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HERPETOFAUNA OF UNIVERSITI MALAYSIA TERENGGANU CAMPUS: SUSTAINING BIODIVERSITY IN CAMPUS GREEN AREA

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Abstract: Universiti Malaysia Terengganu (UMT) campus at Mengabang Telipot, Kuala Nerus has a considerable patch of pristine coastal mangrove forest, comprising more than 13 tree species, and associated fauna, such as bats, birds, insects, and herpetofauna. Over the years, many of the green areas, including mangrove vegetation have been replaced with built-up areas. The objective of this study was to determine the diversity of herpetofauna in green areas around the UMT campus. Samplings of amphibians and reptiles were conducted by using the visual encounter survey technique. A total of 237 individuals representing 22 herpetofauna species was recorded, comprising five amphibians and 19 reptiles. All of the amphibians were regarded as habitat generalist species, while the reptiles were represented by 13 generalist species and 11 habitat specialist species. These species assemblages could be the reflection of the severe degradation of natural habitats, in which the remnant mangrove forests serve as a refuge. The remnant mangrove forests should be protected as these habitats are important to sustain the existence of many herpetofauna species on UMT campus.

KEYWORDS: Amphibians, reptiles, diversity, mangrove, coastal, urbanisation. Tropical

Introduction

Universiti Malaysia Terengganu (UMT) in Mengabang Telipot, Kuala Nerus, is located on the coastal area of Pantai Tok Jembal. The campus was developed on what used to be a predominant coastal mangrove forest. There are more than 13 species of mangrove plants in the forest, harbouring various associated fauna species, including small mammals (bats), birds, insects, and herpetofauna. Herpetofauna in coastal areas are less diverse compared to inland forest, comprising just a few species of amphibians (i.e., frogs and toads) and reptiles (i.e., snakes, skinks, lizards). However, little is known about the diversity of herpetofauna in this ecosystem, due to lack of emphasis and education on the predisposed forest with little intrinsic value. Mangrove forests on the contrary, are the first line of defense against strong waves and storms.

Several studies have been conducted on the diversity of herpetofauna in coastal areas on the east coast of Peninsular Malaysia, such as by Daicus *et al.* (2010) and Lim (2010) at Pantai Melawi, Kelantan, as well as Sharma *et al.* (2007) at Bukit Labohan, Terengganu. These studies have recorded a considerably diverse herpetofauna, especially reptiles in these harsh areas. From all of these studies, the Crab-eating Frog, *Fejervarya cancrivora* was notably present, being the only amphibian species that can adapt well to high saline conditions in mangrove habitat. Grismer *et al.* (2004) has shown that several reptile species are confined to this type of habitat, such as the Mangrove Skink (*Emoia atrocostrata*) and several snakes, such as *Psammodynastes pulverulentus, Cerberus rynchops* and *Ophiophagus hannah* (Grismer *et al.,* 2006).

Most of amphibians and reptiles are

sensitive to habitat alterations, thus, making them vulnerable to uncontrolled urbanization (Christie *et al.,* 2012; Davis & Doherty, 2015). With the ongoing development of UMT campus at Mengabang Telipot, it is timely for us to document the diversity of herpetofauna and to review the importance of establishing the campus as a green area to preserve the urban biodiversity. This paper highlights valuable results that are useful to address the effect of urbanization on local fauna biodiversity on campus.

Materials and Methods

Study Area

The present study was conducted at Universiti Malaysia Terengganu campus (5° 24'11.39" N; 103° 05'9.60" E) at the north-eastern part of Peninsular Malaysia (Figure 1). The campus ground was previously covered by dense coastal mangrove forest. Most of it has been converted into build up areas. Several remnant patches can still be found on the campus area.

Samplings were conducted on three occasions, i.e., (i) 5–11 December 2014, (ii) 10–12 September 2016, and (iii) 3–4 February 2017. Diurnal and nocturnal surveys were conducted to cover the whole campus area. Samplings were carried out by the visual encounter survey (VES) technique. Amphibians and reptiles were captured using bare hands or with the aid of long-handle scoop nets. Once caught, animals were temporarily stored in re-sealable plastic bags prior to species identification. Specimens were released after positive species identification based on Inger and Stuebing (1997), Cox *et al.* (1998), Ibrahim *et al.* (2008) and Norhayati *et al.* (2009). Selected individuals were euthanized using benzocaine, and later, were fixed with 10% neutral-buffered formaldehyde before storing in 70% of alcohol as voucher specimens. All specimens were deposited in General Biology Laboratory of UMT for future references. Previous records of herpetofauna found on the UMT ground that were kept in UMT collection were also reported herein. Generally, anurans and reptiles that encountered in more than one disturbed habitats are considered as a generalist, while those only found in the specific habitat is considered as specialist species (Dunning *et al.,* 1992; Jonsen & Fahrig, 1997).

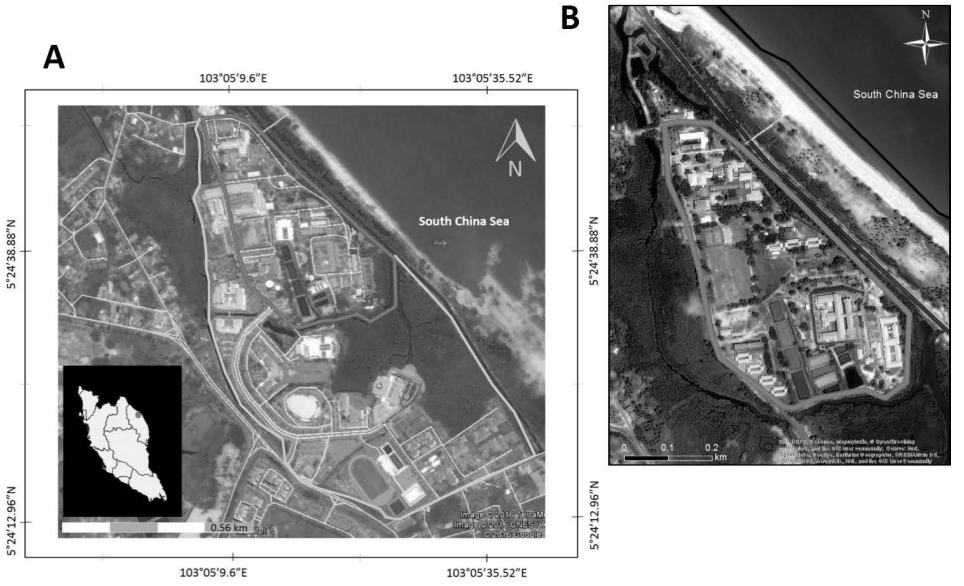

Figure 1. Google map-generated image of Universiti Malaysia Terengganu located in the east coast of Peninsular Malaysia showing the present day infrastructure (A), and the built up and green vegetated areas pre-2000 (B). Inset is the map of Peninsular Malaysia showing the location of Universiti Malaysia Terengganu (red dot) where the study was conducted.

Results and Discussion

A total of 241 individuals of amphibians and reptiles was collected in three separate surveys, representing 25 species of herpetofauna, of which five were amphibians from four families and 20 species were reptiles from eight families (Table 1). The list includes four old records that were not found in the current study, namely, *Dasia olivacea, Ahaetulla nasuta, Boiga dendrophila,* and *Naja kaouthia* (see remarks in Table 1). All five amphibian species were common in disturbed areas and can tolerate well in urban settings. With the exception of *Fejervarya limnocharis,* the other species could be found on buildings; inside buildings, such as in the toilet or dampened places, or near constructed structures. Thus, all of the five amphibian species can be regarded as a commercial species. These species could be breeding in artificial fish ponds found on campus. Most of these species are hardy species that are able to tolerate extreme habitat alteration. *Fejervarya limnocharis* can be found on grassy areas around fish ponds, under trees or on playing fields on campus. Among the amphibians, *Duttaphrynus melanostictus* dominated the catches (71.9 %) and was the most common species.

Table 1. Checklist of amphibians and reptiles in Universiti Malaysia Terengganu from the previous and current studies.

Family	Species	Voucher specimens No.	Habitats	Remarks
AMPHIBIANS				
Bufonidae	*Duttaphyrnus melanostictus* (Schneider, 1799)	UMTHC 0266	G	Prv.
Microhylidae	*Kaloula pulchra* Gray, 1831	UMTHC 0274	G	Prv.
	Microhyla heymonsi Vogt, 1911	Observed*	G	
Dicroglossidae	*Fejervarya limnocharis* (Gravenhorst, 1829)	UMTHC 0277	G	Prv.
Rhacophoridae	*Polypedates leucomystax* (Gravenhorst,1829)	UMTHC 0245	G	Prv.
REPTILES				
Agamidae	*Calotes versicolor* (Daudin, 1802)	Observed*	G	Prv.
	Leiolepis belliana (Hardwick & Gray, 1827)	Observed*	S	Prv.
Varanidae	Varanus salvator (Laurenti, 1768)	Observed*	S	Prv.
Scincidae	*Dasia olivacea* Gray, 1839	Observed	S	Prv.
	Eutropis multifasciata (Kuhl, 1820)	Observed*	G	Prv.
	Eutropis longicaudata (Hallowell, 1857)	Observed*	G	Prv.
	Lygosoma bowringii (Günther, 1864)	UMTHC 0449	S	
Gekkonidae	*Gekko gecko* (Linnaeus, 1758)	UMTHC 0435	S	
	Gehyra mutilata (Wiegmann, 1834)	Observed*	G	Prv.
	Hemidactylus frenatus Dumeril & Bibron, 1836	UMTHC 0439	G	Prv.
	Hemidactylus platyurus (Schneider, 1792)	UMTHC 0442	G	

Family	Species	Voucher specimens No.	Habitats	Remarks
Colubridae	*Ahaetulla nasuta* Lacépède, 1789	Observed	S	Prv.
	Boiga dendrophila Boie, 1827	Observed	S	Prv.
	Chrysopelea ornata (Shaw, 1802)	Observed*	S	
	Coelognathus radiatus (Boie, 1827)	Observed*	G	
	Dendrelaphis pictus (Gmelin, 1789)	Observed	S	Prv.
Homalopsidae	*Enhydris enhydris* (Schneider, 1799)	UMTHC 0452	G	
	Hypsiscopus plumbea (Boie, 1827)	UMTHC 0450	G	
	Homalopsis buccata (Linnaeus, 1758)	UMTHC 0453	S	
Elaphidae	*Naja kaouthia* Lesson, 1831	UMTHC 0550	G	Prv.
Pythonidae	*Malayophyton reticulatus* (Schneider, 1801)	Observed*	G	
Geoemydidae	*Cuora amboinensis* (Daudin, 1802)	Observed*	S	
	Siebenrockiella crassicollis (Gray, 1831)	Observed*	G	
Emydidae	*Trachemys scripta* (Thunberg in Schoepff, 1792)	Observed*	G	

Note: Observed* = specimen with picture taken; G = habitat generalist; S = habitat specialist; and Prv. = records from previous surveys

Reptiles were by far, richer than amphibians living in coastal habitats. Equipped with dry skins and specialized living style, e.g., burrowing, they are able to tolerate habitat modification better than amphibians. The recent surveys recorded 19 species altogether, consisting of gekkos (4 species), skinks and lizards (3 species), snakes (6 species), and freshwater turtles (3 species). The most common family among the reptiles was Colubridae with eight species (Table 1), but two species were not recorded in the present surveys. Most of the reptile species recorded were common to human inhabitants, except for several species, such as *Lygosoma bowringii,* or commonly found in aquatic habitats, including mangrove areas, such as *Boiga dendrophila* and *Homalopsis buccata.* Previously, four species of reptiles were reported, including a python. The absence of these species were stated in Table 1 and discussed further in Systematic Account section. For reptiles, the most dominant species were *G. mutilata* (37.8%), followed by *H. frenatus* (23.8 %).

In terms of habitat preference, all amphibians recorded were categorised as habitat generalists, while for reptiles, 13 were regarded as habitat generalists and 11 were considered as habitat specialists. Classification on species generalists/ specialists was made according to occurrences in the habitat where they were recorded. Criteria of habitat utilization were clearly demonstrated and directly showed whether a particular species was a generalist or specialist, rather than niche or resource portioning that would have required certain techniques to be assessed (Toft, 1985).

Taxonomy
Class Amphibia
Family Bufonidae
***Duttaphyrnus melanostictus* (Schneider, 1799) (Asian Common Toad)**
Figure 2.

Remark: This commensal toad occurred everywhere within the campus and occasionally found during the day. Unlike the other species, this toad is morphologically adapted to dry and harsh conditions (Suazo-Ortuno *et al.,* 2010), such as on campus, due to its rough skin that allows it to withstand dry weather. This species is adapted to live in human-made environment and breed in various areas, such as irrigation ditches, drains, artificial ponds, and waste debris

(Daicus *et al.,* 2010; Shariza and Ibrahim, 2012).

Family Microhylidae
***Kaloula pulchra* Gray, 1831 (Asian Painted Bullfrog)**
Figure 3.

Remark: This species was caught in the toilet and drain at the hostel areas. This species prefers wet and damp places. *Kaloula pulchra* secretes adhesive and slimy skin secretion, which is distasteful to predator (Evans & Brodie, 1994). It can also inflate its body as anti-predator strategies (Soud *et al.,* 2012). This Asian Painted Bullfrog is considered as a commensal species that is common in disturbed and urban areas (Lim *et al.,* 2010).

***Microhyla heymonsi* Vogt, 1911 (Dark-sided Chorus Frog)**
Figure 4.

Remark: *Microhyla heymonsi* male frogs were heard calling after the rain on grassy and clearance areas along the roadside and drains. This species is typically small in size. This commensal frog breeds in stagnant water bodies, such as ponds or in drains. This species is also abundant and adaptable in disturbed or urban areas.

Family Dicroglossidae
***Fejervarya limnocharis* (Gravenhorst, 1829) (Asia Grass Frog)**
Figure 5.

Remark: *Fejervarya limnocharis* was commonly encountered in swamps near forested areas or water canals and drains. Active callings can be heard near rain puddles that form after rainfall or wet grassy areas (Iskandar, 1998; Putra *et al.,* 2012). This species is easily distinguishable from its congener, *F. cancrivora* by having more than half of its toes webbed (Lim *et al.,* 2010).

Family Rhacophoridae
***Polypedates leucomystax* (Gravenhorst, 1829) (Four-lined Tree Frog)**
Figure 6.

Remark: An arboreal frog recorded in this study was abundant near the forested areas on campus. *Polypedates leucomystax* bred in stagnant water bodies and was commonly heard calling near water canals at night in accordance with Lim *et al.* (2010). *Polypedates leucomystax* posseses a versatile breeding behaviour that made it so adaptable to many habitat conditions (including human-made structures, e.g., artificial ponds, toilets and drains). *Polypedates leucomystax* also occupies a wide variety of habitats, such as riverine, forest edge, interior and tree canopy in both less and disturbed forest.

Class Reptilia
Family Agamidae
***Calotes versicolor* (Daudin, 1802) (Common Garden Lizard)**
Figure 7.

Remark: This agile lizard was frequently found during daytime, and has been reported to be commonly found basking under sunlight on roadsides and garden areas (Sumarli *et al.,* 2015). Males of *C. versicolor* can develop red colouration on the head and bodies during breeding season (Ji *et al.,* 2002; Zug *et al.,* 2006; Pandav *et al.,* 2007; Grismer, 2011).

***Leiolepis belliana* (Hardwick & Gray, 1827) (Common Butterfly Lizard)**
Figure 8.

Remark: The most common, ground-dwelling lizard species that preferred sandy habitats on campus. *Leiolepis belliana* was frequently observed in open sandy areas along walkways and roadsides, basking under the sunlight. This species is very agile and quickly retreats into its nearby burrow when approached, and lurks out after several minutes when it is safe (Krysko and Enge, 2005). This species adapts well in human-built up areas, as long as the ground is not covered by tarmac or cement.

Family Varanidae
***Varanus salvator* (Laurenti, 1768) (Water Monitor Lizard)**
Figure 9.

Remark: *Varanus salvator* is the largest reptiles recorded on campus and can be frequently encountered in mangrove areas or close to water bodies on campus during the day. This species

can be found close to buildings, as it is probably attracted to waste and trash. There were past reports of large individuals that were seen, but many small lizards are left, especially near fish ponds today.

Family Scincidae
***Eutropis longicaudata* (Hallowell, 1857) (Long-tailed Sun Skink)**
Figure 10.

Remark: This skink was often found nearby buildings and roadside areas, especially in drains and leaf litter during the day. It quickly retreated into cracks or crevices when threatened. *Eutropis longicaudata* utilizes both man-made structures (drains, holes in concrete and waste dumping site) (Huang, 2006) and natural microhabitats (grass tufts, fallen trunks, rocks) as refuges (Vitt and Blackburn, 1991; Vricibradic and Rocha, 1996) and frequently comes out in open areas for basking (Grismer *et al.,* 2004). This species is distinguished from *E. multifasciata* (see below) by their long tail, dark and wide stripe extending from tip of snout to groin and white on ventral surfaces (Grismer, 2011).

***Eutropis multifasciata* (Kuhl, 1820) (Javan Sun Skink)**
Figure 11.

Remark: In terms of habitat utilization, *E. multifasciata* is similar to other skinks as it commonly found in open areas, basking in sunlight (Grismer *et al.,* 2004) on campus. *Eutropis multifasciata* occupies open areas, including villages and disturbed forests (Li *et al.,* 2010; Ngo *et al.,* 2014), and also in human-made structures, such as drainages, piles of building waste, and building crevices. This species can be distinguished by its relatively short tail with five to seven dark and inconspicuous lines on the dorsal and stout body form (Grismer, 2011).

***Lygosoma bowringii* (Günther, 1864) (Bowring's Supple Skink)**
Figure 12.

Remark: An individual was caught in the grassy area near the mangroves close to an abandoned pond and was considered as rare on campus. Generally, *L. bowringii* inhabits lowland habitats up to mountain forests (Smith, 1935). According to Geissler *et al.* (2011), however, this species seemed to prefer living in open and disturbed habitats, such as pond areas, clearing areas in villages or cities and plantations. This species forages on the ground or forest floor and take refuge in burrows (Grismer, 2011).

Family Gekkonidae
***Gekko gecko* (Linnaeus, 1758) (Tokay gecko)**
Figure 13.

Remark: An adult *Gekko gecko* was found in building crevice far from a forested area at night. This gecko is known to be secretive, and inhabits altered and natural habitats (Lagat, 2009; Grismer, 2011; Rocha *et al.,* 2015). The observed individual was identified as an adult based on body coloration, which is grey on head, body, limbs and tail with large orange spots on all parts and becoming more into blotches on the tail.

***Gehyra mutilata* (Wiegmann, 1834) (Stump-tailed Gecko)**
Figure 14.

Remark: The most dominant reptile commonly found at night on the walls of many buildings in UMT and signboards. This species is recognized as having pale or yellowish brown and faint white marking of vertebral stripes on the back (Grismer, 2011).

***Hemidactylus frenatus* Dumeril & Bibron, 1836 (Common House Gecko)**
Figure 15.

Remark: A very common gecko, which is completely adapted to human-made structures, especially on the walls of buildings and signboards. The coloration of *H. frenatus* is variable, but recognized by its spinose tubercles in transverse rows on tail.

***Hemidactylus platyurus* (Schneider, 1792) (Flat-tailed House Gecko)**
Figure 16.

Remark: Another common house gecko, which was frequently found on a well-lit building, especially at night. This species is distinguishable from other house geckos based

on its flat and tapered tail, having ventrolateral skin flaps on the body, faint marking of hour glass on above and unicolor of yellow for the whole body (Grismer, 2011).

Family Colubridae
***Dendrelaphis pictus* (Gmelin, 1789) (Painted Bronzeback)**

Remark: *Dendrelaphis pictus* is an arboreal and diurnal snake, known to feed mostly on lizards and amphibians (Van Rooijen and Vogel, 2008). An individual of *D. pictus* was found in a drain near the walkway, but it escaped into the bushes nearby. Another observation of this species was made on 17th April 2017 on campus near the compound of the library.

***Coelognathus radiatus* (Boie, 1827) (Copperhead Rat Snake)**
Figure 17.

Remark: *Coelognathus radiatus* was found in a building area. This is a very aggressive snake, but known to be non-venomous and not dangerous to human. This species is usually found in the vicinity of human settlements and agricultural areas, with its diet mainly on rodents and small vertebrates (Stuebing *et al.,* 1999).

***Chrysopelea ornata* (Shaw, 1802) (Golden Tree Snake)**
Figure 18.

Remark: *Chrysopelea ornata* was found on the walkway near the mangrove area during the day. This arboreal snake is capable of gliding through the air between trees. Known to be non-venomous snake and not dangerous to human.

Family Phytonidae
***Malayophyton reticulatus* (Schneider, 1801) (Reticulated Phyton)**
Figure 19.

Remark: *Malayophyton reticulatus* is an opportunist carnivorous snake that inhabits watery and open areas, and known as non-venomous, but it is a strong constricting snake. An individual of *M. reticulatus* was found resting on a branch near the mangrove area during the day on campus. Another individual was found as it crossed the road at night in a human settlement area located approximately 2.5 km from the campus. This species is considered as a generalist, as it is commonly found in disturbed areas, such as swampy areas and human settlement areas.

Family Homalopsidae
***Enhydris enhydris* (Schneider, 1799) (Rainbow Water Snake)**
Figure 20.

Remark: *Enhydris enhydris* is a piscivorous snake that inhabits watery areas (Murphy *et al.,* 1999; Voris and Murphy, 2002; Murphy *et al.,* 2002), known to be non-venomous and not dangerous to human. Two individuals of *E. enhydris* were found in drains. This species is considered as a common snake, as it is commonly found in disturbed areas, especially in irrigation ditches and swampy areas (Stuebing *et al.,* 1999).

***Hypsiscopus plumbea* (Boie, 1827) (Plumbeous Water Snake)**
Figure 21.

Remark: *Hypsiscopus plumbea* is a non-venomous snakes that prey for frogs and tadpoles as its main diet (Murphy *et al.,* 1999; Stuebing *et al.,* 1999; Voris and Murphy, 2002; Mao and Hung, 2015). An individual was found in the drain. This species is similar to *E. enhydris,* typically found in drains or irrigation ditches in disturbed and swampy areas, such as rice paddy fields (Stuebing *et al.,* 1999).

***Homalopsis buccata* (Linnaeus, 1758) (Puff-faced Water Snake)**
Figure 22.

Remark: *Homalopsis buccata* was also found in the same area as *E. enhydris* and *H. plumbea.* This snake was quite aggressive during the attempt to capture it, but it is known to be non-venomous. This species is only found in aquatic habitats, such as rivers, swampy areas, and artificial ponds, mainly feeding on fishes as its main diet (Stuebing *et al.,* 1999).

Family Geomydidae
***Coura amboinensis* (Daudin, 1802) (Amboina box turtle)**
Figure 23.

Remark: *Coura amboinensis* is a semi-aquatic omnivorous turtle that inhabits human-altered habitats (Schoppe, 2008; Ives *et al.,* 2008). This species was frequently encountered crossing the road during the night, probably moving from one water body to another.

***Siebenrockiella crassicollis* (Gray, 1830) (Black Marsh turtle)**
Figure 24.

Remark: *Siebenrockiella crassicollis* is an aquatic omnivorous turtle that is able to inhabit both disturbed and pristine areas (Sharma *et al.,* 2006; Sharma *et al.,* 2007; Auliya, 2007). An adult was found crossing the road on campus. This species is considered as a habitat generalist.

Family Emydidae
***Trachemys scripta* (Thunberg in Schoepff, 1792) (Common Slider turtle)**
Figure 25.

Remark: *Trachemys scripta* is an aquatic omnivorous turtle. This species was introduced to Peninsular Malaysia as petting animal and can be found almost in every pet shop. An adult female was spotted stuck in a dry drainage at UMT campus. This species is considered as a habitat generalist (Gibbons, 1990).

Discussion

Amphibians possess physiological and ecological limitations that cause sensitivity to anthropogenic disturbance and habitat condition (Vitt *et al.,* 1990; Pearman, 1997; Price *et al.,* 2007, Shulse *et al.,* 2010). Coastal habitats on UMT campus are typically dry and simpler in vegetation structures, which are unfavourable to most amphibians that are prone to desiccation (Schwarzkopf & Alford, 1996; Gamble, 2003; Woltz *et al.,* 2008). Thus, all frogs and toads that were recorded in this study were habitat generalists capable of surviving and adapting to the harsh condition of coastal areas.

As reported by Daicus *et al.* (2010) at Pantai Melawi, Kelantan and Sharma *et al.* (2007) at Bukit Labohan, Terengganu, the amphibian assemblages recorded were low in species richness and most were considered as habitat generalists. Additionally, amphibians are typically intolerant to high saline condition within mangrove habitats, except for *F. cancrivora.*

Unlike amphibians, most reptiles were well adapted to desiccation and high temperatures along the coastal terrestrial habitats on UMT campus. Reptiles possess specialized physiological and morphological features to conserve water, such as uric acid secretion, production of dry faeces, impermeable skin, and thermoregulatory behaviour (Munsey, 1972; Snodgrass *et al.,* 2008; Valdecantos *et al.,* 2015) that enable them to thrive well in this area. Additionally, reptiles rely on external heat sources by basking under sunlight to maintain body temperatures that are suitable for normal activity (Spellerberg, 1972; Webb and Whiting, 2005; Muñoz *et al.,* 2016). In addition, these studies also showed that reptiles were unaffected by the saline condition of habitats, which make them able to occupy a wider range of coastal habitats.

Human-made structures on campus have provided many suitable shelters, basking areas, and foraging grounds for most reptiles. For examples, common species, such as *G. mutilata, H. platyurus,* and *H. frenatus* were abundant on walls of buildings to prey upon insects, which are attracted to lights. The abundance of these scansorial geckos and amphibians might also attract certain snakes to hunt for them. Unmanaged food wastes have attracted scavengers, such as *V. salvator* and rodents that are typically preyed upon by predatory snakes, such as *C. radiatus, M. reticulatus,* and *N. kaouthia.* Grassy areas and ornamental gardens on campus provide the perfect shelters and basking areas during the day for common skinks and lizards.

Several studies have shown that coastal mangrove forests provide shelter from predators, cooler and moist environment, conducive for breeding and foraging of many herpetofauna species (Schlaepfer & Gavin, 2001; Dawson & Hostetler, 2008). For instance, *V. salvator, B. dendrophila,* and freshwater turtles (*C. amboinensis* and *S. crassicollis*) rely on mangroves as resting and foraging sites. Water snakes, such as *H. buccata, E. enhydris,* and *H. plumbea* prey upon the fishes in mangroves, particularly during low tides. Thus, this indicates that reptiles rely on both developed areas and natural habitats to access suitable places for hiding, foraging, and breeding. Most importantly, this study demonstrates that mangrove areas serve as a dispersal corridor or temporary refuge (Nagelkerken *et al.,* 2008) for many species, and are equally important as human-made environment in sustaining reptile diversity.

On UMT campus, the mangrove areas have been heavily degraded and surrounded by developed areas, which is exerting a certain pressure on the existing species. Studies have shown that disturbance decreases diversity and increases the abundance of common species, while rare species are highly restricted to undisturbed habitats (Heinan, 1992; Estrada *et al.,* 1993; Power, 1996; Blair, 1996; Glor *et al.,* 2001). Most alarming now, rare species that are fully dependent on mangrove habitats might be eradicated if the urbanization process continued to take place. Thus, an initiative to preserve the remnant mangroves as a green area should be implemented in order to conserve the herpetofauna diversity and the rest of faunas and floras in this important ecosystem. Besides, gazetting the remaining undeveloped areas as a green area can serve as alternatives to provide refuges for urban biodiversity (McFrederick & LeBuhn, 2006; Kadlec *et al.,* 2008). A green area is important as approaches in fostering an interest in conservation issues (Miller, 2005), pollution control and for psychological values, such as recreational areas (Haq, 2011).

Conclusion

The amphibian and reptile assemblages in this area reflect the influences of severe degradation of natural habitats with remnant fringe mangroves serving as refuges. Despite heavy urbanization throughout the campus, most of the amphibians and reptiles are habitat generalists that rely on both remnant natural habitats and disturbed areas. Specialist reptiles, however, remain in mangrove habitats and are most vulnerable towards habitat loss. Wetlands are intended for wildlife use to inhabit or as a refuge from predation. Therefore, construction on wetlands should be coupled with preservation of natural habitat, such as improved riparian preservation and stream mitigation practices. Thus, an integrated management is necessary in order to maintain and protect the remnant mangroves as the last resort to counter habitat loss of amphibians and reptiles on UMT campus. Since this is the first checklist report on herpetofaunal from UMT campus, we hope that all other taxonomic group studies are also compiled and published in the future. Data from the compiled studies can be used to plan proper management and development on campus for long term conservation action.

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References

Auliya, M. (2007). *An identification guide to the tortoises and freshwater turtles of Brunei Darussalam, Indonesia, Malaysia, Papua New Guinea, Philippines, Singapore, and Timor Leste.* TRAFFIC Southeast Asia, Petaling Jaya, Malaysia.

Blair, R. B. (1996). Land use and avian species diversity along an urban gradient.

Ecological Applications, 6:506–519.

Cox, M. J., van Dijk, P. P., Nabhitabhata, J. & Thirakhupt, K. (1998). *A Photographic Guide to Snakes and Other Reptiles of Thailand and South-East Asia.* Asia Books, Bangkok.

Christie, K., Craig, M. D., Stokes, V. L. & Hobbs, R. J. (2012). Home range size and micro-habitat density requirements of *Egernia napoleonis:* Implications for restored Jarrah forest of South Western Australia. *Restoration Ecology,* 20(6): 740-746.

Daicus, B., Hashim, R., Yong, H. S., Diah, S. Z. M., Ahmad, N. & Lim, B. L. (2010). A note on the amphibian fauna at Pantai Melawi Bachok, Kelantan. *Malaysian Journal of Science,* 29: 111-115.

Dawson, D. E. & Hostetler, M. E. (2008). Herpetofaunal use of edge and interior habitats in urban forest remnants. *Urban Habitat* 5(1). <http://www.urbanhabitats.org/v05n01/edgehabitat full.html>

Dunning, J. B., Danielson, B. J. & Pulliam, H. R. (1992). Ecological processes that affect populations in complex landscapes. *Oikos*, 65: 169–175

Davis, R. A. & Doherty, T. S. (2015). Rapid recovery of an urban remnant reptile community following summer wildfire. *PloS One,* 10(5): e0127925.

Estrada, A., Coates-Estrada, R. & Merritt, D. Jr. (1993). Bat species richness and abundance in tropical rain forest fragments and in agricultural habitats at Los Tuxtlas, Mexico. *Ecography*, 16: 309–318.

Evans, C. M., & Brodie, E. D. (1994). Adhesive strength of amphibian skin secretions. *Journal of Herpetology,* 28(4): 499-502.

Gibbons, J. W. (1990). *Life history and ecology of the slider turtle.* Smithsonian Institution, Washington, DC.

Gamble, L. R. (2003). Comparative effectiveness of two trapping techniques for surveying the abundance and diversity of reptiles and amphibians along drift fence arrays. *Herpetological Review,* 34(1): 39.

Glor, R. E., Flecker, A. S., Benard, M. F. & Power, A. G. (2001). Lizard diversity and agricultural disturbance in a Caribbean forest landscape. *Biodiversity and Conservation,* 10(5): 711-723.

Grismer, J. L., L. L. Grismer, I. Das, Y. Norsham, B. L. Lim, T. M. Leong, T. M. Youmans, B. & Kaiser, H. (2004). Species diversity and checklist of the herpetofauna of Pulau Tioman, Peninsular Malaysia with a preliminary overview of habitat utilization. *Asiatic Herpetological Research,* 10: 244-276.

Grismer, L. L., Youmans, T. M., Wood Jr, P. L. & Grismer, J. L. (2006). Checklist of the herpetofauna of the Seribuat Archipelago, West Malaysia with comments on biogeography, natural history and adaptive types. *The Raffles Bulletin of Zoological,* 54(1): 157-180.

Grismer, L. L. (2011). *Lizards of Peninsular Malaysia, Singapore and their Adjacent Archipelagos. Their Description, Distribution, and Natural History.* Frankfurt am Main, Edition Chimaira.

Geissler, P., Nguyen, T., Phung, T., Devender, R., Hartmann, T., Farkas, B. & Böhme, W. (2011). A review of Indochinese skinks of the genus *Lygosoma* Hardwicke & Gray, 1827 (Squamata: Scincidae), with natural history notes and an identification key. *Biologia*, 66(6): 1159-1176.

Huang, W. S. (2006). Ecological characteristics of the skink, *Mabuya longicaudata,* on a tropical East Asian island. *Copeia*, 2006(2): 293-300.

Haq, S. M. A. (2011). Urban green spaces and an integrative approach to sustainable

environment. *Journal of Environmental Protection,* 2(05): 601.

Heinen, J. T. (1992). Comparisons of the leaf litter herpetofauna in abandoned cacao plantations and primary rain forest in Costa Rica: some implications for faunal restoration. *Biotropica*, 24(3): 431-439.

Inger, R. F., & Stuebing, R. B. (1997). *A field guide to the frogs of Borneo.* Natural History Publications.

Ibrahim, J., Shahrul, A. M. S., Norhayati, A., Chan, K. O. & Muin, M. A. (2008). *The Common Amphibians and Reptiles of Penang Island.* Penang State Forestry Department, Penang.

Iskandar, D. T. (1998) *The Amphibian of Java and Bali.* LIPI, Yayasan Kehati, Bogor.

Ives, I. E., Platt, S. G., Tasirin, J. S., Hunowu, I., Siwu, S. & Rainwater, T. R. (2008). Field surveys, natural history observations, and comments on the exploitation and conservation of *Indotestudo forstenii, Leucocephalon yuwonoi,* and *Cuora amboinensis* in Sulawesi, Indonesia. *Chelonian Conservation and Biology,* 7(2): 240-248.

Ji, X., Qiu, Q. B. & Diong, C. H. (2002). Influence of incubation temperature on hatching success, energy expenditure for embryonic development, and size and morphology of hatchlings in the oriental garden lizard, *Calotes versicolor* (Agamidae). *Journal of Experimental Zoology,* 292(7): 649-659.

Jonsen, I. D. & Fahrig, L. (1997). Response of generalist and specialist insect herbivores to landscape spatial structure. *Landscape Ecology,* 12(3), 185-197.

Kadlec, T., Benes, J., Jarosik, V. & Konvicka, M. (2008). Revisiting urban refuges: changes of butterfly and burnet fauna in Prague reserves over three decades. *Landscape* and *Urban Planning*, 85(1): 1-11.

Krysko, K. L. & Enge, K. M. (2005). A new non-native lizard in Florida, the butterfly lizard, *Leiolepis belliana* (Sauria: Agamidae). *Florida Scientist*, 68(4): 247-249.

Lagat, R. D. (2009). A taxonomic account of lizards along established trails in MTS. Palay-Palay Mataas-na-Gulod Protected Landscape, Luzon Island, Philippines. *Philippine Journal of Systematic Biology,* 3(1): 17-28.

Lim, B. L. (2010). Preliminary survey of lizards of Pantai Melawi, Bachok, Kelantan, Malaysia. *Malaysian Journal of Science,* 29: 117-120.

Lim, B. L., Noor-Alif-Wira, O., Chan, K. O., Daicus, B. & Norhayati, A. (2010). An updated checklist of the herpetofauna of Pulau Singa Besar Langkawi, Peninsular Malaysia. *Malaysia Applied Biology,* 39(1): 13-23.

Li, H., Mao, L., Shi, L. & Ji, X. (2010). Many-lined Sun Skinks (*Mabuya multifasciata*) shift their thermal preferences downwards when fasted. *Asian Herpetological Research,* 1:36–39.

Mao, Y. C. & Hung, D. Z. (2015). Management of Snake Envenomation in Taiwan. In. Gopalakrishnakone, P., Faiz S., Gnanathasan C., Habib A., Fernando R., Yang, C. C. (Eds.). *Clinical Toxinology in Asia Pacific and Africa.* Springer, Dordrecht. 1-25.

McFrederick, Q. S. & LeBuhn, G. (2006). Are urban parks refuges for bumble bees *Bombus* spp. (Hymenoptera: Apidae). *Biological Conservation,* 129(3): 372-382.

Miller, J. R. (2005). Biodiversity conservation and the extinction of experience. *Trends in Ecology & Evolution,* 20(8): 430-434.

Muñoz, M. M., Langham, G. M., Brandley, M. C., Rosauer, D. F., Williams, S. E. & Moritz, C. (2016). Basking behaviour predicts the evolution of heat tolerance in Australian rainforest lizards. *Evolution*, 70(11): 2537-

2549.

Munsey, L. D. (1972). Water loss in five species of lizards. *Comparative Biochemistry and Physiology Part A: Physiology,* 43(4): 781-794.

Murphy, J. C., Voris, H. H., Karns, D. R., Chan-Ard, T. & Suvunrat, K. (1999). The ecology of the water snakes of Ban Tha Hin, Songkhla Province, Thailand. *Natural History Bulletin of the Siam Society*, 47:129–147.

Murphy, J. C., Voris, H. K., Stuart, B. L. & Platt, S. G. (2002). Female reproduction in the rainbow water snake, *Enhydris enhydris* (Serpentes, Colubridae, Homalopsinae). *Tropical Natural History,* 2(1): 31-37.

Nagelkerken, I., Blaber, S. J. M., Bouillon, S., Green, P., Haywood, M., Kirton, L. G. & Somerfield, P. J. (2008). The habitat function of mangroves for terrestrial and marine fauna: a review. *Aquatic Botany,* 89(2): 155-185.

Norhayati, A., Belabut, D. M., Juliana, S. & Chan, K. O. (2009). Amphibians and reptiles of Malaysia. Retrieved from http://www. amphibia.my.

Ngo, C. D., Ngo, B. V., Truong, P. B. & Duong, L. D. (2014). Sexual size dimorphism and feeding ecology of *Eutropis multifasciata* (Reptilia: Squamata: Scincidae) in the central highlands of Vietnam. *Herpetological Conservation and Biology,* 9: 322-333.

Pandav, B. N., Shanbhag, B. A. & Saidapur, S. K. (2006). Functional significance of posthatching residual yolk in the lizard, *Calotes versicolor. Journal of Herpetology,* 40(3): 385-387.

Pearman, P. B. (1997). Correlates of amphibian diversity in an altered landscape of Amazonian, Ecuador. *Conservation Biology,* 11(5): 1211-1225.

Power, M. E., Tilman, D., Estes, J. A., Menge, B. A., Bond, W. J., Mills, L. S. & Paine, R. T. (1996). Challenges in the quest for keystones: identifying keystone species is difficult-but essential to understanding how loss of species will affect ecosystems. *BioScience*, 46(8): 609-620.

Price, S. J., Howe, R. W., Hanowski, J. M., Regal, R. R., Niemi, G. J. & Smith, C. R. (2007). Are anurans of Great Lakes coastal wetlands reliable indicators of ecological condition? *Journal of Great Lakes Research,* 33: 211-223.

Rocha J. C. Piva, P., Batista, J. & Machado, D. C. (2015). Occurrence of the tokay gecko, Gekko gecko Linnaeus 1758 (Squamata, Gekkonidae), an exotic species in southern Brazil. *Herpetology Notes,* 8: 8-10.

Putra, K., Rizaldi & Tjong, D. H. (2012). Komunitas anura (Amphibia) pada tiga tipe habitat perairan di Kawasan Hutan Harapan Jambi. *Jurnal Biologi Univesitas Andalas,* 1(2): 156-165.

Schlaepfer, M. A. & Gavin, T. A. (2001). Edge effects on lizards and frogs in tropical forest fragments. *Conservation Biology,* 15:1079-1090.

Smith M. A. (1935). *The Fauna of British India, including Ceylon and Burma. Reptilia and Amphibia. Vol. II. Sauria.* Taylor & Francis Ltd., London.

Schoppe, S. (2008). *The Southeast Asian box turtle Cuora amboinensis (Daudin, 1802) in Malaysia.* NDF Workshop Case Studies, WG 7- Reptiles and amphibians Case Study 6. 18 pp.

Schwarzkopf, L. & Alford, R. A. (1996). Desiccation and shelter-site use in a tropical amphibian: comparing toads with physical models. *Functional Ecology,* 10(2): 193-200.

Stuebing, R. B., Inger, R. F. & Tan, F. L. (1999). *Field Guide to the Snakes of Borneo.*

Natural History Publications (Borneo). Kota Kinabalu.

Shariza, S. & Ibrahim, J. (2012). The amphibian diversity of Bukit Jana, Taiping, Perak. *Tropical Life Sciences Research,* 23(2): 49-57.

Sharma, D. S. K., Wahab, A. Z. A. & Darmaraj, M. R. (2006). A note on the reptiles of Pasir Raja (including Gunung Mandi Angin), Jengai and Jerangau Forest Reserves, Terengganu. In. Muda, A., Jaafar, N., Sabran, M.R., Som, J.M., Nizam, M.S. & Latiff, A. (Eds.). *Gunung Mandi Angin, Terengganu Pengurusan, Persekitaran Fizikal, Kepelbagaian Biologi dan Pelancongan Ekologi. Siri Kepelbagaian Biologi Hutan No.7, Jabatan Perhutanan Semenanjung Malaysia,* 32: 434-440.

Sharma, D. S. K., Chong, D. K. F., Darmaraj, M. R., Lau, M. M., Ng, B. S., Abdul Wahab, A. Z., Nurul Ain, E. & Nor Zalipah, M. (2007). An annotated preliminary checklist of reptiles of Bukit Labohan Forest Reserve and the Ma'Daerah turtle sanctuary, Kemaman, Terengganu. In Sharma, D., Abdul Wahab, A. Z., Basri, N., Awang Ali Bema, D. N. (Eds.). *Biodiversity Expedition in Bukit Labohan, Ma'Daerah, Terengganu.* WWF-Malaysia, Petaling Jaya. 73-80.

Shulse, C. D., Semlitsch, R. D., Trauth, K. M. & Williams, A. D. (2010). Influences of design and landscape placement parameters on amphibian abundance in constructed wetlands. *Wetlands*, 30(5): 915-928.

Snodgrass, J. W., Casey, R. E., Simon, J. A. & Gangapura, K. (2008). Ecotoxicology of amphibians and reptiles in urban environments: an overview of potential exposure routes and bioaccumulation. *Urban Herpetology,* 3: 177-196.

Soud, R., Mazumdar, K., Gupta, A. & Talukdar, S. (2012). Defensive and burrowing behaviour of *Kaloula assamensis* Das *et al.,* 2004 and *Kaloula pulchra* Gray, 1831 (Microhylidae). *Frog leg,* 18: 48-50.

Spellerberg, I. F. (1972). Temperature tolerances of southeast Australian reptiles examined in relation to reptile thermoregulatory behaviour and distribution. *Oecologia*, 9(1): 23-46.

Suazo-Ortuna, I., Alvarado-Diaz, J. & Martinez-Ramos, M. (2010). Riparian areas and conservation of herpatofauna in a tropical dry forest in Western Mexico. *Biotropica*, 43(2): 237-245.

Sumarli, A. X., Grismer, L. L., Anuar, S., Muin, M. A. & Quah, E. S. (2015). First report on the amphibians and reptiles of a remote mountain, Gunung Tebu in northeastern Peninsular Malaysia. *Check List,* 11(4): 1679.

Toft, C.A. 1985. Resource partitioning in amphibians and reptiles. *Copeia*, 1985(1): 1–21.

Valdecantos, S., Martínez, V. & Labra, A. (2015). Description of a proctodeal gland present in three South American *Liolaemus* lizards (Iguania: Liolaemidae). *Salamandra*, 51(2): 182-186.

Van Rooijen, J. & Vogel, G. (2008). Contributions to a review of the *Dendrelaphis pictus* complex (Serpentes: Colubridae)–1. Description of a sympatric species. *Amphibia-Reptilia,* 29(1): 101-115.

Vitt, L. J., Caldwell, J. P., Wilbur, H. M. & Smith, D. C. (1990). Amphibians as harbingers of decay. *BioScience*, 40:418.

Vitt, L. J. & Blackburn, D. G. (1991). Ecology and life history of the viviparous lizard *Mabuya bistriata* (Scincidae) in the Brazilian Amazon. *Copeia*, 1991:916–927.

Voris, H. K. & Murphy, J. C. (2002). The prey and predators of homalopsine snakes. *Journal of Natural History,* 36(13): 1621-1632.

Vrcibradic, D. & Rocha, C. F. D. (1996). Ecological differences in tropical sympatric skinks (*Mabuya macrorhyncha* and *Mabuya*

agilis) in Southeastern Brazil. *Journal of Herpetology,* 30:60–67.

Webb, J. K. & Whiting, M. J. (2005). Why don't small snakes bask? Juvenile broad-headed snakes trade thermal benefits for safety. *Oikos*, 110(3): 515-522.

Woltz, H. W., Gibbs, J. P. & Ducey, P. K. (2008). Road crossing structures for amphibians and reptiles: informing design through behavioural analysis. *Biological Conservation,* 141(11): 2745-2750.

Zug, G. R., Brown, H. H., Schulte, J. A. & Vindum, J. V. (2006). Systematics of the garden lizards, *Calotes versicolor* group (Reptilia, Squamata, Agamidae), in Myanmar: Central dry zone populations. *Proceedings of the California Academy of Sciences,* 57(2): 35-68.

Figure 2. *Duttaphrynus melostictus*

Figure 3. *Kaloula pulchra*

Figure 4. *Microhyla heymonsi*

Figure 5. *Fejervarya limonocharis*

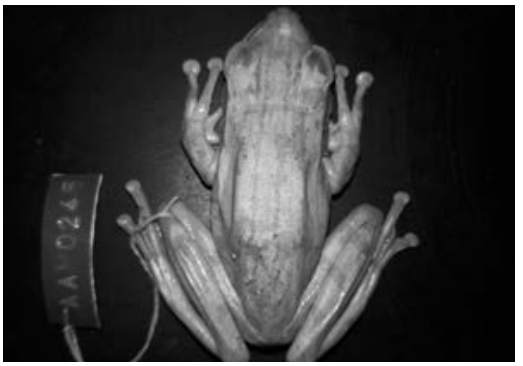

Figure 6. *Polypedates leucomystax*

Figure 7. *Calotes versicolor*

Figure 8. *Leiolepis belliana*

Figure 9. *Varanus salvator*

Figure 10. *Eutropis longicaudata*

Figure 11. *Eutropis multifasciata*

Figure 12. *Lygosoma bowringii*

Figure 13. *Gekko gecko*

Figure 14. *Gehyra mutilata*

Figure 15. *Hemidactylus platyurus*

Figure 16. *Hemidactylus frenatus*

Figure 17. *Coelognathus radiatus*

Figure 18. *Chrysopelea ornata*

Figure 19. *Malayophyton reticulatus*

Figure 20. *Enhydris enhydris*

Figure 21. *Hypsiscopus plumbea*

Figure 22. *Homalopsis buccata*

Figure 23. *Coura amboinensis*

Figure 24. *Siebenrockiella crassicollis*

Figure 25. *Trachemys scripta*