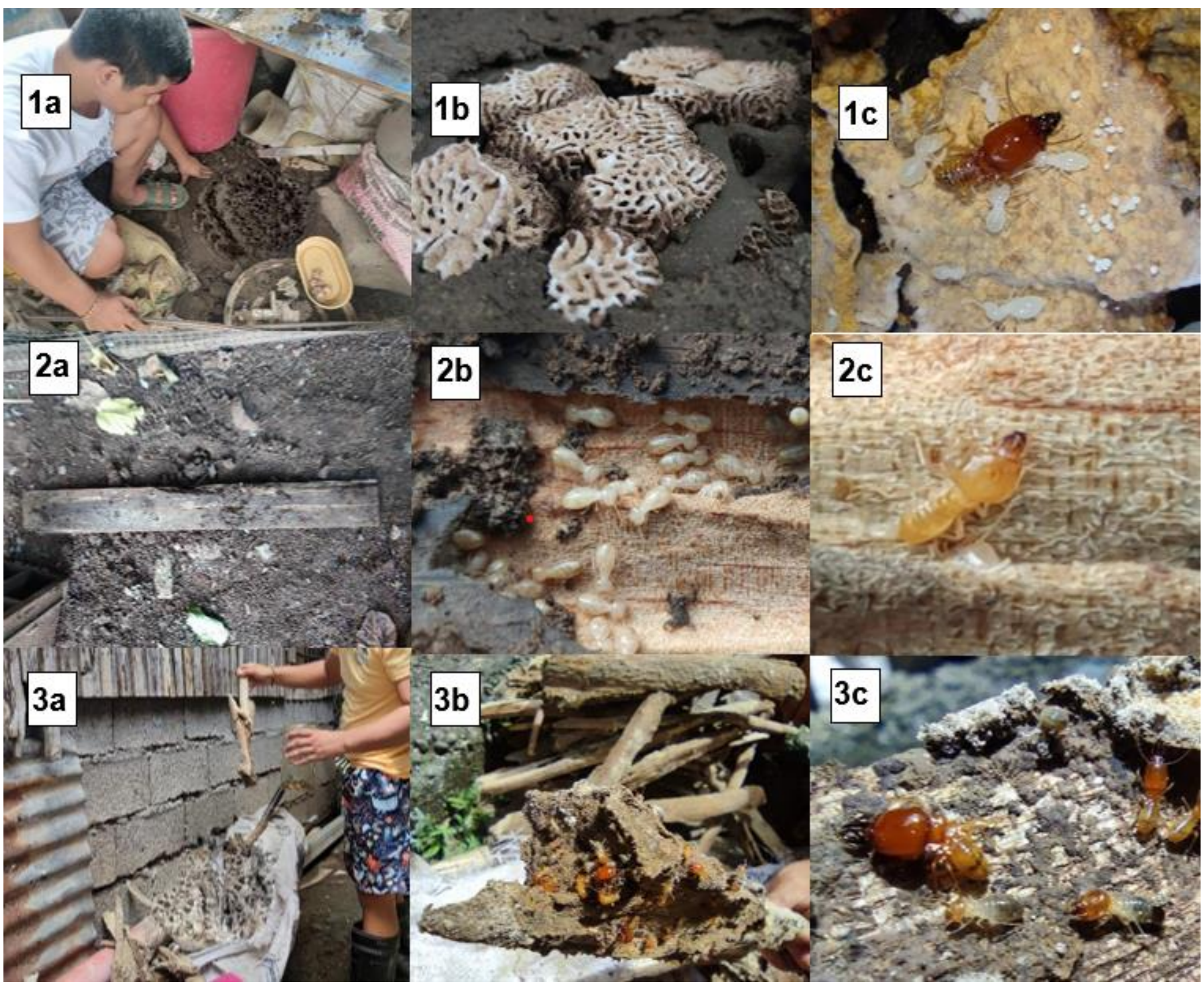


Figure 3 1a) Mound of *Macrotermes gilvus*, 1b) *Macrotermes gilvus* fungus comb, 1c) Inner shot of *Macrotermes gilvus* fungus comb. 2a) Secondary nest of *Schedorhinotermes intermedius* in timber, 2b) Closeup shot of *Schedorhinotermes intermedius* microhabitat, 2c) *Schedorhinotermes intermedius* soldier, 3a) Mound of *Macrotermes gilvus* within the pile of wood, 3b) Close up shot of *Macrotermes gilvus* microhabitat, 3c) Soldier and worker of *Macrotermes gilvus*.

Termite Diet

Macrotermes gilvus is commonly known as a fungus cultivator. Hyodo et al., (2000) is a species of termite genus *Macrotermes* found across a large area in southern Asia, stretching from Burma to Indonesia and the Philippines. They have a complex diet and an interesting symbiotic relationship with fungus. This particular termite species builds a specialized structure known as a fungus comb, within which termite workers diligently cultivate and nourish fungus (Figure 3). The emergence of fungal buds within the fungus comb serves as an indicator of successful cultivation. Subsequently, the termite colony proceeds to consume these fungal buds.

The mutualistic association between this particular termite species and the fungus is paramount for their survival. Due to their inability to independently digest cellulose and lignin, these termites rely on cultivating a specific type of mushroom that provides the necessary enzymes for breaking down these compounds. In a study by Martin, (1991), fungus-growing termites rely on ingested fungal enzymes to digest cellulose effectively. These enzymes are crucial in decomposing cellulose and extracting necessary nutrients to ensure their survival. On the other hand, *Schedorhinotermes intermedius*, based on ecological observation, primarily feeds cellulose-rich materials such as timber that are directly in contact with the ground.

Termite Architecture

Noirot and Darlington, (2000) state that the nest's structure reflects inherent behavior, altered through interaction with the surroundings. Subterranean termites create a mud tube as part of their living and protection. Woodrow et al., (1999) state that a mud tube is constructed using a substance called "carton material," a combination of fecal matter and partially processed wood resembling mud. According to Miller, (2010), mud tubes created by subterranean termites foraging also construct a fourth type of mud tube. In addition to termite architecture, mound-building termite makes the fungus comb to cultivate the particular fungus to feed the entire colony. Ohkuma et al., (2001) comb-like structures of the fungus comb serve as a nurturing environment for the growth of symbiotic fungi. Within its mound, a chamber is created in preparation for fungus cultivation, and the creation of a royal section is also centered on termite architecture. As Ladley and Bullock, (2005) mentioned, termites successfully construct a dome around the source of pheromones. This dome is roughly hemispherical, with its center aligned to the queen (Figure 4).

Table 2 Morphometric measurements of collected termite species in Pinatilan, Valencia City.

	Station 1 Purok-1		Station 2 Purok-7			Station 3 Purok-12	
	Macrotermes gilvus		*Schedorhinotermes intermedius*			*Macrotermes gilvus*	
	Soldier	Worker	Soldier Minor	Soldier Major	Worker	Soldier	Worker
Total body length (cm)	0.7	0.3	0.3	0.5	0.4	0.7	0.3
Head length (cm)	0.3	0.1	0.1	0.2	0.1	0.3	0.1
Abdomen length (cm)	0.4	0.2	0.2	0.3	0.3	0.4	0.2

The data (Table 2) includes measurements of termite soldiers and workers in three stations. The *Macrotermes gilvus* soldiers consistently have a body length of 0.7 cm across stations 1 and 3, while the *Schedorhinotermes intermedius* minor soldier in station 2 measures 0.3 cm, followed by its prominent soldier that measures 0.5 cm. Conversely, the workers have a consistent body length of 0.3 cm across all stations and species. These findings suggest species-specific differences in soldier body lengths, with *Macrotermes gilvus* soldiers larger than *Schedorhinotermes intermedius* soldiers. However, the worker termites maintain a consistent size across species and stations.

Morphology of termites from pinatilan, valencia city

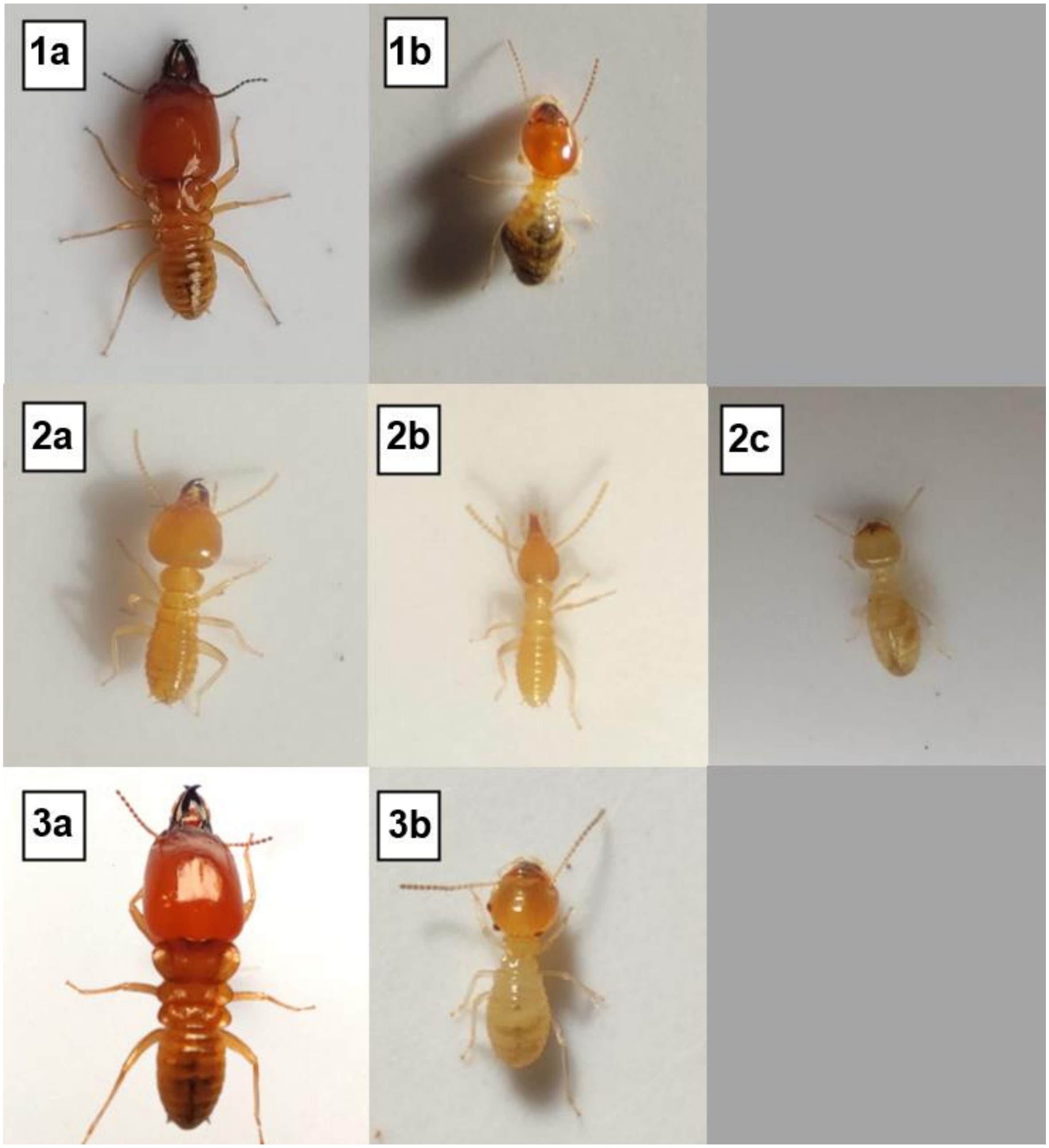


Figure 4 1a) Soldier of *Macrotermes gilvus*, 1b) *Macrotermes gilvus* worker, 2a) Foremost soldier of *Schedorhinotermes intermedius*, 2b) Minor soldier of *Schedorhinotermes intermedius*, 2c) *Schedorhinotermes intermedius* worker, 3a) Soldier of *Macrotermes gilvus,* 3b) *Macrotermes gilvus* worker

4. CONCLUSION

The study findings indicate that two of the three established termite stations in Barangay Pinatilan, Valencia City, exhibited consistent outcomes in morphometric measurements and type of termite species. Specifically, both Station 1 and Station 3 were found to be inhabited by *Macrotermes gilvus* termites. Conversely, Station 2 was observed to be populated by *Schedorhinotermes intermedius* termites. Through meticulous investigations, the collected data suggests that each termite station possesses distinct ecological parameters represented by numerical values. This implies that the termite species discovered in this area thrive under specific environmental conditions. Describing their ecological preferences helps comprehend behavior, distribution, and survival, enabling effective management strategies. Documenting termite microhabitats offers insights into nesting and feeding preferences, aiding in hotspot identification and control measures. Moreover, these data provide valuable insights for humans to comprehend the autecology of these termite species. Further termite species found in different stations

Acknowledgment
The authors would like to express their heartfelt appreciation to the individuals who played a significant role in the completion of this research project. Firstly, we would like to extend our deepest gratitude to Doctor Jan Sobotnik for his invaluable expertise in identifying the termite species. His profound knowledge of termite identification greatly enriched our understanding. To Mr. Dave Mohagan for sharing his thoughts and ideas about termite micro-habitat. We would also like to thank Virginia Orevillo for her diligent assistance in collecting termite samples, ensuring the accuracy of our data. Nelly Monton and Letecia Torculas deserve special thanks for their support in providing the necessary materials for the collections. Additionally, Francisco Mutia, Sarah Jean Torculas, and Armando Alabado graciously allowed us to conduct our studies in their residences. Their cooperation and hospitality were invaluable. Their contributions and support were crucial to completing this research project.

Author's Contribution
This study was a collaborative effort involving all authors. The study's design and statistical analysis were conducted by Author MVO, who also wrote the study protocol and the initial version of the manuscript. Supervisors of the project, Authors ABM oversaw the work. Additionally, Authors MVO and ABM conducted literature searches and managed laboratory work. The final manuscript was reviewed and approved by all authors.

Informed consent
Not applicable.

Ethical approval & declaration
In this article, as per the animal regulations in Department of Animal Biology, Central Mindanao University, Philippines, the authors observed the foraging behavior, ecology, and morphology of Termite species in Barangay Pinatilan, Philippines. The Animal ethical guidelines are followed in the study for species observation, identification & experimentation.

Conflicts of interests
The authors declare that there are no conflicts of interest.

Funding
The study has not received any external funding.

Data and materials availability
All data associated with this study are present in the paper.

REFERENCES AND NOTES

1. Bignell DE, Eggleton P. Termites in ecosystems. Termites: evolution, sociality, symbioses, ecology 2000; 363-87. doi: 10.1007/978-94-017-3223-9_17
2. Bignell DE. Termite ecology in the first two decades of the 21st century: a review of reviews. Insects 2019; 10(3):60. doi: 10.3390/insects10030060
3. Bignell DE. Termites as soil engineers and soil processors. In Intestinal microorganisms of termites and other invertebrates 2006; 183-220. Berlin, Heidelberg: Springer Berlin Heidelberg. doi: 10.1007/3-540-28185-1_8
4. Enagbonma BJ, Babalola OO. Potentials of termite mound soil bacteria in ecosystem engineering for sustainable agriculture. Ann Microbiol 2019; 69:211-219. doi: 10.1007/s13213-019-1439-2
5. Hyodo F, Inoue T, Azuma JI, Tayasu I, Abe T. Role of the mutualistic fungus in lignin degradation in the fungus-growing termite Macrotermes gilvus (Isoptera; Macrotermitinae). Soil Biol Biochem 2000; 32(5):653-8. doi: 10.1016/S0038-0717(99)00192-3
6. Korb J. Termite mound architecture, from function to construction. Biology of termites: a modern synthesis 2011; 3: 49-73. doi: 10.1007/978-90-481-3977-4_13
7. Korb J. Thermoregulation and ventilation of termite mounds. Naturwissenschaften 2003; 90:212-9. doi: 10.1007/s00114-002-0401-4

8. Ladley D, Bullock S. The role of logistic constraints in termite construction of chambers and tunnels. J Theor Biol 2005; 234 (4):551-64. doi: 10.1016/j.jtbi.2004.12.012
9. Martin MM. The evolution of cellulose digestion in insects. Philosophical Transactions of the Royal Society of London. Series B: Biol Sci 1991; 333(1267):281-8. doi: 10.1098/rstb.1991.0078
10. Miller DM. Subterranean termite biology and behavior. Virginia Cooperative Extension Publication 2010; 444-502.
11. Noirot C, Darlington JP. Termite nests: architecture, regulation and defence. Termites: evolution, sociality, symbioses, ecology. New York: Springer 2000; 121-39. doi: 10.1007/978-94-017-3223-9_6
12. Ohkuma M, Maeda Y, Johjima T, Kudo T. Lignin degradation and roles of white rot fungi: Study on an efficient symbiotic system in fungus-growing termites and its application to bioremediation. Riken Review 2001; 39-42.
13. Schmidt S, Kildgaard S, Guo H, Beemelmanns C, Poulsen M. The chemical ecology of the fungus-farming termite symbiosis. Nat Prod Rep 2022; 39(2):231-48. doi: 10.1039/D1NP00022E
14. Traniello JF, Leuthold RH. Behavior and ecology of foraging in termites. Termites: evolution, sociality, symbioses, ecology. Dordrecht: Kluwer Academic 2000; 141-68. doi: 10.1007/978-94-017-3223-9_7
15. Woodrow RJ, Grace JK, Yates III JR. Hawaii's Termites: An Identification Guide. Cooperative Extension Service 1999.
16. Zachariah N, Singh S, Murthy TG, Borges RM. Bi-layered architecture facilitates high strength and ventilation in nest mounds of fungus-farming termites. Sci Rep 2020; 10(1):13157. doi: 10.1038/s41598-020-70058-2