

Species Richness Estimation of Reptiles in Selected Sites of Tasik Kenyir, Hulu Terengganu, Malaysia



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Abstract The knowledge on the composition of reptile species at Tasik Kenyir and its vicinity is still lacking as there is no comprehensive checklist available to date. This study aimed to provide a checklist and to estimate the species richness of reptiles in recreational forests located at and around Tasik Kenyir, namely Sungai Buweh, Belukar Bukit, Sekayu, and Saok. Visual Encounter Survey (VES), pitfall trapping, and opportunistic survey methods were used in this study. From 46 sampling days between April 2015 and February 2016, a total of 118 individuals from 26 species, 19 genera and nine families of reptiles were successfully recorded. Almost half of the reptile species belongs to family Gekkonidae (42%), followed by Agamidae (23%) and Scincidae (11%). The most abundant species observed were *Eutropis multifasciata* (24%), *Hemidactylus frenatus* (16%) and *Gekko monarchus* (13%). Eleven of the recorded species are protected under Wildlife Conservation Act 2010 and nine species are listed as Least Concern by IUCN 2016. The number of species estimated by non-parametric estimators, Chao 1 and Chao 2 were 35 and 39 species respectively. The results from this study could be useful to monitor the impact of habitat changes and human disturbances at Tasik Kenyir and the neighbouring areas.

Keywords Estimation · Reptiles · Richness · Tasik Kenyir

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Introduction

Reptiles play important roles in ecosystems, as prey and predators, grazers, agents for seed dispersal, commensal species, and their often specific microhabitat associations may be used to illustrate evolutionary processes of speciation (Raxworthy et al. 2008; Read 1998). Due to its ecological relevance, the declines of reptile populations may cause negative impact on the natural systems. In order to maintain healthy ecosystems, biodiversity studies are crucial as they provide the knowledge to prioritize conservation areas and habitats, and to model sustainable use of resources (Sohdi et al. 2004). Species richness data for instance are vital so that the responsible authorities are aware of the wildlife present in an area. Mitigation measures that need to be included in the development plans considering the plight of the animals can be developed using the data, thus ensuring the continued existence of the species in their natural habitat. Without substantial amount of biodiversity publications, species will be prone to extermination as no action taken on threats faced by a particular species.

In Malaysia, most of the reptile studies were focusing on species richness (Sumarli et al. 2015, 2016; Voris 2015; Shahriza and Ibrahim 2014; Nurulhuda et al. 2014; Amirah et al. 2013; Quah et al. 2013; Shahriza et al. 2012; Chan et al. 2010a, b; Ibrahim et al. 2008, 2012, 2013; Grismer et al. 2004, 2006, 2014a, b, c) and only a single study have been published on the estimation of species richness (van Rooijen et al. 2011). It has been reported that 397 species of reptiles have been recorded around Malaysia and among them, an approximate of 256 species (65%) were identified to be present in Peninsular Malaysia (Das and Norsham 2007). Since then, many new species have been discovered along with the rediscovery of rare species (Grismer et al. 2008a, b, c, 2009, 2010a, b, 2011, 2014a, b, c, 2016a, b, c, d; Sumarli et al. 2016; Grismer and Quah 2015; Johnson et al. 2012; Grismer 2008, 2011; Chan et al. 2010a; Wood et al. 2009). These discoveries clearly show that Malaysian forests are very rich in reptile assemblage, which underlines the need for more studies and surveys to be carried out.

Reptiles in Tasik Kenyir, Hulu Terengganu are still understudied although this place is a home to a significant number of flora and fauna (Faizah et al. 2015). Therefore, this study was conducted to examine the species richness of reptiles in selected sites surrounding Tasik Kenyir, Terengganu. It is hoped that this study can be useful for future reptile studies, and for the conservation and management purposes at Tasik Kenyir and other similar habitats particularly in Terengganu.

The survey was conducted from April 2015 to February 2016 at four sampling sites located at and around Tasik Kenyir, Terengganu, namely Sungai Buweh, Belukar Bukit, Sekayu and Saok, (Table 1, Fig. 1). These four sampling sites are recreational areas surrounded by lowland dipterocarp forests. They were chosen as the study sites because there were no or very limited information on reptilian fauna of these areas which may harbour a diverse set of species.

In this study, pitfall trapping method was used to collect samples at all sites but not in all occasions. In order to increase the probability of reptiles to fall into the traps, drift fences from aluminium sheets, wire nets or fallen logs were used. The

Table 1 List of sampling sites, dates and methods used

Site	Date	Methods
Sungai Buweh	20.4.2015 – 26.4.2015	VES; 14 PT
(5° 08' 56.0" N 102° 46' 20.2" E)	28.4.2015	OS
	26.8.2015	OS
	23.1.2016	OS
Belukar Bukit	15.5.2015 – 21.5.2015	VES; 18 PT
(4° 53' 27.0" N 102° 59' 36.1" E)	25.9.2015 – 1.10.2015	VES; 18 PT
Sekayu	21.6.2015 – 27.6.2015	VES; 4 PT
(4° 57' 50.1" N 102° 57' 28.1" E)	17.10.2015 – 24.10.2015	VES; 30 PT
Saok	22.2.2016 – 28.2.2016	VES; 30 PT
(5° 00' 35.8" N 102° 39' 01.2" E)		

VES Visual Encounter Survey, PT pitfall traps, OS opportunistic sampling (opportunistic samplings were done by other members of our zoological survey team)



Fig. 1 Map showing the four sampling sites around Tasik Kenyir, Hulu Terengganu. (Source: Google Maps)

numbers of pitfall traps used were unequal between sampling sites due to geographical constraint and manpower limitations. Visual Encounter Surveys (VES) was also conducted to search and to collect reptiles. Active searching were carried out for three sessions per day (in the morning, evening and at night time) along an approximately 1 km transect, for 2–3 h per session. All observed reptile species were recorded and captured, when possible, using sweep nets, hand-picking device, or simply by hand grabbing.

The specimens were placed inside an individual plastic or cloth bag and were taken back to the laboratory for sample processing. Voucher specimens were preserved in 10% formalin and stored in 70% ethanol and deposited in laboratory situated in Centre of Kenyir Ecosystems Research, Kenyir Research Institute, Universiti Malaysia Terengganu (UMT) for future reference. Taxonomy of reptiles or species identification was based on Das (2004, 2007, 2010). The conservation status of the reptile species was assessed based on IUCN Red List of Threatened Species (IUCN 2016) and Wildlife Conservation Act 2010.

To estimate the species richness of reptiles in the study area, the data were analysed using non-parametric richness estimators calculated in EstimateS version 9.1 (Colwell 2013) Chao 1 and Chao 2 (Chao 1984). Chao 1 uses abundance-based data while Chao 2 uses incidence-based data. These estimators use information on the frequency of rare species in a sample to estimate the number of undetected species in an assemblage (Gotelli and Chao 2013; Gotelli and Colwell 2011).

Checklist of Reptiles

From 46 sampling days, 118 individuals of reptiles from nine families, 19 genera and 26 species were recorded from study sites at and around Tasik Kenyir, Terengganu (Table 2). The most abundant family was Gekkonidae (42%) followed by Agamidae (23%), Scincidae (11%), and the other six families, Geoemydidae, Trionychidae, Varanidae, Colubridae, Elapidae and Viperidae each contributed 4% for the total number of species (Fig. 2). The most diverse reptile genus recorded were *Hemidactylus* with three species followed by two species for *Draco*, *Gonocephalus*, *Cyrtodactylus*, *Gekko* and *Eutropis* each. Only one species was recorded for the genus *Cyclemys*, *Dogania*, *Aphanotis*, *Calotes*, *Cnemaspis*, *Gehyra*, *Hemiphyllodactylus*, *Luperosaurus*, *Lipinia*, *Varanus*, *Calamaria*, *Naja* and *Tropidolaemus*. The proportion of species that have been assessed for their conservation status was 54%. Based on IUCN 2016, only nine out of the 26 species were categorised as Least Concern and the rest were not yet assessed. In Wildlife Conservation Act 2010, 11 of the total species recorded were protected, mostly in the Agamidae family.

The numbers of reptile species estimated by Chao 1 and Chao 2 estimators were all higher than the number of observed species, 26 (Table 3, Fig. 3). The percentage of observed richness based on the estimated richness of Chao 1 and Chao 2 was 74% and 67% respectively.

In this study, Belukar Bukit and Sekayu have the highest number of reptile species, mainly because the sampling duration in these study sites were longer, 14 and 15 days respectively, compared to Sungai Buweh (10 days) and Saok (seven days). Restricted time allows limited coverage area for sampling activities, thus contributes to limited finding of species (Ibrahim et al. 2012; Shahrizza et al. 2012). Herpetological surveys especially require longer periods of sampling due to the elusive and secretive nature of amphibians and reptiles (Ibrahim et al. 2013) therefore

Table 2 Checklist of reptiles in selected sites of Tasik Kenyir, Terengganu

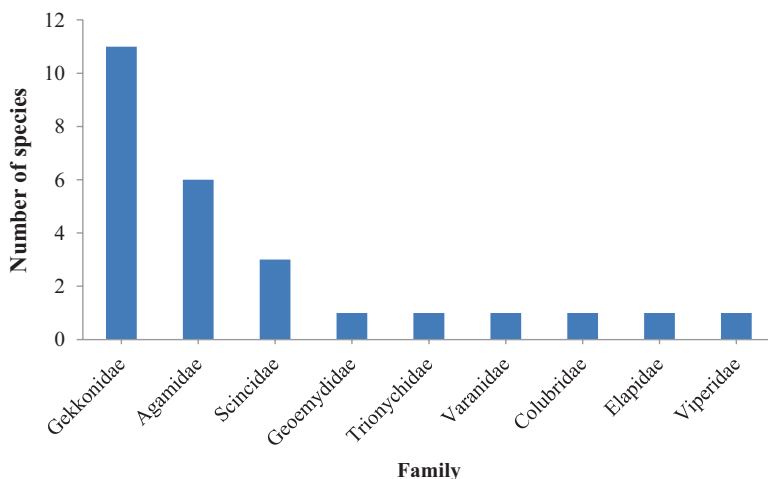
Order family species	Common name	SB	BB	SK	SO	WCA 2010	IUCN 2016
Chelonia							
Geoemydidae							
<i>Cyclemys</i> sp.	Leaf turtle	0	2	0	0	NA	NA
Trionychidae							
<i>Dogania subplana</i>	Malayan softshell turtle	0	0	0	1	P	LC
Squamata							
Agamidae							
<i>Aphaniotis fusca</i>	Brown shrub lizard	0	1	0	0	P	LC
<i>Calotes versicolor</i>	Garden lizard	0	0	1	0	P	NA
<i>Draco melanopogon</i>	Black-bearded flying lizard	0	1	1	0	P	NA
<i>Draco sumatranus</i>	Common flying lizard	0	0	1	0	NP	NA
<i>Gonocephalus bellii</i>	Blue-necked angle-headed lizard	2	1	0	1	P	NA
<i>Gonocephalus grandis</i>	Giant angle-headed lizard	0	1	1	0	P	LC
Gekkonidae							
<i>Cnemaspis peninsularis</i>	Peninsular rock gecko	3	1	2	0	NP	NA
<i>Cyrtodactylus consobrinus</i>	Peter's bent-toed gecko	3	0	1	0	P	NA
<i>Cyrtodactylus quadrivirgatus</i>	Four-striped bent-toed gecko	2	0	0	1	P	NA
<i>Gehyra mutilata</i>	Common four-clawed gecko	2	0	0	0	NP	NA
<i>Gekko monarchus</i>	Warty house gecko	2	3	7	3	NP	NA
<i>Gekko smithii</i>	Smith's giant gecko	0	3	0	0	NP	LC
<i>Hemidactylus craspedotus</i>	Friilly forest gecko	0	1	0	0	NP	NA
<i>Hemidactylus frenatus</i>	Asian house gecko	0	14	4	1	NP	LC
<i>Hemidactylus garnotii</i>	Garnot's house gecko	0	2	1	0	NP	NA
<i>Hemiphyllodactylus typus</i>	Common worm gecko	0	0	0	1	NP	NA
<i>Luperosaurus browni</i>	Brown's camouflage gecko	0	0	0	1	NP	NA
Scincidae							
<i>Eutropis longicaudata</i>	Long-tailed ground skink	1	0	0	0	NP	NA
<i>Eutropis multifasciata</i>	Common sun skink	3	12	13	0	NP	NA
<i>Lipinia vittigera</i>	Common striped skink	2	0	0	0	NP	NA
Varanidae							
<i>Varanus salvator</i>	Water monitor lizard	0	6	5	1	P	LC
Colubridae							
<i>Calamaria pavementata</i>	Brown reed snake	1	0	0	0	NP	LC
Elapidae							
<i>Naja kaouthia</i>	Monocled cobra	0	0	1	0	P	LC
Viperidae							

(continued)

Table 2 (continued)

Order family species	Common name	SB	BB	SK	SO	WCA 2010	IUCN 2016
<i>Tropidolaemus wagleri</i>	Wagler's keeled green pit viper	0	0	1	0	P	LC
	No. of individual	21	48	39	10		
	No. of species	10	13	13	8		
	No. of genus	8	9	11	8		
	No. of family	4	5	6	4		
	No. of individual	118					
	No of genus	19					
	No. of species	26					
	No. of family	9					

Study sites: *SB* Sungai Buweh, *BB* Belukar Bukit, *SK* Sekayu, *SO* Saok; Conservation status: *WCA* Wildlife Conservation Act, *IUCN* International Union for Conservation of Nature

**Fig. 2** Composition of reptile in each family in selected sites of Tasik Kenyir, Terengganu

additional surveys in the study sites are necessary to increase the chances of species detection. Gekkonidae was found to be the most dominant family at Tasik Kenyir with almost half of the total species recorded (42%) were from this family. This is because most of the species in this family such as *Gehyra mutilata*, *Gekko monar-chus*, *G. smithii*, *Hemidactylus frenatus* and *H. garnotii* were considered as commensal species and were easily spotted around human residences. Some of these species may come from nearby forested habitats to forage in human habitations where the food source is available.

Eutropis multifasciata from family Scincidae (Fig. 4) was the most abundant species (23.7%) recorded in this study, found at all study sites except Saok. This

Table 3 Number of estimated species from abundance- and incidence-based richness estimators, and the percentage of predicted richness actually observed of reptiles in the study area

Estimators	Mean±SD	Percentage observed
Chao 1	35.09 ± 7.33	74%
Chao 2	39.13 ± 9.29	67%

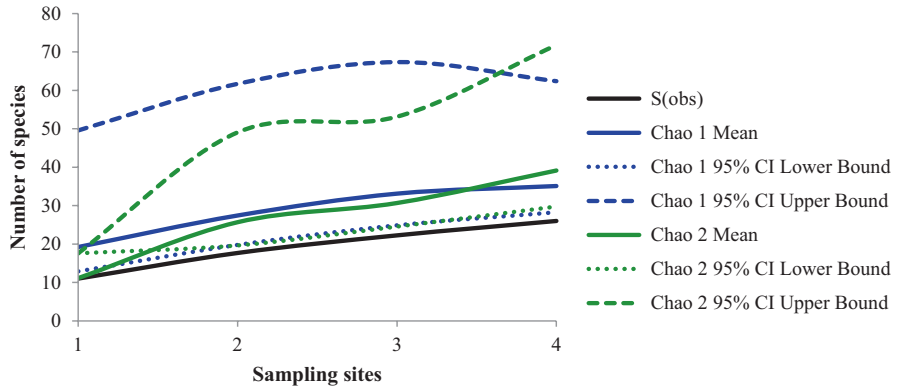


Fig. 3 Observed species, $S(obs)$, Chao 1 and Chao 2 estimator curves for number of reptile species



Fig. 4 *Eutropis multifasciata* was observed basking on a rock at Taman Pertanian Sekayu, Kenyir, Terengganu. (Photograph by Fathihi Hakimi Rosmidi)



Fig. 5 *Tropidolaemus wagleri*, Wagler's keeled green pit viper (female)

commensal species is known to be common in forest edges and around human settlements. The specimens of this species were found around buildings, along forest trails, and on rocky outcrops near water bodies. Two individuals of *E. multifasciata*, one in Sekayu and one in Belukar Bukit were caught in cage traps that were used by other zoological team members to catch small mammals. Two individuals of *Cyclemys* sp. were also caught in cage traps placed along the river banks in Belukar Bukit.

In this study, only three snake species managed to be recorded. *Calamaria pavementata* was observed on the ground near rocky area of Sungai Buweh waterfall while *Naja kaouthia* and *Tropidolaemus wagleri* (Fig. 5) were both found along the river at Sekayu. The low number of snakes spotted may be due to their highly elusive and cryptic behaviour. Longer sampling duration may not necessarily produce a higher number of snake species encountered. For instance, only three species of snakes were documented by Ibrahim et al. (2012) in Bukit Perangin Forest Reserve, Kedah from January 2009 till end of May 2010.

One of the interesting species encountered in the study area was *Luperosaurus browni* (Fig. 6), which was found tangled in a mist nest deployed for bird survey at Saok. This species is highly elusive as it dwells in the canopy, and the grey-brown colouration of this small gecko enables it to camouflage well on tree trunks.

The Chao 1 and Chao 2 species richness estimator showed a completeness of 74% and 67% respectively. Although this result revealed an acceptable estimate based on the sampling efforts (Shazali et al. 2016), additional surveys with standardised sampling methods are highly recommended to better estimate the reptile species composition at Tasik Kenyir. The duration of sampling of this study ranged from seven to 15 days per study site, which was not enough to cover the entire forests, rivers and waterfalls, especially with limited manpower.



Fig. 6 *Luperosaurus browni* (Brown camouflage gecko) found in Saok, Tasik Kenyir, Terengganu

Conclusion

Based on this study, Tasik Kenyir is expected to hold a higher number of reptile species, as suggested by the estimators (up to 39 species), and the opportunities to discover rare and new species are infinite. Extensive surveys covering areas deep in the forest that are more pristine should be conducted to establish a better picture of its reptile diversity. All of the study sites are always frequented by visitors from time to time therefore it is hoped that this study would be useful for the management purposes of Tasik Kenyir. The composition of reptiles and other taxa should be taken into account before any changes to the habitat is made in order to avoid species loss especially for species that are sensitive to environmental changes.

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References

- Amirah, H., Mohd Azmeer, A. B., Sharma, D., Nurolhuda, N., Sharma, R., Ahmad Ridzuan, Y. A., & Ibrahim, J. (2013). An updated checklist of the herpetofauna of the Belum-Temengor forest reserves, Hulu Perak, Peninsular Malaysia. Proceedings of the 3rd Annual International Conference Syiah Kuala University (AIC Unsyiah) in conjunction with the 2nd International Conference on Multidisciplinary Research (ICMR). Banda Aceh, 2012. Banda Aceh: Syiah Kuala University Press.

- Chan, K. O., Grismer, L. L., Shahrul, A., Quah, E., Muin, M. A., Savage, A. E., Grismer, J. L., Norhayati, A., Remegio, A. C., & Greer, L. F. (2010a). A new endemic Rock Gecko *Cnemaspis* Strauch 1887 (Squamata: Gekkonidae) from Gunung Jerai, Kedah, northwestern Peninsular Malaysia. *Zootaxa*, 2576, 59–68.
- Chan, K. O., van Rooijen, J., Grismer, L. L., Daicus, B., Mohd. Abdul Muin, M. A., Hamidi, J., Gregory, R., & Norhayati, A. (2010b). First report on the herpetofauna of Pulau Pangkor, Perak, Malaysia. *Russian Journal of Herpetology*, 17(2), 139–146.
- Chao, A. (1984). Nonparametric estimation of the number of classes in a population. *Scandinavian Journal of Statistics*, 11, 265–270.
- Colwell, R. K. (2013). Estimates: Statistical estimation of species richness and shared species from samples. Version 9. Retrieved from <http://purl.oclc.org/estimates>.
- Das, I. (2004). *Lizards of Borneo*. Kota Kinabalu: Natural History Publications (Borneo).
- Das, I. (2007). *Amphibians and reptiles of Brunei: A pocket guide*. Kota Kinabalu: Natural History Publications (Borneo).
- Das, I. (2010). *A pocket guide to the reptiles of South-east Asia*. London: New Holland Publishers.
- Das, I., & Norsham, Y. (2007). Status of knowledge of the Malaysian Herpetofauna. In L. S. L. Chua, L. G. Kirton, & L. G. Saw (Eds.), *Status of biological diversity in Malaysia and threat assessment of plant species in Malaysia: Proceedings of the Seminar and Workshop 28–30 June 2005* (pp. 31–38). Kepong: Forest Research Institute Malaysia.
- Faizah, M. S., Abdullah, M. T., Che Aziz, A., & Ismail, R. (2015). *Geopark Tasik Kenyir*. Kuala Terengganu: Penerbit Universiti Malaysia Terengganu.
- Gotelli, N. J., & Chao, A. (2013). Measuring and estimating species richness, species diversity, and biotic similarity from sampling data. In S. A. Levin (Ed.), *Encyclopedia of Biodiversity* (2nd ed., pp. 195–211). Cambridge, MA: Academic.
- Gotelli, N. J., & Colwell, R. K. (2011). Estimating species richness. In A. E. Magurran & B. J. McGill (Eds.), *Frontiers in measuring biodiversity* (pp. 39–54). New York: Oxford University Press.
- Grismer, L. L. (2008). A new species of insular skink (Genus *Sphenomorphus* Fitzinger 1843) from the Langkawi Archipelago, Kedah, West Malaysia with the first report of the herpetofauna of Pulau Singa Besar and an updated checklist of the herpetofauna of Pulau Langkawi. *Zootaxa*, 1691, 53–66.
- Grismer, L. L. (2011). *Lizards of Peninsular Malaysia, Singapore and their adjacent archipelagos*. Frankfurt: Edition Chimaira.
- Grismer, L. L., & Quah, S. H. E. (2015). The rediscovery of *Sphenomorphus malayanus* Doria, 1888 (Squamata: Scincidae) from the Titiwangsa Mountain Range of Peninsular Malaysia and its re-description as *S. senja* sp. nov. *Zootaxa*, 3931(1), 63–70.
- Grismer, J. L., Grismer, L. L., Das, I., Norsham, S. Y., Lim, B. L., Tzi, M. L., Youmans, T. M., & 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, 247–279.
- Grismer, L. L., Youmans, T. M., Wood, P. L., Jr., & Grismer, J. L. (2006). Checklist of the herpetofauna of the Seribu Archipelago, West Malaysia with comments on biogeography, natural history and adaptive types. *The Raffles Bulletin of Zoology*, 54(1), 157–180.
- Grismer, L. L., Chan, K. O., Nurulhuda, N., & Sumontha, M. (2008a). A new species of karst dwelling gecko (Genus *Cnemaspis* Stauch 1887) from the border region of Thailand and Peninsular Malaysia. *Zootaxa*, 1875, 51–68.
- Grismer, L. L., Grismer, J. L., Wood, P. L., Jr., & Chan, K. O. (2008b). The distribution, taxonomy, and redescription of the geckos *Cnemaspis affinis* (Stoliczka 1887) and *C. flavolineata* (Nicholls 1949) with descriptions of a new montane species and two new lowland, karst-dwelling species from Peninsular Malaysia. *Zootaxa*, 1931, 1–24.
- Grismer, L. L., Norhayati, A., Chan, K. O., Daicus, B., Muin, M. A., Grismer, J. L., & Wood, P. L., Jr. (2008c). Two new diminutive species of *Cnemaspis* Strauch 1887 (Squamata: Gekkonidae) from Peninsular Malaysia. *Zootaxa*, 2019, 40–56.

- Grismer, L. L., Wood, P. L., Jr., & Grismer, J. L. (2009). A new insular skink of the genus *Sphenomorphus* Strauch 1887 (Squamata: Scincidae) from Pulau Perhentian Besar, Terengganu, Peninsular Malaysia. *Tropical Life Sciences Research*, 20, 51–69.
- Grismer, L. L., Chan, K. O., Quah, E., Muin, M. A., Savage, A. E., Grismer, J. L., Norhayati, A., Greer, L. F., & Remegio, A. C. (2010a). Another new, diminutive Rock Gecko (*Cnemaspis* Strauch) from Peninsular Malaysia and a discussion of resource partitioning in sympatric species pairs. *Zootaxa*, 2569, 55–66.
- Grismer, L. L., Shahrul, A., Quah, E., Muin, M. A., Chan, K. O., Grismer, J. L., & Norhayati, A. (2010b). A new spiny, prehensile-tailed species of *Cyrtodactylus* (Squamata: Gekkonidae) from Peninsular Malaysia with a preliminary hypothesis of relationships based on morphology. *Zootaxa*, 2625, 40–52.
- Grismer, L. L., Quah, E. S. H., Siler, C. D., Chan, K. O., Wood, P. L., Jr., Grismer, J. L., Shahrul Anuar, M. S., & Norhayati, A. (2011). Peninsular Malaysia's first limbless lizard: A new species of skink of the genus *Larutia* (Bohme) from Pulau Pinang with a phylogeny of the genus. *Zootaxa*, 2799, 29–40.
- Grismer, L. L., Lukman, H. B. I., Awang, M. T., Syed, A. R., & Ahmad, B. A. (2014a). A new species of lowland skink (genus *Lipinia* Gray, 1845) from northeastern Peninsular Malaysia. *Zootaxa*, 3821(4), 457–464.
- Grismer, L. L., Wood, P. L., Jr., Anuar, S., Riyanto, A., Norhayati, A., Muin, M. A., Sumontha, M., Grismer, J. L., Chan, K. O., Quah, E. S. H., & Pauwels, O. S. A. (2014b). Systematics and natural history of Southeast Asian Rock Geckos (genus *Cnemaspis* Strauch, 1887) with descriptions of eight new species from Malaysia, Thailand, and Indonesia. *Zootaxa*, 3880(1), 1–147.
- Grismer, L. L., Wood, P. L., Jr., Ahmad, A., Sumarli, A. S., Vasquez, J. J., Ismail, L. H., Nance, R., Mohd-Amin, M. A., Othman, M. N., Rizaijessika, S. A., Kuss, M., Murdoch, M., & Cobos, A. (2014c). A new species of insular Rock Gecko (Genus *Cnemaspis* Strauch, 1887) from the Bidong Archipelago, Terengganu, Peninsular Malaysia. *Zootaxa*, 3755(5), 447–456.
- Grismer, L. L., Wood, P. L., Jr., Shahrul, A., Davis, H. R., Cobos, A. J., & Murdoch, M. L. (2016a). A new species of karst forest Bent-toed Gecko (genus *Cyrtodactylus* Gray) not yet threatened by foreign cement companies and a summary of Peninsular Malaysia's endemic karst forest herpetofauna and the need for its conservation. *Zootaxa*, 4061(1), 1–17.
- Grismer, L. L., Quah, E. S. H., Wood, P. L., Jr., Shahrul, A., Muin, A., Davis, H. R., Murdoch, M. L., Grismer, J. L., Cota, M., & Cobos, A. J. (2016b). Dragons in the mist: Three new species of *Pseudocalotes* Fitzinger (Squamata: Agamidae) from sky island archipelago of Peninsular Malaysia. *Zootaxa*, 4136(3), 461–490.
- Grismer, L. L., Wood, P. L., Jr., Shahrul, A., Grismer, M. S., Quah, E. S. H., Murdoch, M. T., Muin, M. A., Davis, H. R., Aguilar, C., Klabacka, R., Cobos, J., Aowphol, A., & Sites, J. W., Jr. (2016c). Two new Bent-toed Geckos of the *Cyrtodactylus pulchellus* complex from Peninsular Malaysia and multiple instances of convergent adaptation to limestone forest ecosystems. *Zootaxa*, 4105(5), 401–429.
- Grismer, L. L., Wood, P. L., Jr., Muhammad, F. S., Baizul, H. B., Rizal, S. A., Ahmad, B. A., & Quah, E. S. H. (2016d). On the taxonomy and phylogeny of the skinks *Lipinia sekayuensis* and *Lipinia surda* Boulenger from Peninsular Malaysia. *Zootaxa*, 4147(1), 59–66.
- Ibrahim, J., Shahrul Anuar, M. S., Norhayati, A., Chan, K. O., & Muin, M. A. (2008). *The common amphibians and reptiles of Penang Island*. Penang: Penang State Forestry Department.
- Ibrahim, J., Zalina, A., Shahriza, S., Shahrul Anuar, M. S., Nur Hafizah, I., Amirah, H., Nurul Dalila, A. R., Min, M. A., & Amirudin, I. (2012). Checklist of the herpetofauna of Bukit Perangin Forest Reserve, Kedah, Malaysia. *Sains Malaysiana*, 41(6), 691–696.
- Ibrahim, J., Amirah, H., Shahriza, S., Nur Hafizah, I., Zalina, A., Yap, C. H., Nurliza, A. M., & Nur Hafizah, C. Z. (2013). Additions to the herpetofauna of Jerejak Island, Penang, Peninsular Malaysia. *Malayan Nature Journal*, 64(4), 213–232.
- IUCN Red List of Threatened Species. (2016). Retrieved from <http://www.iucnredlist.org/>.

- Johnson, C. B., Quah, S. H. E., Anuar, S., Muin, M. A., Wood, P. L., Jr., Grismer, J. L., Greer, L. F., Chan, K. O., Norhayati, A., Bauer, A. M., & Grismer, L. L. (2012). Phylogeography, geographic variation, and taxonomy of the Bent-toed Gecko *Cyrtodactylus quadrivirgatus* Taylor, 1962 from Peninsular Malaysia with the description of a new swamp dwelling species. *Zootaxa*, 3406, 39–58.
- Nurulhuda, Z., Juliana, S., Fakhru Hatta, M., Daicus, B., Chan, K. O., Shukor, M. N., & Norhayati, A. (2014). Species composition of amphibians and reptiles in Krau Wildlife Reserve, Pahang, Peninsular Malaysia. *Check List*, 10(2), 335–343.
- Quah, E. S. H., Shahrul Anuar, M. S., Muin, M. A., Nur Amira, A. R., Fatim Syakirah, M., & Grismer, L. L. (2013). Species diversity of herpetofauna of Bukit Panchor State Park, Penang, Peninsular Malaysia. *Malayan Nature Journal*, 64(4), 193–211.
- Raxworthy, C. J., Pearson, R. G., Zimkus, B. M., Reddy, S., Deo, A. J., Nussbaum, R. A., & Ingram, C. M. (2008). Continental speciation in the tropics: Contrasting biogeographic patterns of divergence in the *Uroplatus* leaf-tailed gecko radiation of Madagascar. *Journal of Zoology*, 275, 423–440.
- Read, J. L. (1998). Are geckos useful bioindicators of air pollution? *Oecologia*, 114, 180–187.
- Shahriza, S., & Ibrahim, J. (2014). Reptiles of Lata Bukit Hijau, Kedah, Malaysia. *Songklanakarini Journal of Science and Technology*, 36(1), 37–44.
- Shahriza, S., Ibrahim, J., Shahrul Anuar, M. S., & Abdul Muin, M. A. (2012). Herpetofauna of Peta area of Endau-Rompin National Park, Johor, Malaysia. *Pertanika Journal of Tropical Agricultural Science*, 35(3), 553–567.
- Shazali, N., Sultana, P. H. R., Nurul, F. D. A. T., Rafik, M., Nurshilawati, A. L., Nur Mukminah, N., & Tingga, R. C. T. (2016). Small mammals from Miri, northeastern region of Sarawak, Malaysian Borneo: Note on new locality records. *Check List*, 12(2), 1863.
- Sohdi, N. S., Koh, L. P., Brook, B. W., & Ng, P. K. L. (2004). Southeast Asian biodiversity: An impending disaster. *Trends in Ecology & Evolution*, 19(12), 654–660.
- Sumarli, A. X., Grismer, L. L., Shahrul, A., Muin, M. A., & Quah, E. S. H. (2015). First report on the amphibians and reptiles of a remote mountain, Gunung Tebu in northeastern Peninsular Malaysia. *Check List*, 11(4), 1679.
- Sumarli, A., Grismer, L. L., Wood, P. L., Jr., Ahmad, B. A., Syed, R., Ismail, L. H., Nur Amalina, M. I., Norhayati, A., & Linkem, C. W. (2016). The first riparian skink (Genus: *Sphenomorphus* Strauch, 1887) from Peninsular Malaysia and its relationship to other Indochinese and Sundaic species. *Zootaxa*, 4173(1), 29–44.
- van Rooijen, J., Chan, K. O., Grismer, L. L., & Norhayati, A. (2011). Estimating the herpetofaunal species richness of Pangkor Island, Peninsular Malaysia. *Bonn Zoological Bulletin*, 60(1), 3–8.
- Voris, H. K. (2015). Marine snake diversity in the mouth of the Muar River, Malaysia. *Tropical Natural History*, 15(1), 1–21.
- Wood, P. L., Jr., Grismer, J. L., Grismer, L. L., Norhayati, A., Chan, K. O., & Bauer, A. M. (2009). Two new montane species of *Acanthosaura* Gray, 1831 (Squamata: Agamidae) from Peninsular Malaysia. *Zootaxa*, 2012, 28–46.