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PERSISTENCE OF PRIMATE AND UNGULATE COMMUNITIES ON FORESTED ISLANDS IN LAKE KENYIR IN NORTHERN PENINSULAR MALAYSIA

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ABSTRACT

As more rivers in Southeast Asia's forested landscapes are dammed, artificial land-bridge islands are becoming more ubiquitous. While the mammal faunas on these islands are poorly studied, they provide unique opportunities to investigate the impacts of fragmentation and isolation on insular biota. During the course of a 60-day survey of small (<20 ha), medium (20–50 ha) and large (>50 ha) forested islands in Lake Kenyir, Peninsular Malaysia, four primates and three ungulate species were detected on these islands, while the entire complement of six primates were found at nearby mainland sites. Five ungulates were detected on mainland sites. Notably, white-thighed surili (*Presbytis siamensis*) and white-handed gibbon (*Hylobates lar*) were found to have persisted on islands as small as 1.1 ha two decades post-isolation, although no ungulates were observed on the three smallest (<10 ha) islands. Observed diversity patterns of primate and ungulate assemblages on forest islands may be the result of patchy, resource-influenced distributions pre-flooding, and differential abilities to disperse across the water matrix post-flooding. Further studies should resample species occurrence, on top of collecting data on abundance, demographics and genetic variability in these isolated mammalian communities.

Keywords: dams, isolation, Lake Kenyir, mammals, Peninsular Malaysia, Southeast Asia

INTRODUCTION

Mammalian communities on tropical land-bridge islands worldwide have been little studied but are increasingly relevant in the light of understanding persistence patterns in small habitat patches as tropical forests become rapidly lost and fragmented globally (RIITTERS *ET AL.*, 2000; GIBSON *ET AL.*, 2013). Among the few such studies that have been conducted, most were confined to the Neotropics, such as Barro Colorado in Panama (e.g. CARPENTER, 1965; MITTERMEIER, 1973; PHILIPS, 1995), islands in Lago Guri in Venezuela (e.g. NORCONK, 1996; NORCONK & GRAFTON, 2003) and Lake Petit-Saut in French Guyana (COSSON *ET AL.*, 1999). Few such examples are available from Southeast Asia although the region supports high mammalian diversity and endemism (CRANBROOK *ET AL.*, 1983; FRANCIS, 2008), with diverse assemblages of primates, ungulates, carnivores and rodents. In recent decades, major hydroelectric projects in this region, particularly in Thailand, Lao PDR and Malaysia, have resulted in the formation of large man-made impoundments that flood extensive tracts of low-lying tropical rainforest (NAKHASATHIEN, 1989; LAWRENCE, 2009; WOODRUFF, 2013). This has led to the formation of

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large numbers of land-bridge islands with isolated communities of wildlife trapped in the remnant habitats therein (e.g. LYNAM & BILLICK, 1999; YONG *ET AL*., 2011; WOODRUFF, 2013). In one of the best documented examples, the construction of the Rajjaprabha Dam in southern Thailand flooded 16,500 ha of mostly low-lying forest to form the Chiew Larn Reservoir (LYNAM & BILLICK, 1999). In Sarawak, Malaysian Borneo, the Bakun Dam project resulted in the flooding of an even larger area, with nearly 70,000 ha of forest inundated (KEONG, 2005)

Studies on islands in the Chiew Larn Reservoir found that small mammal communities on land-bridge islands became more nested five years post inundation, with adaptable species increasing in abundances (LYNAM & BILLICK, 1999), while GIBSON *ET AL*. (2013) reported the near-complete extinctions of these mammalian assemblages 26 years on, partly in response to an invasive competitor (*Rattus tiomanicus*) from disturbed habitats. While lessons drawn from understanding the dynamics of wildlife communities on land-bridge islands may not be completely applicable to real forest fragments within a matrix of non-forest habitats (YONG *ET AL*., 2011) given the varying degree of permeability of the deforested matrix to dispersing species, studies of wildlife assemblages over time on land-bridge islands can help better understand how biodiversity broadly responds to habitat fragmentation and isolation, and particularly so in a matrix (i.e., water) hostile to most species.

I report here on diurnal primate and ungulate communities repeatedly surveyed on six land-bridge islands and two control mainland sites in Lake Kenyir, Peninsular Malaysia, over four sampling periods between 2007 and 2008.

STUDY AREA

Lake Kenyir (4°59'44"N, 102°39'54"E) (Fig. 1) is a large freshwater reservoir created in 1986 by the damming of the Kenyir River, a major tributary of the Terengganu River. It is located entirely within Terengganu State in northern Peninsular Malaysia. The damming of the river resulted in the flooding of approximately 370 km^2 of lowland dipterocarp rainforest at an elevation of 145 m above sea level (FURTADO *ET AL*., 1977). A collection of ridges and hilltops which were once part of the forested landscape were fragmented post-inundation into some 340 land-bridge islands, of which six were surveyed in this study. These islands are classified by area into small (<20 ha: Latak, Petelat, Yazid), medium (20–50 ha: Kuala Laban) and large (>50 ha: Jerangau, Jelatang) (Table 1). Topographically, all the islands surveyed are very similar because they are mainly steep hilltops and ridgelines with similar logging histories (YONG *ET AL*., 2011) and are covered mainly by logged lowland dipterocarp forest, with small areas of regenerating secondary forest, scrub and bamboo stands near their coastlines. Two forested mainland sites (named and referred to subsequently as "ML1" and "ML2") were surveyed as control sites. The forest on these mainland sites is contiguous with the Taman Negara National Park, a large protected landscape (ca. 434,000 ha) that straddles the Malaysian states of Terengganu, Pahang and Kelantan.

METHODS

During a survey of birds and butterfly assemblages at the field sites from June 2007 to February 2008, spanning 60 field days, I opportunistically documented encounters with

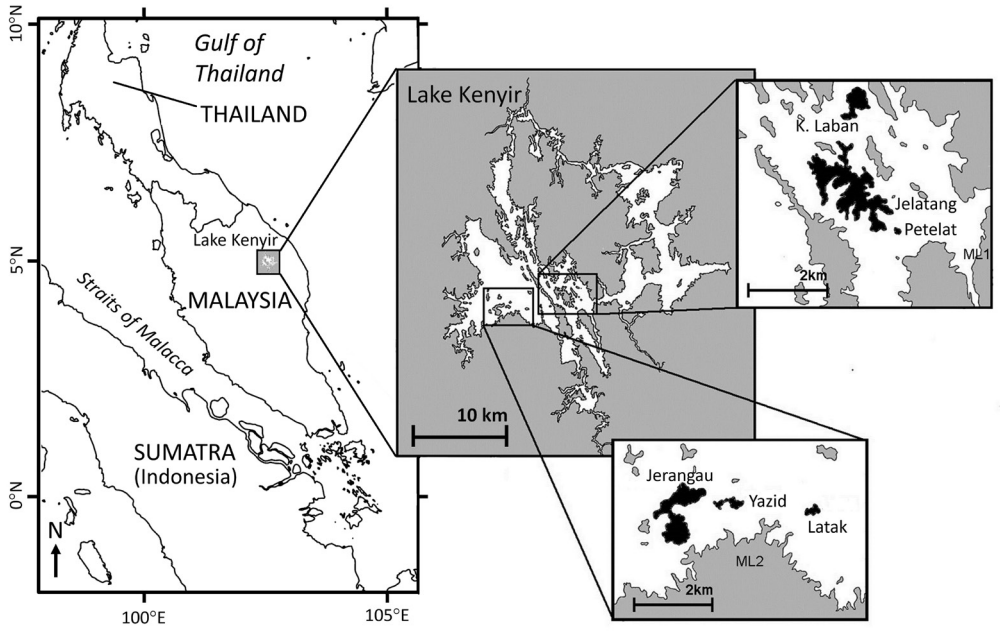

Figure 1. Map of Lake Kenyir, highlighting the study areas and islands.

primates and ungulates. Each island was visited and surveyed at least six times (i.e., three morning and three afternoon surveys for the smallest island) by a single observer (DLY) using a series of sampling points located along randomly chosen forest transects marked at least 100 m from the coastline. Transects had from 6 (Petelat) to 22 (Jelatang) sampling points spaced approximately100 m apart. Transects linking the sampling points were walked between 0700 and 1200 h, and 1400 to 1800 h. The transects joining these points ranged from 0.2 km for the smallest islands to 0.5 km in length for islands with large hinterlands (e.g. Jerangau).

A primate species was considered as present only if it was visually encountered, or if species-specific vocalisations were heard. Incidental observations of presence, especially sounds of "primates crashing through the canopy" were not considered as these signs alone do not allow reliable identification. However, repeated surveys allowed species to be eventually identified even when many first observations were incidental. Ungulates were considered as present based on direct observation, vocalisation (e.g. Asian elephant, red muntjac), dung (e.g. Asian elephant), fresh footprint in soft mud, or nest structures found (Eurasian wild pig). Repeated sampling of each island should lead to detection of all diurnal primate species occurring therein, although the crepuscular behaviour of some ungulates like chevrotains and muntjacs means that these sometimes may have been overlooked. Additionally, the low detectability of some species and the influence of rain on mammal signs like footprints may result in species being missed, and as such the absence of an ungulate should only be taken as indicative. Mammalian taxonomy and nomenclature here follows Francis (2008).

RESULTS AND DISCUSSION

Six primate and six ungulate species were recorded during the surveys (Table 1). On the mainland control sites, all six primates were encountered. Species richness of primate, and of all mammal species pooled, was strongly correlated with island area (R^2 = 0.847, 0.554 respectively) (Fig. 2). Three primate species were encountered on the largest island (Jelatang), which is separated from the mainland by nearly 0.9 km of water. Two species were encountered on Jerangau, the next largest island. Siamang (*Symphalangus syndactylus*) and southern pig-tailed macaque (*Macaca nemestrina*) were not encountered on any island. Interestingly, a small group of white-thighed surili (*Presbytis siamensis*) was encountered on Petelat (1.1 ha), while at least one pair of the white-handed or lar gibbon (*Hylobates lar*) was encountered on Latak. Dusky leaf monkey (*Trachypithecus obscurus*) was encountered on an island only on Laban. Lar gibbon and white-thighed surili were the most persistent primates, occurring on four of six islands. Three ungulate species, including Asian elephant (*Elephas maximus*), were noted on Jerangau but none of the other islands supported any ungulates except for the Eurasian wild pig (*Sus scrofa*), which was detected on three islands (Table 1). Sambar, Malayan tapir and red muntjac were only recorded in mainland sites although all three species are known to swim well and can occur on island sites. Ungulates were mostly indirectly observed, with less than five visual encounters in total. I found no signs of hunting (e.g. snare traps, shotgun pellets) during fieldwork over the survey period, so it is unlikely that absence of a primate species at a site was the result of hunting pressure. While heavily forested Chergau Island (1,000 ha) was not systematically surveyed, I noted the occurrence of gibbons and both species of langurs on that island based on their distinctive vocalisations.

Although my findings are based on limited survey effort, some inferences can be drawn. First, richness of primates, and all mammal species pooled, was strongly correlated with island area, and is thus consistent with species-area relationships well studied in biogeography. Second, given the right conditions (e.g. food plant availability) and patch attributes (e.g. fragment shape, vegetation structure), and absence of hunting, isolated mammalian assemblages, especially primates, can persist over two decades. While I found no evidence of breeding, these primates may persist beyond one generation relative to the mean lifespan (estimated at >12 years for some *Presbytis* spp., 40 years for lar gibbon (ROWE, 1996; WIEGL & JONES, 2005), as indicated by the occurrence of gibbons and langurs on even the smallest islands. The absence of primates on some small islands like Yazid may be due to patchy distributions across the landscape pre-isolation (e.g. LAMBERT *ET AL.*, 2003) resulting in few or no individuals being trapped in some islands when flooding occurred, or that steep ridges and hills may lack plants attractive to foraging primates. Additionally, the fact that no island supported two leaf monkeys may be the result of competitive exclusion; however more islands, particularly large islands, need to be surveyed to test such a hypothesis rigorously.

Remnant populations of species like gibbons and langurs may occur on some islands because these primates were unable to disperse post-inundation and thus were effectively "trapped" (see NORCONK & GRAFTON, 2003), unlike good swimmers such as long-tailed macaque (*Macaca fascicularis*) and Eurasian wild pig. Most importantly, my findings suggest that small forest islands can support reasonably large arboreal mammalian species beyond one generation, although the same cannot be said for ungulates, many of which are swimmers which may eventually disperse to more extensive habitats on the mainland. Consequently, these remnant mammalian communities are likely to be shaped by differing dispersal abilities

Table 1. Distribution of primate and ungulate species recorded across survey sites. Site attributes are given below the species list.

Species	ML1	ML2	Jelatang	Jerangau	Laban	Latak	Yazid	Petelot
PRIMATES								
Siamang (*Symphalangus syndactylus*)		+						
Lar gibbon (*Hylobates lar*)	+	+	+	+		+		
White-thighed surili (*Presbytis siamensis*)	+	+	+	+		+		+
Dusky leaf monkey (*Trachypithecus obscurus*)	+	+			+			
Long-tailed macaque (*Macaca fascicularis*)	+	+	+					
Southern pig-tailed macaque (*Macaca nemestrina*)	+	+						
Observed (primate) species richness	5	6	3	2	1	2	0	1
UNGULATES								
Asian elephant (*Elephas maximus*)	+	+		+				
Malayan tapir (*Tapirus indicus*)		+						
Eurasian wild pig (*Sus scrofa*)	+	+	+	+	+			
Sambar (*Rusa unicolor*)	+	+						
Red muntjac (*Muntiacus muntjak*)		+						
Lesser mouse-deer (*Tragulus kanchil*)				+				
Observed (ungulate) species richness	3	5	1	3	1	0	0	0
OTHER LARGE MAMMALS								
Malayan sun bear (*Helarctos malayanus*)	+							
Tiger (*Panthera tigris*)	+							
Mammal species richness (pooled)	8	11	4	5	2	2	0	1
Isolation (km)	-	-	0.889	0.222	0.389	0.611	0.625	1.625
Area (km^2)	-	-	1.276	1.194	0.352	0.079	0.052	0.011
Number of sampling points	30	26	22	15	13	7	6	6

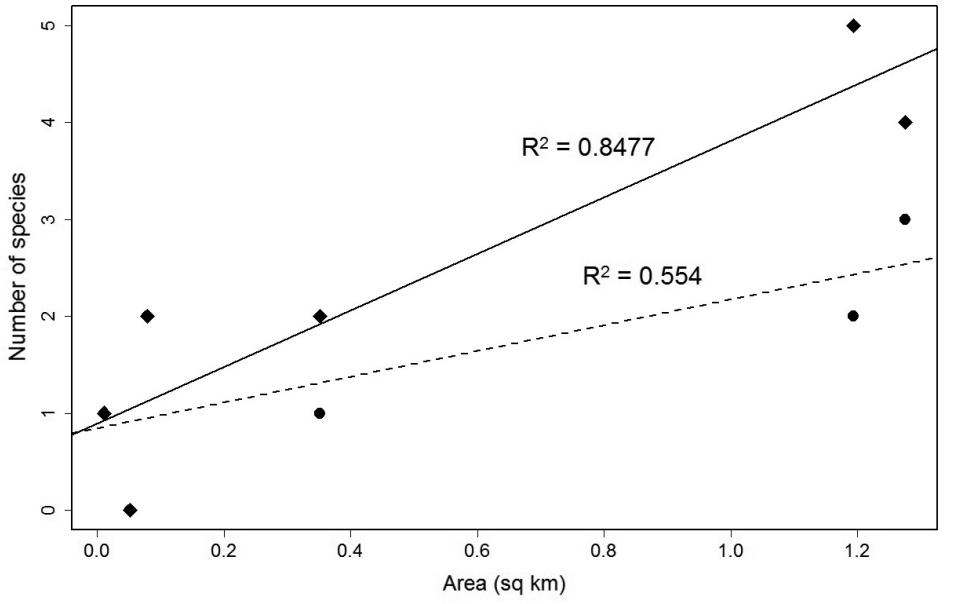

Figure 2. Relationship between species richness and island area. Circle-shaped points and the dotted line represent primate species richness; diamond-shaped points and the bold line represent pooled primate and ungulate species richness.

across the water matrix, with poor dispersers like langurs and various rodents and insectivores dominating these insular mammal assemblages.

Being drawn from incidental observations during bird and butterfly surveys, the results presented here are only indicative, although these observations were drawn from standardised and repeated surveys for other taxa. Given their distinctive calls and diurnal habits, I am confident that all occurring primates with the exception of the nocturnal greater slow loris (*Nycticebus coucang*) were detected. However, the nocturnal habits of many smaller ungulates and their less visible signs mean that repeated and targeted surveys using camera traps will be needed to detect all species present. Repeated surveys standardised over time may also allow occupancies of individual species to be estimated, and which will be more informative than presence-absence data drawn from a single survey.

At present, the construction of major dams is ongoing or planned for many parts of Southeast Asia, including forested landscapes in Sarawak (Malaysian Borneo), Cambodia, Laos and Myanmar (e.g. DUDGEON, 2000; KEONG, 2005). In Southeast Asia, hydroelectric projects have caused extensive habitat loss and fragmentation, most prominently studied in southern Thailand's Chiew Larn Reservoir, a development that resulted in significant habitat and biodiversity loss within inundated parts of the Khlong Saeng Wildlife Sanctuary and Khao Sok National Park (WOODRUFF, 2013), including decline and extirpations of native small mammal communities (GIBSON *ET AL.*, 2013). Similar studies conducted in Peninsular Malaysia's Lake Kenyir have also documented impoverished bird, butterfly and dung beetle

assemblages on land-bridge islands (e.g. QIE *ET AL*., 2011; YONG *ET AL*., 2011), but not of mammals. Clearly as dams become increasingly popular as a means to generate electricity for rising energy demand in Southeast Asia, fragmentation of contiguous forest landscapes will become increasingly prevalent, contributing to overall biodiversity loss across the region. From a conservation standpoint, hydroelectric projects may, however, provide unique opportunities for scientific study, as such landscape-scale natural experiments document the ecological effects of fragmentation and isolation on island biotas (DIAMOND, 2001).

This study suggests that long-lived and poor-dispersing mammal species such as primates can persist on small forested islands at short to medium time scales, in contrast to ungulates which may disperse more widely. More comprehensive surveys should be carried out on Lake Kenyir's insular mammalian communities, especially for primates, ungulates and rodents, to increase the sampling coverage of forest land-bridge islands, while at the same time extending data collection to include species abundance and demographics. Additionally, genetic material which can be obtained from mammalian fecal samples should be systematically collected as this can be used to estimate the degree of inbreeding depression based on the extent of genetic variability in these mammal populations (e.g. KOHN & WAYNE, 1997).

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