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Research Paper

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DIVERSITY OF SMALL NON-VOLANT MAMMALS IN THE CENTER FOR ECOLOGICAL DEVELOPMENT AND RECREATION (CEDAR), BUKIDNON, PHILIPPINES

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ARTICLE HIGLIGHTS

- Six murid rodent species, including one endemic and five non-native species, were recorded in CEDAR, Bukidnon.
- Semi-natural habitats were dominated by endemic (*Rattus* cf. *everetti*), while human-modified habitats were dominated by non-native rodents.
- Human-modified habitats had higher rodent diversity than semi-natural habitats.
- *Rattus tanezumi* and *Rattus* cf. *exulans* adapted to both habitat types.
- Semi-natural habitats are vital for conserving native rodent diversity.

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ABSTRACT

This study assessed the diversity and species composition of murid rodents in two habitat types: semi-natural and human-modified within the Center for Ecological Development and Recreation (CEDAR) in Impasug-ong, Bukidnon, Philippines. A total of 640 trap nights were conducted using live traps across both habitats, yielding six (6) rodent species: one (1) native (*Rattus* cf *everetti*) and five (5) non-native species (*Rattus* cf *exulans*, *Rattus* cf *norvegicus*, *Rattus tanezumi, Mus musculus*, and an undetermined *Rattus* species). Station 1 (semi-natural habitat) was dominated by the native species, while Station 2 (human-modified habitat) was dominated by non-native species. Diversity analysis using the Shannon-Wiener Index showed higher diversity in the human-modified habitat (H' = 1.280) compared to the semi-natural habitat (H' = 1.004), supporting the hypothesis that habitat modification influences rodent diversity. The exclusive presence of *R.* cf. *everetti* in the semi-natural habitat emphasizes the sensitivity of native species to disturbance, while *R. tanezumi* and *R.* cf. *exulans* were found in both habitats, indicating their adaptability to varied environments. These findings support the hypothesis that habitat modification influences rodent diversity, and human-modified habitats are more species rich dominated by non-native species. The study highlights the importance of conserving semi-natural habitats and highlights the utility of rodents as bioindicators for assessing ecological integrity in forest habitats. The study recommends broader mammalian surveys, wildlife monitoring, and the regulation of wildlife reintroduction in CEDAR.

Keywords: conservation, Mindanao, Muridae, rodents, species diversity

INTRODUCTION

Despite having a smaller land area, the Philippines exhibits a high-level mammalian endemicity (Balete *et al.* 2008, 2009; Rickart *et al.* 2011). The Philippines has one of the highest densities of endemic mammalian species in the world (Heaney *et al.* 2010; Rickart *et al.* 2011). Moreover, these unique species are found significantly within the Greater Mindanao ecoregion (Heaney *et al.* 2006). Amongst the Philippine mammals, rodents under the Muridae family make up more than one-third of land mammals. As such, they are one of the mammalian taxa that undergo high diversification (Singleton *et al.* 2007; Ong & Rickart 2008).

Mammalian fauna is among the most threatened in the world, and global biodiversity is quickly declining (Ong & Rickart 2008; Rickart *et al.* 2011). The Philippines has likewise seen a significant decline in its species and habitat. Human activities and habitat modifications and fragmentation of forest habitats are strongly linked to this rapid decrease in wildlife (Reginaldo & Ong 2020). Moreover, habitat specialization contributes to an increase in the loss of species. Some species of rodents, specifically native species, are highly habitat-specific and are directly affected by the habitat alterations conducted in the area. In disturbed areas, the level of adaptation of species depends on the ecological specialization that determines the species' susceptibility to disturbance, along with the species' capacity to adapt to altered habitats (Martínez *et al.* 2004; Rickart *et al.* 2011; Püttker *et al.* 2013; Reginaldo & Ong 2020).

The presence of non-native species in natural forests affects the richness and diversity of native species. The non-native species' range is often found in disturbed habitats rather than main forest regions. The presence of large populations of non-native species in the forest indicates an ecological imbalance within the habitat. Healthy forest habitats provide native rodents an advantage and limit the infiltration of non-native species. Therefore, rodent populations, both native and non-native, are excellent indicators of forest conditions, especially when there is a presence of disturbance within habitats (Aplin *et al.* 2003; Rickart *et al.* 2007; Salibay & Luyon 2008).

The Center for Ecological Development and Recreation (CEDAR) is an example of an area that undergoes habitat alteration. Along with its growing recognition as an ecotourism destination, habitat alteration, including the building of infrastructure such as cabins and covered courts and recreation facilities like swimming pools and cottages became prominent. Thus, disrupting the natural forest landscapes as well as the rodent assemblage in the area. In the case of CEDAR, the full extent of the influence and effect of habitat modification on the diversity of rodents has not been investigated in semi-natural habitat and human-modified habitat. Moreover, there are no data available or published studies on the diversity of rodents. As a result, there is a knowledge gap regarding rodent species assemblage across two habitat types. As well as the potential impacts of habitat modification in the area. It is hypothesized that habitat modification influences the diversity of rodents. The human-modified habitat is more species-rich and diverse in comparison to the semi-natural habitat. The study aimed to determine the species composition, species richness, and diversity of rodents and compare the diversity of rodents between two habitat types.

MATERIALS AND METHODS

Place and Duration of the Study

The study was conducted in the Center for Ecological Development and Recreation (CEDAR), a protected area located in Barangay Impalutao, Impasug-ong, Bukidnon (Fig. 1). All required government authorizations were secured prior to the study, including approval from the Municipal Mayor and the Municipal Environment and Natural Resources Office (MENRO) of Malaybalay City, as well as a Gratuitous Permit (No. R10202333) issued by the Department of Environment and Natural Resources (DENR) Region X.

A total of 16 days during the month of March and April 2023 were spent in the sampling of rodents. The unit of sampling effort for this study uses the trap night, which is defined as one baited trap installed for 24 hours (Balete *et al.* 2013). Throughout the duration of this study, a total of 640 trap nights were covered across the two habitat types. Trap success, calculated as the percentage of traps that successfully captured rodents. Station 1 recorded 26 captures (8.13% success) and Station 2 recorded 24 captures (7.50% success). Overall, 50 captures were recorded from 640 trap nights, resulting in an overall trap success rate of 7.81%. Weather during the sampling period varied, as trapping was conducted weekly under both rainy and dry conditions, which may have influenced capture rates.

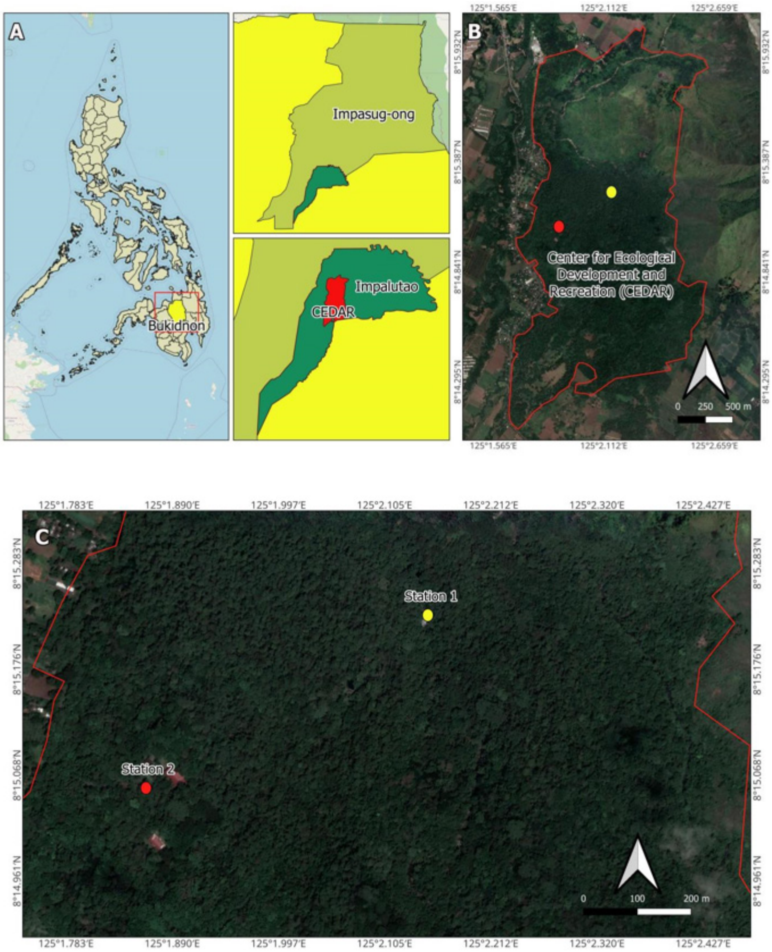

Figure 1 Map of study location

Notes: (A) Inset map of Impalutao, Impasug-ong, Bukidnon, Philippines; (B) CEDAR Border; and (C) Location of study sites.

Figure 2 Actual photos of the two habitat types present in CEDAR

Notes: A & B. Station 1 (Semi-natural habitat); C & D. Station 2 (Human-modified habitat).

Establishment of Sampling Stations

The habitat types present in CEDAR were classified upon field reconnaissance following the criteria of Mallari *et al.* (2011), which define habitat types as cultivation areas, early secondary growth, advanced secondary growth, and old-growth forests based on vegetation structure. Two sampling stations were examined in CEDAR based on their habitat types: Station 1 – Semi-natural habitat (Fig. 2 A&B) and Station 2 – Human-modified habitat (Fig. 2 C&D).

Station 1 is a semi-natural habitat dominated by *Shorea* spp., with an elevation ranging from 762 to 784 masl. Station 2 is a human-modified habitat comprised of early secondary-growth forests consisting of newly regenerating forests less than 20 years old, characterized by saplings and several small to medium-sized trees. Its elevation ranges from 773 to 796 masl. In addition, Station 2 is within tourist destinations and human settlements, including houses, swimming pools, and camping grounds.

Sampling Techniques

Following the methods of Balete *et al.* (2013), 40 live traps measuring 11 cm x 11 cm x 23 cm and 15 cm x 15 cm x 30 cm were used in the sampling of rodents (Balete *et al.* 2013; Reginaldo & Ong 2020). The traps were strategically placed near entrances of burrows, fallen trees, and roots 5 – 10 meters apart (Heaney 2001; Balete *et al.* 2008, 2009).

For each station, a total of 20 traps were placed (Balete *et al.* 2013; Villancio *et al.* 2020). Furthermore, trap lines which are the route along which a series of traps were set are maintained and subjected to change location after the third day (Heaney 2001; Balete *et al.* 2009; Rickart *et al.* 2011). Marking the installed traps using neon-colored cloth was done to facilitate easy retrieval or resetting (Salibay & Luyon 2008). The traps were baited with small bits of roasted coconuts coated with peanut butter, live earthworms, and banana before dusk and were checked in the early morning the following day (Heaney 2001; Heaney *et al.* 2006; Balete *et al.* 2008, 2009; Rickart *et al.* 2011). Checking, re-baiting, and collection of captured rodents was conducted twice a day, i.e., at 5:00 AM – 7:00 AM, and at (4:00 PM – 6:00 PM) (Balete *et al.* 2008, 2009; Guaza *et al.* 2016).

Capture, Mark, and Release

Captured rodents were immobilized using cloth bags following Salibay and Luyon (2008). The rodents were placed inside a cloth bag and gently guided toward the tip of the bag until they were cornered. The rodent was held firmly but carefully to minimize movement, ensuring both safe handling and accurate measurements. Once secured, the bag was opened to expose the rodent's body for morphometric measurements. This method restricts the rodent's ability to struggle excessively, allowing safe handling and accurate morphological measurements. To avoid duplication in the record, recaptured individuals were marked by cutting a small portion of fur near the tail (Reginaldo & Ong 2020).

Species Identification

Identification and classification of species were carried out based on Heaney *et al.* (2002), Heaney *et al.* (1998), and other existing literature, checklist, and guides online (Balete *et al.* 2013). Sex classification and morphometrics were taken following the morphometrics guide on rodents adopted from Heaney *et al.* (2006) and the Guide on morphometrics on head + body, tail, pes, and ear length adopted from Aplin *et al.* (2003).

The measurements included the: 1) Head + body length; 2) Tail length; 3) Hind foot length; 4) Ear length; 5) Weight; 6) Color and texture of the fur; 7) Position of the pads in the soles of the feet; 8) Distinguishing characteristics such as color and length of the vibrissae (whiskers), size and color of the incisor teeth, detailed patterning and hairiness of the tail (Aplin *et al.* 2003; Heaney *et al.* 2006; Balete *et al.* 2008; Guaza *et al.* 2016). The unit of measurement was in millimeters (mm) and grams (g). Digital calipers, weighing scales, a tape measure, a pencil, and a record book were used (Heaney *et al.* 2006). Moreover, the taxonomic classification and identification of specimens were confirmed by Dr. Mariano Roy Duya of the University of the Philippines, Diliman.

Collection and Preservation of Voucher Specimens

A total of three representative members of each species were collected as voucher specimens (Munian *et al.* 2020). Following the 2016 Guidelines of the American Society of Mammalogists, euthanasia or humane killing was done by placing the rodents in a killing jar with a cloth soaked in ethyl acetate (Sikes & Animal Care and Use Committee of the American Society of Mammalogists 2016).

In processing the voucher specimens, saturated formalin solution was injected into the shoulders, thighs, neck, and chest cavity (Aplin *et al.* 2003; Heaney *et al.* 2006; Balete *et al.* 2008, 2009, 2013). The voucher specimen was placed in 10% formalin solution and later transferred to 70% ethanol (Aplin *et al.* 2003; Heaney *et al.* 2006; Balete *et al.* 2008, 2009, 2013).

Rarefaction and Extrapolation of Diversity

To test if the sampling is adequate to capture all of the species within the sampling sites, species accumulation curves were used (Reginaldo & de Guia 2014). Calculating species accumulation rates for each sampling location assesses the effectiveness of the study. This is the best indication of the thoroughness of sampling for species richness of small mammals in any location where pre-existing knowledge is poor or nonexistent, as in much of the Philippines (Heaney 2001; Rickart *et al.* 2007; Balete *et al.* 2008, 2009, 2011).

Species accumulation curves were calculated using iNEXT Online with 95% confidence level, to evaluate the sampling effort and to ensure the sampling adequacy for small non-volant mammal assemblages in the two habitat types in CEDAR (Chao *et al.* 2014; Chao *et al.* 2016; Munian *et al.* 2020). Microsoft Excel was employed to calculate the Shannon-Wiener Diversity Index (H') which determined the diversity of the rodents, using the following formula (Shannon & Wiener 1946).

$$H' = \sum[(pi)\times\ln(pi)]$$

where:

H' = the species diversity index
Σ = the sum of the calculations
pi = the proportion of individuals of each species belonging to the ith species of the total number of individuals.
ln = the natural log

RESULTS AND DISCUSSION

Species Composition and Richness of Rodents

A total of six murid rodent species belonging to two genera were recorded in the Center for Ecological Development and Recreation (CEDAR). In terms of ecological distribution, *Rattus* cf *everetti* Günther, 1879, was the only native rodent recorded in CEDAR. The other five species were non-native, these included *Mus musculus* Linnaeus, 1758; *Rattus* cf *exulans* Peale, 1848; *Rattus* cf *norvegicus* Berkenhout, 1769; *Rattus tanezumi* Temminck, 1845; and one undetermined species of *Rattus* sp. (Fig. 3).

A total of 320 trap nights were conducted in each sampling station. In Station 1, three (3) species were recorded with a total of 26 captures while in Station 2, five (5) species of rodents were recorded with a total of 24 captures. Both natives (14 individuals) and non-natives (12 individuals) were present in Station 1 and only non-natives (24 individuals) were in Station 2 (Table 1).

The *R. everetti* is a native species known to be geographically widespread in the Philippines, and they are known to inhabit different types of habitats (Balete *et al.* 2008; Balete *et al.* 2009; Rickart *et al.* 2011). According to Rickart *et al.* (2007), native species are dependent on and closely associated with relatively undisturbed habitats. This explains the absence of native species in Station 2 (human-modified habitat), where disturbances and anthropogenic activities are very high (Table 1). Moreover, the relationship between natives and non-natives is known to be inversely proportional, wherein the high species richness of non-natives may result in the low species richness of natives as a result of ecological invasion and competition (Rickart *et al.* 2007).

On the other hand, Station 2 had the greatest number of non-native murid rodent species (24 individuals) with *R. tanezumi* as the most abundant non-native species (11 individuals). *R. tanezumi* is a commensal species widespread throughout the Philippines (Heaney *et al.* 2006). Although they occur abundantly in close association with humans, they are sometimes common in disturbed forests (Heaney *et al.* 2006; Rickart *et al.* 2011). Furthermore, according to Rickart *et al.* (2007), non-native species can also thrive in forest habitats, hence explaining the presence of these species in Station 1.

As such, Station 1 was dominated by native murid rodent species while Station 2 was dominated by non-native murid rodent species (Table 1). This pattern was likewise observed in Mt. Hamiguitan, Eastern Mindanao (Balete *et al.* 2008) and different mountain ecosystems in Luzon, i.e., Balbalasang (Kalinga), Mt. Bahanaw (Quezon), and Mt. Natib (Bataan) (Rickart *et al.* 2007).

Although non-native species typically inhabit disturbed habitats, their presence in the intact forest may indicate their capacity for invasive dispersal (Rickart *et al.* 2007). In CEDAR, *R. tanezumi* and *R.* cf *exulans*, for example, were present in both stations. The aforementioned species are known to be widely distributed in agroecosystems and disturbed forests (Rickart *et al.* 2007). Non-native species dwell in disturbed areas, and native species tend to thrive in forests with low to moderate disturbances.

According to Rickart *et al.* (2011), diversity patterns and abundance of species have frequently been attributed to level of disturbance in a habitat. Accordingly, there is a significant effect on the richness of rodent species and their response to such disturbance. Furthermore, the variety of native species is highest in a comparatively unaltered habitat, and it decreases as disturbance levels rise. Thus, the level of disturbance in an area is crucial for the survival of native species. For example, the Philippine endemic species such as *Tupaia everetti* and *Baletemys kampalili* are highly dependent on undisturbed habitats (Rowsey *et al.* 2022; Senarillos & Ibañez 2023).

In terms of abundance, a total of 50 individuals were captured from the 640 trap nights covering the two sampling stations. In Station 1 (semi-natural habitat), *R.* cf *everetti* (14 individuals) had the greatest number of individuals, followed by *R. tanezumi* (7 individuals), and *R.* cf *exulans* (5 individuals). On the other hand, in Station 2 (human-modified habitat), *R. tanezumi* (11 individuals) had the greatest number of individuals, followed by *R.* cf *norvegicus* (7 individuals), *R.* cf *exulans* (4 individuals), *R.* sp. (1 individual), and *M. musculus* (1 individual). All of the native murid rodent species were restricted in station 1 (14 individuals) while the non-natives appeared to be present in both stations (36 individuals) (Fig. 4).

Figure 3 Rodent species in CEDAR
Notes: A. *Rattus* cf *everetti*; B. *Rattus tanezumi*; C. *Rattus* sp.; D. *Mus musculus*; E. *Rattus* cf *norvegicus*; F. *Rattus* cf *exulans*.

Table 1 Species composition and richness of murid rodents in the two habitat types in CEDAR

Family	Scientific name	Common name	Station 1	Station 2
			Semi-natural habitat	**Human-modified habitat**
Muridae	*Mus musculus* Linnaeus, 1758	House mouse	0	1
Muridae	*Rattus* cf *exulans* Peale, 1848	Polynesian rat	5	4
Muridae	*Rattus* cf *everetti* Günther, 1879	Philippine forest rat	14	0
Muridae	*Rattus* cf *norvegicus* Berkenhout, 1769	Norway rat	0	7
Muridae	*Rattus tanezumi* Temminck, 1845	Oriental house rat	7	11
Muridae	*Rattus* sp.		0	1
		TOTAL	**26**	**24**
		Total Trap nights	320	320
		Number of native individuals	14	0
		Number of non-native individuals	12	24

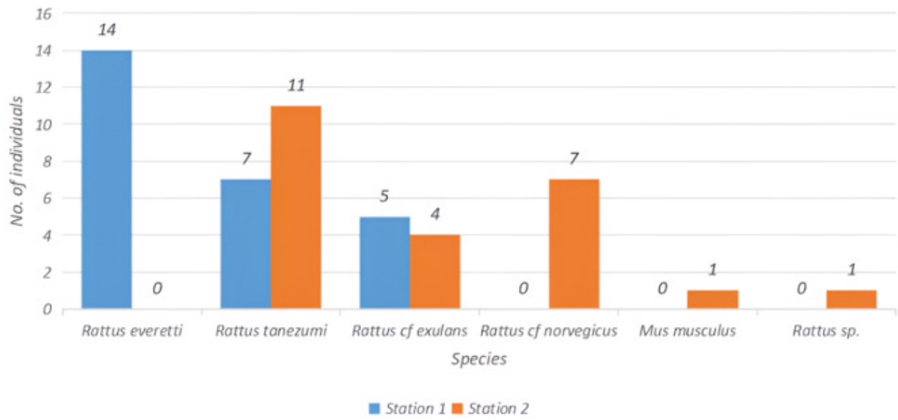

Figure 4 Species richness and abundance of rodents in two habitat types in CEDAR

One factor that affects the species richness and abundance of rodents is the vegetation characteristics, availability, and variations of resources (particularly food) that the organisms may use (Heaney 2001; Mayamba *et al.* 2020). Station 1 primarily supports native rodent species due to the presence of abundant natural food resources and suitable habitat structure. Observed potential food sources include seeds and fruits from dominant dipterocarp trees (*Shorea* spp.) and plant material from vines and grasses such as *Bambusa* sp., which likely serve as natural foods for *R.* cf *everetti*. In addition, *R.* cf *everetti* is omnivorous and may also consume insects and other small invertebrates in the habitat (Miller *et al.* 2008). These resources, along with dense vegetation providing shelter, create favorable conditions for native rodents that depend on intact forest environments (Heaney 2001). However, some non-native species, such as *R.* cf *exulans* and *R. tanezumi*, were also recorded in Station 1. These species, typically associated with human-altered habitats, are capable of dispersing into relatively undisturbed forests as long as sufficient food resources are available (Rickart *et al.* 2007, 2011). Their presence in Station 1 likely reflects their ecological flexibility and ability to exploit natural food resources in the forest.

Moreover, soil characteristics and composition played a major role in the abundance of rodents, wherein a range of vegetative plants provide food and cover to the rodents and hence, increase the survival and abundance of rodents in an area (Mayamba *et al.* 2020). Although soil characteristics were not directly analyzed in this study, their influence on rodent richness and abundance can be inferred through vegetation structure, prey availability, and species ecology. Productive soils support dense vegetation and seed- and fruit-producing plants, which provide food and shelter for native rodents such as *R.* cf *everetti*. High natural food availability associated with productive soils supports diverse and abundant plant and invertebrate resources, which in turn influence the composition and distribution of rodent communities. These observations support the role of soil characteristics as an indirect but important factor shaping rodent assemblages, consistent with previous studies (Heaney 2001; Mayamba *et al.* 2020).

Trap success in the study area was 7.81%, with 26 captures recorded in Station 1 (8.13%) and 24 captures in Station 2 (7.50%) over 640 trap nights. The similarity in trap success between stations suggests comparable habitat conditions and resource availability. The productivity in both stations likely supports abundant natural food resources, which may influence rodent foraging behavior, particularly for species with specific dietary preferences. According to Mohd-Taib & Ishak (2021), the amount of food in the field also has an impact on the success of the trapping since an abundance of food sources may lower the likelihood that the animal will be caught, especially if the type of bait being employed is widely accessible in the region. Thus, forest productivity has a major impact on the existence and quantity of animals. This finding supports the notion that native Philippine animals depend on and are reliant on their native forest habitat for food and resources (Heaney *et al.* 1998; Guaza *et al.* 2016). For example, *Crocidura grayi* and *Chrotomys gonzalesi* exhibit a strong preference for earthworms (Heaney 2001; Balete *et al.* 2009). This strongly suggests that species having specific diets and preferences will contribute to the presence or absence of a certain species in a specific habitat (Heaney 2001).

Another factor that affects that influence the richness and distribution of rodents is the presence of competition in an area. According to Heaney *et al.* (2001), arthropod competitors such as ants and small mammals compete heavily for food resources. Lastly, weather such as rain does not affect the richness and abundance of rodents. However, according to Mayamba *et al.* (2020), distinct seasonal differences between the wet and dry seasons could influence the distribution of rodents, leading to variations in rodent populations in the area.

Interestingly, CEDAR recorded a higher species richness compared to other rodent studies in some notable mountains of Mindanao such as Mt. Hamiguitan (4 species) (Balete *et al.* 2006); Mt. Hamiguitan Range Wildlife Sanctuary expansion sites (4 species) (Amoroso *et al.* 2019); Mt. Arayat (3 species) (Villancio *et al.* 2020); Mt. Kongking (2 species) (Villancio *et al.* 2020) and Mt. Malindang (2 species) (Mohagan *et al.* 2015) (Fig. 5).

Since the high species richness of rodents in CEDAR is mainly due to the dominance of non-native rodent populations, the proximity of human settlements and agroecosystems may explain the higher number of species when compared to other sites in Mindanao. Some non-natives such as *R. exulans* and *R. tanezumi*, are typically found in farms or agroecosystems and other human-altered habitats. However, these rodents were able to disperse and establish themselves in relatively undisturbed forest habitats (Rickart *et al.* 2007; 2011). Another factor affecting species richness and abundance of rodents in CEDAR is the rate of maturation and reproduction of non-natives which are abundant in the study sites. Non-native rodent species reproduce rapidly and produce large litters, which allows them to spread and establish populations in both semi-natural and human-modified habitats (Rickart *et al.* 2007).

Rarefaction Curve/Species Accumulation Curve Analysis

Individual-based rarefaction and extrapolation curves show that Station 1 tends to be an asymptote and reaches a plateau; hence, sampling effort was enough. The solid lines show the number of actual individuals recorded, and the broken lines are the expected direction if the sampling continues. However, for Station 2 there is a need for additional sampling since the curve is still approaching upwards and does not show a plateau (Fig. 6). According to Balete *et al.* (2008), to accurately describe and record patterns of species diversity and abundance in environments, longer-term sampling may be required.

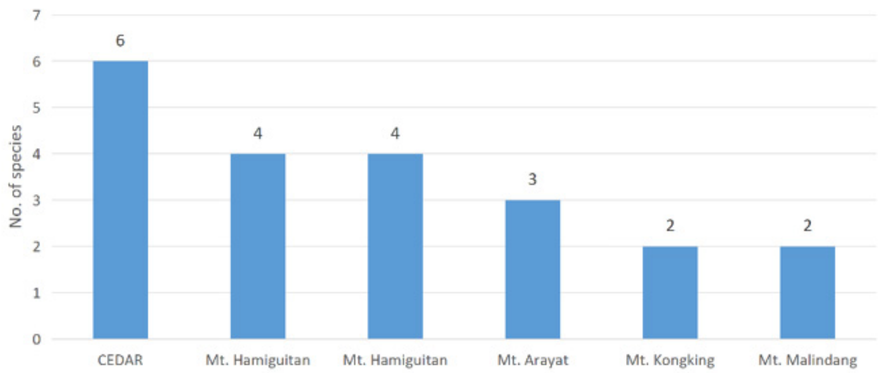

Figure 5 Comparison of species richness of rodents in Mindanao

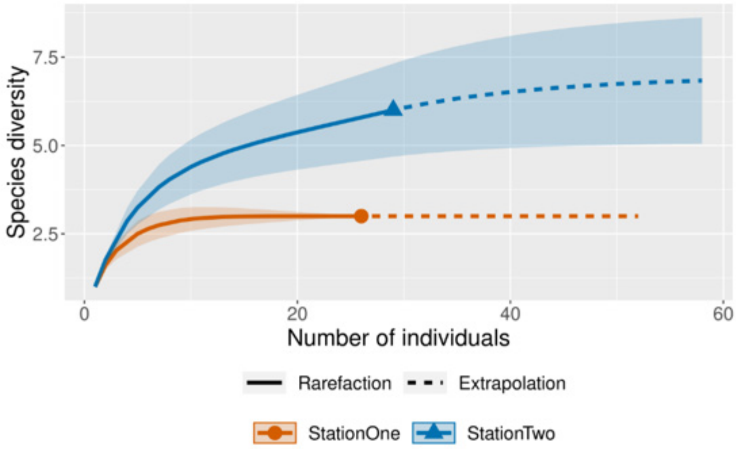

Figure 6 Individual-based rarefaction and extrapolation (R/E) curves for the rodents among habitat types in CEDAR

Notes: Species richness was generated using iNEXT q = 0; Chao1 in iNEXT online software, represented by solid lines (interpolation) and dashed lines (estimated extrapolation) with a 95% confidence level.

Table 2 Shannon-Wiener diversity index of rodent species in CEDAR

Shannon-Wiener diversity index	Station 1 (Semi-natural habitat)	Station 2 (Human-modified habitat)	Overall diversity
H’	1.004	1.280	1.465

Shannon-Weiner Diversity Index Analysis

As predicted, Station 2 (human-modified habitat) with H' = 1.280 had a higher diversity index value compared to station 1 (semi-natural habitat) with H’ = 1.004 (Table 2). This may be explained by the higher species richness and abundance of murid rodents in Station 2.

Furthermore, diversity patterns and abundance of species have frequently been attributed to the level of disturbance in a habitat. Moreover, Station 2 (human-modified habitat) had a significant level of disturbance attributed to the abundance of non-native species in the area. The overall mammalian diversity in CEDAR (H’ = 1.465) showed to be higher than the study of Amoroso *et al.* (2019) in Mt. Hamiguitan, Bukidnon (H’ = 0.615) and Mohagan *et al.* (2015) in Mt. Apo (H’ = 0.741), Mt. Kitanglad (H’ = 0.487), Mt. Hamiguitan (H’ = 0.603), and Mt. Malindang (H’ = 0.61). The results of the study imply the importance of comparative surveys along disturbance gradients which could provide useful insights into the ecology of mammals in the understudied ecosystems as well as in the impact of human modification on the natural landscapes.

CONCLUSION

The study demonstrated that habitat modification significantly influences rodent diversity and species composition in the Center for Ecological Development and Recreation (CEDAR), Bukidnon, Philippines. Human-modified habitats supported a higher diversity of rodents but were predominantly occupied by non-native, generalist species, whereas semi-natural habitats provided important refuges for native rodents, particularly *Rattus* cf. *everetti*. These findings highlight the ecological consequences of anthropogenic disturbance, which favors adaptable non-native species while reducing the occurrence of habitat-specialist native species. The study reinforces the importance of conserving semi-natural forest habitats to protect native biodiversity and maintain ecological integrity. Furthermore, the results support the use of rodents as effective bioindicators for monitoring habitat quality and environmental change in tropical forest ecosystems. Continued long-term biodiversity monitoring and broader mammalian surveys will be essential for informing conservation stratiegies and sustainable management practices within CEDAR.

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REFERENCES

Amoroso V, Mohagan A, Coritico F, Laraga S, Lagunday N, Domingo KL, …, Ponce R. 2019. Status of mammals in the expansion sites of the Mt. Hamiguitan range wildlife sanctuary, Mindanao, JESAM 22(2):6–12. DOI: 10.47125/jesam/2019_2/02

Aplin KP, Brown PR, Jacob J, Krebs CJ, Singleton GR. 2003. Field methods for rodent studies in Asia and the Indo-Pacific. ACIAR (No. 435-2016-33720).

Balete DS, Heaney LR, Alviola PA, Rickart EA. 2013. Diversity and distribution of small mammals in the Bicol Volcanic Belt of southern Luzon Island, Philippines. J Nat Hist Mus 1:61–86.

Balete DS, Heaney LR, Veluz MJ, Rickart EA. 2009. Diversity patterns of small mammals in the Zambales Mts., Luzon, Philippines. Mamm Biol 74(6):456–466. DOI: 10.1016/j.mambio.2008.05.006

Balete DS, Quidlat RS, Ibañez JC. 2008. The non-volant mammals of Mt. Hamiguitan, Eastern Mindanao, Philippine. BNat Sci 3(1&2):65–80.

Chao A, Gotelli NJ, Hsieh TC, Sander EL, Ma KH, Colwell RK, Ellison AM. 2014. Rarefaction and extrapolation with Hill Numbers: A framework for sampling and estimation in species diversity studies. Ecol Monogr 84(1):45–67. DOI: 10.1890/13-0133.1

Chao A, Ma KH, Hsieh TC. 2016. User's guide for iNEXT online: Software for interpolation and Extrapolation of species diversity. Inst. Stat. Available from: http://chao. stat. nthu. edu. tw/wordpress/software_download.

Guaza MCP, Yap KML, Singson SGT, Nor SP, Amado RL, Torres MAJ, …, Requieron EA. 2016. Comparative diversity and composition of small non-volant mammals in areas found on Soccsksargen Region, Philippines. JBES 8(2):255 –264.

Heaney LR. 1998. A synopsis of the mammalian fauna of the Philippine Islands. Fieldiana. Zoology New Series 88:1 –61.

Heaney LR. 2001. Small mammal diversity along elevational gradients in the Philippines: An assessment of patterns and hypotheses. Glob Ecol Biogeogr 10(1):15 –39. DOI: 10.1046/j.1466-822x.2001.00227.x

Heaney LR, Ingle NR, Sedlock JL, Tabaranza Jr BR. 2002. Nonflying mammals of Mindanao Island, Philippines. Environ Conserv Prog the Field Museum 1(1):1–2.

Heaney LR, Tabaranza Jr BR, Rickart EA, Balete DS, Ingle NR. 2006. The mammals of Mt. Kitanglad Nature Park, Mindanao,Philippines.FieldianaZool2006(112):1–63.DOI: 10.3158/0015-0754(2006)186[1:TMOMKN]2.0.CO;2

Mallari NAD, Collar NJ, Lee DC, McGowan PJ, Wilkinson R, Marsden SJ. 2011. Population densities of understorey birds across a habitat gradient in Palawan, Philippines: Implications for conservation. Oryx 45(2):234 –242.

Martínez JJ, Millien V, Simone I, Priotto JW. 2014. Ecological preference between generalist and specialist rodents: spatial and environmental correlates of phenotypic variation. Biol J Linn Soc 112(1):180–203. DOI: 10.1111/bij.12268

Mayamba A, Byamungu RM, Broecke BV, Leirs H, Hieronimo P, Nakiyemba A, …, Mulungu LS. 2020. Factors influencing the distribution and abundance of small rodent pest species in agricultural landscapes in Eastern Uganda. J Vertebr Biol 69(2):20002-1. DOI: 10.25225/jvb.20002

Miller RW, Stuart AM, Joshi RC, Banks PB, Singleton GR. 2008. Biology and management of rodent communities in complex agroecosystems-rice terraces. Philippine rats: ecology & management. PhilRice. Science City of Muñoz, Nueva Ecija, Philippines. p. 25–36.

Mohagan AB, Nuneza OM, Escarlos JJ, Gracia AJ, Selpa ECT, Baguhin LJB, Amoroso VB. 2015. Diversity and endemism of terrestrial mammals in four long term ecological research sites in Mindanao, Philippines.

Mohd-Taib FS, Ishak SN. 2021. Bait preferences by different small mammal assemblages for effective cage-trapping. Malaysian J of Sci 40(2):1-15. DOI: 10.22452/mjs.vol40no2.1

Munian K, Azman SM, Ruzman NA, Fauzi NFM, Zakaria AN. 2020. Diversity and composition of volant and non-volant small mammals in northern Selangor State Park and adjacent forest of Peninsular Malaysia. Biodivers Data J 8. DOI: 10.3897/BDJ.8. e50304.

Püttker T, Bueno AA, dos Santos de Barros C, Sommer S, Pardini R. 2013. Habitat specialization interacts with habitat amount to determine dispersal success of rodents in fragmented landscapes. J Mammal 94(3):714–726. DOI: 10.1644/12-MAMM-A-119.1

Reginaldo AA, de Guia APO. 2014. Species richness and patterns of occurrence of small non-flying mammals of Mt. Sto Tomas, Luzon Island, Philippines. Philipp Sci Lett 7(1):34–44.

Reginaldo AA, Ong PS. 2020. Structure of small non-flying mammal communities in disturbed habitats in the Central Cordillera, Luzon Island, Philippines. Philip Sci Lett 13:81–94.

Rickart EA, Balete DS, Heaney LR. 2007. Habitat disturbance and the ecology of small mammals in the Philippines. JESAM 10(2). Available from: https://www.academia.edu/download/34043108/128__2007__Disturbance_gradients.pdf

Rickart EA, Balete DS, Rowe RJ, Heaney LR. 2011. Mammals of the northern Philippines: Tolerance for habitat disturbance and resistance to invasive species in an endemic insular fauna. Divers Distrib 17(3):530–541. DOI: 10.1111/j.1472-4642.2011. 00758.x

Rowsey DM, Duya MRM, Ibañez JC, Jansa SA, Rickart EA, Heaney LR. 2022. A new genus and species of shrew-like mouse (Rodentia: Muridae) from a new center of endemism in eastern Mindanao, Philippines. J Mammal. DOI: 10.1093/jmammal/gyac057.

Salibay C, Luyon, HAV. 2008. Distribution of native and nonnative rats (*Rattus* spp.) along elevational gradient in a Tropical Rainforest of Southern Luzon, Philippines. Ecotropica 14(2):129–136.

Senarillos TLP, Ibañez JC. 2023. Notes on the Nest Architecture and Nest Site Characteristics of Mindanao Treeshrew (*Tupaia everetti* Thomas, 1892) from Dinagat Islands, Philippines. Philipp J Sci 152(2):725–729. DOI: 10.56899/152.02.18

Sikes RS, Animal Care and Use Committee of the American Society of Mammalogists. 2016. 2016 Guidelines of the American Society of Mammalogists for the use of wild mammals in research and education. J Mammal 97(3):663–688. DOI: 10.1093/jmammal/gyw078

Singleton GR, Brown PR, Jacob J, Aplin KP, Sudarmaji. 2007. Unwanted and unintended effects of culling: A case for ecologically-based rodent management. Integr Zool 2(4):247–259. DOI: 10.1111/j.1749-4877.2007.00067.x

Villancio GG, Duco RA, Labiano G, Beloy JF, Purificacion DM, Bejar SG, …, Austria E. 2020. Volant and small non-volant mammals of Dinagat Island, Philippines. Philipp J Sci 150(S1):443–453. DOI: 10.56899/150.S1.33