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VERTEBRATES FAUNA OF PULAU TINGGI, JOHOR, MALAYSIA

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Abstract: Islands are known for confining high disproportionality of threatened species diversity. Documenting the fauna richness in a particular island could serve as baseline information for conservation purposes in the future. Hence, a study on vertebrates using a camera trap in Pulau Tinggi, an island located in the southern part of the state of Johor was conducted from June to October 2019. A total of twenty-two camera traps were deployed for five months in Gunung Semudu and an added expedition in Sebirah in August 2019. A total of 12 species comprised of nine families of mammals, birds and herpetofauna were documented based on 166 trapping night efforts. The most abundant vertebrates were the long-tailed macaque (*Macaca fascicularis*) followed by the Maxomys sp and unknown rodent. In addition, species of concern such as the Nicobar pigeon (*Caloenas nicobarica*) and grey-headed fish eagle (*Haliaeetus ichthyaetus*) were discovered during the study. The presence of species of concern in Pulau Tinggi indicates the conservation importance and proper management of the island should be formulated to ensure the continuity of the island`s biological diversity.

Keywords: Biodiversity, camera trap, Pulau Tinggi, mammal, bird, herpetofauna, South China Sea, Johor.

Introduction

Pulau Tinggi is one of the islands located in the South China Sea to the north and in the middle arc of the Seribuat Archipelago in the east off the coast of Johor (Azman *et al*., 2008). The International Union for Conservation of Nature (IUCN) is classified as a world-protected area. The island is surrounded by 62 islands, including Pulau Ibol, Pulau Apil, Pulau Mentinggi, Pulau Nanga Kecil, Pulau Penyembang, Pulau Simbang and Pulau Lanting (Department of Marine Park Malaysia, 2012). Among the Seribuat Archipelago, the most intensive research was conducted in Pulau Tioman by scientists on various groups of organisms including herpetofauna (Grismer *et al.,* 2004), avian (Sodhi *et al.*, 1999), butterflies (Quek *et al.,* 1999), mammals (Lim *et al.,* 1999) and plants (Latiff *et al*., 1999). However, only limited research on terrestrial animals has been done in Pulau Tinggi and documentation on vertebrate diversity is lacking.

Camera trapping is a passive tool for conservation and wildlife research; it is simple and equipped with a remote-triggered device. The camera is triggered when it senses motion and an image will be recorded. The high technology of remote cameras can prevent limitations of long-term monitoring or hard-to-detect animals by researchers (Tim van Berkel, 2014). Camera traps were used to study diverse types of terrestrial mammals (Mccallum, 2013) as this method minimised the encounter between humans and wildlife, thus, preventing the change in animal behaviour with extended monitoring periods (Tim van Berkel, 2014). Camera trap replaces the traditional method and makes it possible to observe nocturnal and

elusive animals that avoid contact with humans (Balme *et al.,* 2009; Burton, 2012).

Islands constitute approximately 5.3% of the land area on Earth. Marine island is rich in species diversity (Bernie, 2015). 61% of the total species are listed as extinct in the IUCN red list, with 37% of species listed as critically endangered being island species (Bernie, 2015). Therefore, the potential of extinction is much greater on the islands than on the mainland. Oceanic islands and Peninsular Malaysia had 8.1 times greater vertebrate endemism than the mainland (Kier, 2009). To know the importance of documenting the diversity information especially on vertebrates on the island, the objective of this study was to document the species diversity of vertebrates including mammals, birds and herpetofauna in Pulau Tinggi using camera traps. The study result would serve as baseline information for any future management and conservation development plan for the state and federal authorities.

Materials and Methods

Study Area

The study areas were focused on Sebirah and Gunung Semudu of Pulau Tinggi (Figure 1). Both localities were less studied as most previous studies focused on the mainland or other bigger islands that were considered isolated (Ricketts *et al*., 2005; Loehle & Eschenbach, 2012). However, Pulau Tinggi is unique compared to other surrounding islands, where the island is one of the largest islands in the East Johor Island Archipelago; this impassioned the researcher to have an in-depth investigation. The summit of the hill is up to 610 m (Ibrahim *et al.,* 2019) and the total area of the island is 16 km^2. The weather on this island is hot and humid throughout the year (Department of Marine Park Malaysia, 2012). Low logging activity preserves the inner part of the island, maintaining the primary forest with a dense canopy (Azman *et al*., 2008). Figure 1 shows the location of Pulau Tinggi and each camera trap with checkpoints 1 and 2: Teluk Siam checkpoints 3 and 4: Kampung

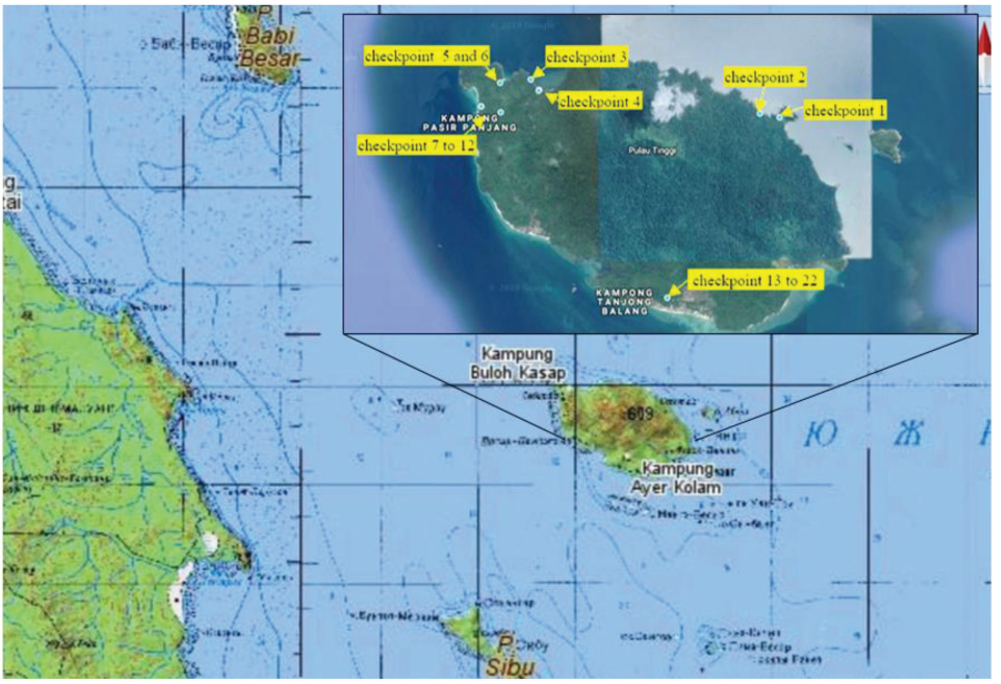


Figure 1: Map of Pulau Tinggi and camera trap checkpoint
(Source: Soviet Military Maps, version 5.1.3, revision 3840, build 1702, 2018 ATLOGIS geoinformatics GmbH & Co. KG)

Buluh Kasap, checkpoints 5-12: Pulau Sebirah and checkpoints 13-22: Gunung Semudu.

Deployment of Camera Trap

A total of 22 cameras were deployed to Pulau Tinggi areas from June 2019 until October 2019. Twenty-two individual sites were randomly selected within a 500 x 500 m grid square and the placement of camera traps was based on a stratified randomised design. All stations consisted of one remotely triggered infrared camera trap model Reconyx HyperFire HC500 (commercially available; Reconyx Inc., Holmen, WI, USA). The camera was fixed on trees at a height of 0.5 m from the ground using a cable lock and positioned at an optimum angle for sensor detection. The camera setting was fixed into high capture rates with a 5-second trigger speed to allow the trap to capture the rarely observed species. The coordination of all camera traps was recorded using a GPS device.

Artificial salt licks were placed in front of each camera trap station to attract wildlife and maximise the chance to photograph wildlife. Information such as the date, time and location were automatically recorded in each picture triggered by the camera trap. The captured images were used for the identification of recorded fauna. All animal images captured in the camera trap were identified to species level when possible following Medway (1978) and Francis (2019). The recorded data were summarised in Microsoft Excel datasheets. Several statistical results were calculated to infer the frequency and relative abundance of each species captured in camera traps. The capture frequency of a species was calculated based on total image captured of a species in a camera trap within 24 hours proportional to the total images that were triggered. Relative abundance was inferred based on the total image captured of a species for 100 days of trap nights divided by the total images taken by a camera trap.

Results

A total effort of 166 camera trap nights produced 14,099 photographic images (Table 1). There were 2,239 positive images among the total number of recorded images. From these efforts, a total of 12 species (10 known species and two unknown species) of nine families of vertebrates comprised of Muridae, Bovidae, Cercopithecidae, Varanidae, Columbidae, Accipitridae and two families of unknown species were documented using 22 camera traps placed surrounding Pulau Tinggi.

Of 12 species recorded, six species were represented by birds, followed by mammals of four species and two species of herpetofauna (Table 2). Two species were classified as Near Threatened (NT) under the IUCN Red List of Threatened Species captured on camera traps. The Nicobar pigeon (*Caloenas nicobarica*) was recorded in one deployed camera trap. The grey-headed fish eagle (*Icthyophaga ichthyaetus*) was another threatened species captured by the camera traps. On the other hand, there were approximately 30 free-roaming cows in Kampung Sebirah; most of these cows were infected with the suspected zoonotic disease of cattle as there were black patches on the body. The images of the captured vertebrates are illustrated in Figure 2.

Table 1: The number of trap nights and the number of photographed images during each study session

Study Period	No. of Trap Nights	Total No. of Recorded Image	No. of Positive Images
June 2019-July 2019	30	565	191
July 2019-August 2019	30	2,371	58
August 2019-September 2019	27	7,004	1,374
September 2019-October 2019	29	4,159	616
Total	**116**	**14,099**	**2,239**

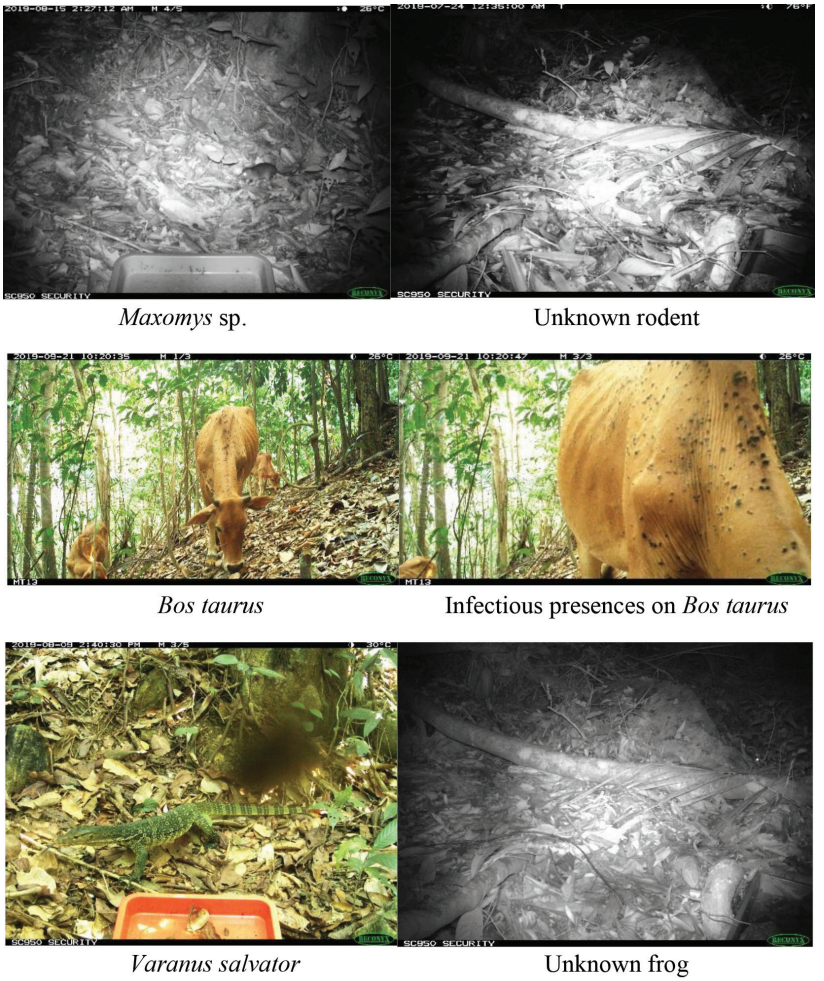
Table 2: The checklist of vertebrates that were identified from results obtained using camera traps

Family	Species	Capture	Coordinate	Note
Bovidae	*Bos taurus*	17-19,21-22	N02.1848 E 104.0550	Located in Sebirah, Zoonotic disease observed
Cercopithecidae	*Macaca fascicularis*	12	N 02.29490 E 104.12708	Eating Centipede: Scolopendra sp.
Varanidae	*Varanus* sp.	13	N 02.29455' E 104.12731	Salt lick
Muridae	*Maxomys* sp.	13, 15	N 02.29533' E 104.12699 N 02.29455' E 104.12731	Salt lick
	Unknown rodent	15	N 02.29455' E 104.12731	
	Unknown frog	13	N 02.29533' E 104.12699	
Columbidae	*Chalcopaps indica*	16	N 02°18'33.2" E104°08'01.4"	
Muscicapidae	*Copsychus malabaricus*	16	N 02°18'33.2" E104°08'01.4"	
Accipitridae	*Icthyophaga ichthyaetus*	20	N02°17'42.3" E104°07'38.3"	Captured in 1 same camera
Accipitridae	*Nisaetus cirrhatus*	20	N 02°17'42.3" E104°07'38.3"	
Accipitridae	*Haliaeetus leucogaster*	20	N 02°17'42.3" E104°07'38.3"	
Columbidae	*Caloenas nicobarica*	17	N 02°17'42.9" E104°07'35.5"	3 individual species captured on 1 camera

The relative abundance of recorded vertebrates varied throughout the sampling period. The most abundant vertebrates recorded based on 100 days of the image captured were long-tail macaque (*Macaca fascicularis*), with a total of 62.1 individuals, followed by cows with 24.9 individuals and forest rodents of *Maxomys* species with 7.64 individuals (Table 3). The rest of the species recorded amounted from 0.1 up to 1.2 individuals during 100 days of captured images.

Discussion

The result of the study is a preliminary insight into vertebrates that inhabit Pulau Tinggi, Johor. Based on the total species recorded through camera traps, the diversity of vertebrates was significantly lower compared to vertebrate diversity in other islands of Peninsular Malaysia (e.g., Pulau Tioman: Lim *et al.,* 1999; Sodhi *et al.,* 1999; Grismer *et al.,* 2002; Pulau Perhentian: Tamblyn *et al.,* 2005; David *et al.,* 2016; Rahim *et al.,* 2016; Baqi *et al.,* 2021; Pulau Bidong: Roslan *et al.,* 2016; Hamza *et al.,* 2018; Pulau



Maxomys sp. Unknown rodent

Bos taurus Infectious presences on *Bos taurus*

Varanus salvator Unknown frog

Figure 2: Camera trapping images of vertebrate fauna in Pulau Tinggi

Pangkor: Mohd-Taib *et al.,* 2019a,b). Island systems generally had fewer species than continental areas due to their small size and geographical isolation (Jønsson & Holt, 2015). It is reported that islands that are found nearer to the mainland will have a higher diversity of species as it is easier to be colonised. In contrast, those more isolated islands will be more difficult to access, causing fewer species to occupy them. Apart from isolation, size does influence the diversity of species found on an island as follows the theory of island biogeography (MacArthur, 2010). On the other hand, the sampling method on the vertebrate diversity in Pulau Tinggi should be considered. Most studies on vertebrates in islands were based on multiple approaches, for instance, using several traps coupled with observations that resulted in significantly higher diversity data on vertebrates. This study was based on the method of camera traps alone and the results might be improved if coupled with other sampling methods.

Only a particular species or a group of species will be able to adapt to the harsh environment of the island and prevail. One of the species that were able to adapt to such an island was the long-tailed macaque (*Macaca fascicularis*). The long-tailed macaque is one of the well-adapted primates that can live in almost all known ecosystems. The high abundance of

Table 3: Total number of images photographed, capture frequency (capture per 24 hours) and relative abundance (capture per 100 trap nights)

Family	Species	Total No. of Photograph	Capture Frequency (photograph per 24 hours)	Relative Abundance (capture per 100 trap nights)
Bovidae	*Bos taurus*	559	5.99	24.9
Cercopithecidae	*Macaca fascicularis*	1,390	14.90	62.08
Varanidae	*Varanus* sp.	4	0.04	0.18
Muridae	*Maxomys* sp.	171	1.83	7.64
	Unknow rodent	27	0.29	1.20
	Unknown frog	8	0.08	0.36
Columbidae	*Chalcopaps indica*	6	0.06	0.27
Muscicapidae	*Copsychus malabaricus*	11	0.12	0.49
Accipitridae	*Icthyophaga ichthyaetus*	7	0.07	0.31
Accipitridae	*Nisaetus cirrhatus*	11	0.12	0.50
Accipitridae	*Haliaeetus leucogaster*	23	0.25	1.03
Columbidae	*Caloenas nicobarica*	22	0.23	0.98
Total		**2,239**	**23.98**	**99.94**

this primate pictures the suitability of the island to accommodate a healthy population size. Nevertheless, Pulau Tinggi is unique as it is home to some rare species such as the Nicobar pigeon. It is reported that the population size of the species was decreasing due to deforestation and poaching. The presence of this species indicates that the island provides a suitable environment, food resources and a high possibility for its reproduction. Apart from that, the presence of a Grey-headed fish eagle in the island signifies the abundance of food resources. Besides naturally occurring species, the locals introduced cows to the island. Domestic cows were introduced by the locals, supplying milk, meat and hides and ploughing the fields (Price, 2000). However, the owners left the domestic cows unattended for various reasons including a lack of workforce and high cost which led to the cows roaming the island freely. Besides that, the outbreak of cattle diseases among the cows might be another reason the cattle were left untreated as it will be costly and unprofitable to the owners.

It is believed that Pulau Tinggi has more hidden species to be discovered. Pulau Tinggi is an island with low disturbance and hunting pressure for wildlife. More systematic sampling and comprehensive methods will help document more species within the island. Apart from that, the protection for the island should be in place immediately. Government should frequently exercise the existing laws such as the Environmental Quality Act and Wildlife Conservation Act (2010) to ensure sustainable development and protection of the island ecosystem and biodiversity. Pulau Tinggi is a potential ecotourism destination and home to fishermen in the region and several tourist spots. Any future development within the island should be done with sound information collated from a scientific approach to preserving the existing biodiversity.

Conclusion

The result presented in the current study is a preliminary insight into vertebrates found

in Pulau Tinggi, Johor using a camera trap approach. Further studies that comprehend systematic and holistic multiple approaches should be conducted to document the diversity of vertebrates within the island. The information collected through the study could serve as baseline information for local authorities and managers to formulate proper management plans to ensure that the biodiversity of Pulau Tinggi prevails and is preserved for a long period.

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