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DIVERSITY OF RODENTS AND TREESHREWS IN DIFFERENT HABITATS IN WESTERN SARAWAK, BORNEO

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A diverse community of 63 rodent species and nine treeshrew species are found in Borneo (Phillipps & Phillipps, 2016). They play an important role in providing ecosystem services by contributing to pollination, seed dispersal, and germination; and also food for larger carnivores (Shanahan & Compton, 2000; Morand *et al*., 2006; Payne & Francis, 2007; Phillipps & Phillipps, 2016). Bornean tropical forests have been lost, degraded, and fragmented by anthropogenic activities since the early 1970s (Bryan *et al*., 2013; Gaveau *et al*., 2014), consequently created new or alternative habitats for rodents and treeshrews especially resilient, adaptive, or opportunistic species that can thrive in such disturbed areas while forest-dependent species would decline in number or become locally extinct (Traweger *et al*., 2006; Palmeirim *et al*., 2020).

This study was conducted to determine the species richness and abundance of rodents and treeshrews in four different habitats (i.e. forest, oil palm plantation, rural villages, and urban area) in the western part of Sarawak, Borneo. The data collected from this study is important and useful in contributing new knowledge on the occupancy of anthropogenically created habitats for rodents and treeshrews and gives an insight into how each rodent and treeshrew species responded to human disturbance in term of their species richness and abundance in each habitat type.

Live-trapping using baited cage traps was conducted in the western part of Sarawak (i.e. Bau District, Samarahan District, Serian District, and Kuching City), comprising of a total of seven forests (primary forest, secondary lowland agro-forest, limestone forest, and peat swamp forest), four oil palm plantations, six rural villages, and six urban areas. The trapping session in each habitat type was stopped once the targeted number of 50 or more small mammals were caught. These four habitat types were selected because they are the main landscape in western Sarawak and have been subjected to different degrees of disturbance from a human. Forest sites were categorized as the least disturbed areas and urban sites as the most disturbed areas. Trapped rodents and treeshrews were anesthetized using chloroform (Ng *et al*., 2017). Their morphometric measurements were taken and photographed to aid in species identification. The method of catching rodents and treeshrews generally followed that of Aplin *et al*. (2003). Identification of rodents and treeshrews was according to the field guide by Phillipps and Phillipps (2016). The species diversity of trapped rodents and treeshrews was determined based on the Shannon diversity index (*H*').

A total of 5924 trap nights yielded 239 individuals of rodents and treeshrews, comprising of 14 species, four species of treeshrews (family Tupaiidae), four species of squirrels (family Sciuridae), and six species of rats (family Muridae) (Table 1). The *p*-value obtained from the Kruskal-Wallis test shows the species diversity of rodents and treeshrews was significantly different (p=0.0058) among forests, oil palm plantations, rural villages, and urban areas. Dunn's posthoc test shows the species diversity of these small mammals in forests was different from both rural villages and urban areas (p<0.05). Forest harbored the most number of species (13 species) and the most diverse community (H'=1.941). Although the forest sites in this study are accessible to human, it is still the least disturbed habitat compared to oil palm plantations, rural villages and urban areas. This result was similar to Bernard *et al*. (2009) and Wells *et al*. (2014) where the small mammal species richness was found to be higher in the forest than in other anthropogenically

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Table 1. Species composition, the conservation status of captured rodents and treeshrews, and Shannon diversity indices of four habitats in Western Sarawak

Common name	Species name	Habitats				IUCN 2016	WLPO 1998
		F	OPP	RV	U		
Large Treeshrew	*Tupaia tana*	13	6	–	–	LC	Protected
Lesser Treeshrew	*Tupaia minor*	4	–	–	–	LC	Protected
Plain Treeshrew	*Tupaia longipes*	1	–	–	–	LC	Protected
Slender Treeshrew	*Tupaia gracilis*	3	2	–	–	LC	Protected
Low's Squirrel	*Sundasciurus lowii*	2	–	–	–	LC	Not listed
Plantain Squirrel	*Callosciurus notatus*	3	9	1	6	LC	Not listed
Shrew-faced Ground Squirrel	*Rhinosciurus laticaudatus*	3	–	–	–	NT	Not listed
Three-striped Ground Squirrel	*Lariscus insignis*	1	–	–	–	LC	Not listed
Dark-tailed Tree Rat	*Niviventer cremoriventer*	2	–	–	–	LC	Not listed
Asian House Rat	*Rattus tanezumi*	2	24	63	41	LC	Not listed
Malaysian Field Rat	*Rattus tiomanicus*	1	1	–	–	LC	Not listed
Muller's Rat	*Sundamys muelleri*	24	18	1	5	LC	Not listed
Polynesian Rat	*Rattus exulans*	–	–	1	–	LC	Not listed
Whitehead's Rat	*Maxomys whiteheadi*	1	1	–	–	VU	Not listed
	Total individuals	60	61	66	52		
	Shannon index (*H'*)	1.941	1.484	0.235	0.662		

F indicates forests; OPP indicates oil palm plantations; RV indicates rural villages; U indicates urban; LC indicates least concern; NT indicates near threatened; VU indicates vulnerable; – indicates no individual was trapped; IUCN indicates International Union for Conservation of Nature Red List of Threatened Species 2016; WLPO indicates Wild Life Protection Ordinance 1998.

modified habitats. Forest is an important natural habitat for small mammals, particularly treeshrew species in this study. The four treeshrew species (i.e. *Tupaia tana*, *T. minor*, *T. longipes,* and *T. gracilis*), three squirrels (*Sundasciurus lowii*, *Rhinosciurus laticaudatus,* and *Lariscus insignis*), and three rats (*Niviventer cremoriventer, Rattus tiomanicus,* and *Maxomys whiteheadi*) were trapped in the forests were missing from rural villages and urban sites. All treeshrews were listed as protected species under the Wild Life Protection Ordinance (WLPO) 1998.

Oil palm plantation had the next most diverse small mammal community (*H*'=1.484, seven species). Two treeshrew species were caught in an oil palm smallholding near Kampung Tanah Putih, Samarahan where some of the cage traps were set within 100 meters from the boundary of a forest due to the small land area of the smallholding. Treeshrews from the forest might have entered the oil palm area to forage on palm fruits. Forest patches adjacent to the oil palm plantations are important in maintaining the richness of rodent and treeshrew species in oil palm plantations (Azhar *et al*., 2014), but this has created some conflicts between wildlife conservationist and planters who do not like the presence of these small mammals in their oil palm plantations.

On the other hand, rural villages had fewer species (four species) and the least diverse small mammal community (*H*'=0.235); whereas urban areas had the least number of species (three species), but slightly more diverse community than rural villages (*H*'=0.662). This may due to the higher occurrence probabilities of other rodent species (i.e. *Callosciurus notatus* and *Sundamys muelleri*) in an urban area than in the rural villages beside the predominant species, *R. tanezumi.* Although the species richness declined in rural villages and urban areas, both habitats had comparably high trap success (5.8% and 5.4% respectively). This is attributed to the abundance of the synanthropic rat species, *Rattus tanezumi*. Blasdell *et al*. (2019) reported that *R. tanezumi* is a dominant species in both suburban and urban areas in western Sarawak. The abundant *R. tanezumi* found in human settlements would have serious public health concerns as this species of commensal rat carries pathogens that have been reported to cause significant morbidity and mortality to humans (Meerburg *et al*., 2009; Himsworth *et al*., 2013; Blasdell *et al*., 2019).

In conclusion, this study showed that when forests are converted into rural villages and urban areas, all four treeshrew and three squirrel species that are associated with forest habitats are not able to adapt to these new habitats and were absent in villages and urban sites. In contrast, synanthropic species such as *R. tanezumi* are well adapted and thrived in human-modified habitats.

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