

## Is the New Guinea Emerald Tree Monitor Lizard (*Varanus prasinus*) Native to Mainland Australia?

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**Abstract** - We summarize and evaluate anecdotal information and observations about the potential occurrence of the New Guinea emerald tree monitor lizard, *Varanus prasinus* (Schlegel, 1839), on mainland Australia. Several independent but unconfirmed reports about sightings of large green lizards in the rainforests on Cape York Peninsula have been published in the last 40 years, but still no photographs or voucher specimens exist. The closest confirmed occurrence of *V. prasinus* to mainland Australia is on Moa (also known as Mua or Banks) Island, one of the islands in the Torres Strait that separates New Guinea from Australia. The shallow tropical waters of the Sahul Shelf surrounding these small islands were dry land during Pleistocene glacial periods and facilitated faunal exchanges between both huge landmasses in the past. Consequently, a natural occurrence of *V. prasinus* on Cape York, together with the endemic *Varanus keithhornei* (Wells and Wellington, 1985), the canopy goanna, seems plausible. Likewise, a possible polymorphism in the color pattern of the latter species as a putative result of repeated introgression and/or hybridisation events as source for the sightings of green tree monitors deserves further investigations. Therefore, we encourage future field work in this remote area to finally answer the question if the New Guinea emerald tree monitor is native to mainland Australia.

### Introduction

Tree monitor lizards are among the most colorful reptiles in the world. This applies particularly to the New Guinea emerald tree monitor lizard, *Varanus prasinus* (Schlegel, 1839), which is characterized by a brilliant light green background coloration in combination with black chevrons on the dorsum (see Fig. 1). This color pattern is thought to provide camouflage in the rainforest canopy. There are, however, some partly or entirely melanistic species in this closely-related group such as *V. beccarii* or *V. bogerti* (Ziegler *et al.*, 2007). In

general, the distribution range of the *V. prasinus* group is concentrated around New Guinea and its various off-shore islands (Koch *et al.*, 2013). While most species are endemic to single islands, such as Waigeo (*V. boehmei*), Misool (*V. reisingeri*), Batanta (*V. macraei*) or Biak (*V. kordensis*), *V. prasinus* has by far the widest distribution.

The known range of *V. prasinus* includes the lowland rainforests of New Guinea and several islands of the Torres Strait in the south (Koch *et al.*, 2014). Colonization of these islands by the highly arboreal tree



Fig. 1. The New Guinea emerald tree monitor (*Varanus prasinus*) showing its characteristic brilliant green coloration with black dorsal chevrons. Photographed by **Gunther Schmida**.

monitor lizards was fostered during the Pleistocene, when global sea levels were considerably lower than today (Jongsma, 1970; McCulloch *et al.*, 1999) and the Sahul shelf formed a continuous landmass over long periods of the past 2,500,000 years (Voris, 2000).

Lavery *et al.* (2012) recently summarized the distribution of *V. prasinus* on the various Torres Strait Islands and provided both the traditional and modern English island names (Table 1). Accordingly, *V. prasinus* occurs on Boigu (Talbot) Island (Clarke, 2004; Schaffer, 2010), Dauan ([Mt.] Cornwallis) Island (Günther, 1879; Loveridge, 1934; see also NMW 12390, two juvenile specimens, and BMNH 1878.10.14.4-6, a young and an adult according to Boulenger, 1885), and Saibai (Borsboom, 2007), all of which lie only a few kilometers off the coast of Papua New Guinea. Further south, the species inhabits Mabuiag (Mabuyag/Jervis) Island (Borsboom, 2007), Badu (Mulgrave) Island (TSRA undated a), and Moa (Mua/Banks) Island (Whittier and Moeller, 1993; Wilson 1996; Ingram, 2008). The latter island is considered the southernmost occurrence of *V. prasinus* (Whittier & Moeller, 1993), which is known to the local people as Wyniss (Wilson, 1996). On Boigu Island it is called Tamai (Schaffer, 2010). Interestingly, photographs by Rohan Clarke ([http://www.pbase.com/wildlifeimages/varanus\\_prasinus](http://www.pbase.com/wildlifeimages/varanus_prasinus)) show a specimen from Boigu Island with the same yellowish background coloration as is typical for *V. reisingeri* from Misool Island off the coast of West Papua, Indonesia

(Eidenmüller & Wicker, 2005), and demonstrate the intraspecific variation of this species (see also Koch *et al.*, 2014).

Notably, a publication from the Torres Strait Regional Authority (TSRA, undated b) stated, that *V. prasinus* represents a “significant species” on Ki(r)riri (Hammond) Island. Kiriri in turn is close to Muralug (Prince of Wales) Island, the largest of the Torres Strait Islands situated only a short distance off the coast of Cape York Peninsula (Fig. 2). In this regard, Schaffer (2010) claimed that *V. prasinus* is also found on Prince of Wales Island and referred to Whittier & Moeller (1993) for this record, but in their article nothing regarding this island is mentioned. In addition, Boulenger (1885) listed four adult voucher specimens (BMNH 1878.10.16.35-38 according to an BMNH online catalogue) of *V. prasinus* from Mer (Murray), one of the easternmost of the Torres Strait Islands, and the TSRA Land and Sea Management Unit (2013) stated, that *V. prasinus* might also occur on Ugar (Stephens) Island, although verified reports were not yet available. Borsboom (2007: 3) also reports *V. prasinus* from Mer (Murray) Island far to the east, stating “Islanders on Mer Island currently report ‘the monitor is frequently seen on the island in a variety of habitats, most recently in the village and the scrub adjacent to the airstrip’, ‘crediting this information to M. Helling (in litt. Nov. 2006), Landcare Officer, Torres Strait Regional Authority.

Table 1. Occurrence of *V. prasinus* on the Torres Strait islands.

Traditional Island Name	English Island Name	Source	Evidence/Remarks
Boigu	Talbot	Clarke, 2004; Schaffer, 2010	Photographs by Rohan Clarke ( <a href="http://www.pbase.com/wildlifeimages/varanus_prasinus">http://www.pbase.com/wildlifeimages/varanus_prasinus</a> ) show a specimen with yellowish background coloration as is typical for <i>V. reisingeri</i>
Dauan	[Mt.] Cornwallis	Günther, 1879; Loveridge, 1934; Boulenger, 1885	NMW 12390 (two juvenile specimens), BMNH 1878.10.14.4-6 (a young and an adult according to Boulenger 1885)
Saibai	-	Borsboom, 2007	-
Mabuiag/Mabuyag	Jervis	Borsboom, 2007	-
Badu	Mulgrave	TSRA undated a	-
Moa/Mua	Banks	Whittier and Moeller, 1993; Wilson, 1996; Ingram, 2008	-
Kiriri/Keriri	Hammond	TSRA, undated b	-
Muralug	Prince of Wales	Schaffer, 2010	He claimed that <i>V. prasinus</i> is found on Prince of Wales Island and referred to Whittier and Moeller (1993), but therein no such island record is mentioned
Mer	Murray Island	Boulenger, 1885; Borsboom, 2007	Islanders on Mer Island currently report 'the monitor is frequently seen on the island in a variety of habitats, most recently in the village and the scrub adjacent to the airstrip'
Ugar	Stephens Island	TSRA Unit, 2013	-

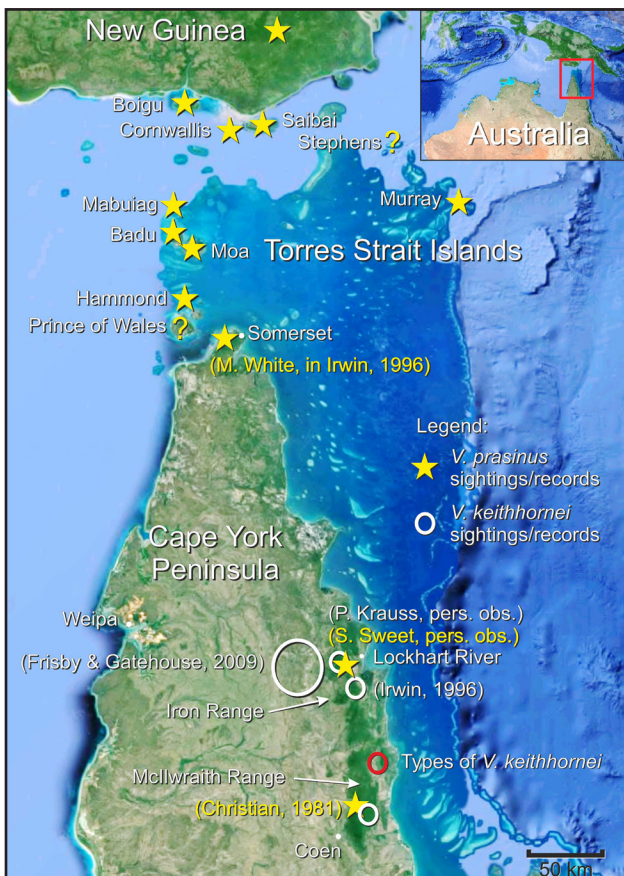


Fig. 2. Map of the Cape York Peninsula showing the confirmed and unconfirmed occurrences of tree monitors on the Torres Strait Islands and mainland Australia. See the text for the respective sources to single (island) records. The rainforests of the Iron and McIlwraith Ranges and around Somerset are indicated by the green land cover.





Fig. 3. The canopy goanna (*V. keithhornei*) is a rather melanistic tree monitor endemic to the Iron and McIlwraith Ranges of Australia's Cape York Peninsula. Photographed by Jannico Kelk.

### Tree Monitors on Mainland Australia: A Historical Perspective

Cogger (1975) first mentioned unconfirmed records of tree monitors from the Northern Cape York Peninsula. A few years later, Czechura (1980) published the first record of *V. prasinus* sensu lato for mainland Australia. Despite differences in coloration and pattern (the lizards had a predominantly black background color with indistinct yellow chevrons across the body), he allocated the three specimens (QM J31566, QM J35450, QM J35451) collected east of Coen in the Iron and McIlwraith Ranges to *V. prasinus* (see also Covacevich *et al.*, 1982), which at that time was considered polytypic with four subspecies (Mertens, 1963). Subsequently, Wells & Wellington (1985) noticed the taxonomic distinctness of the Cape York tree monitors and described them as a new species, *Odatia* (= *Varanus*) *keithhornei*, the canopy goanna (Fig. 3). At the same time, *V. prasinus* was restricted to New Guinea and the Torres Strait Islands. The following year, Cogger (1986) described the distribution area of bright emerald-green *V. prasinus* as including the Northern Cape York Peninsula. Likewise, Wilson and Knowles (1988) listed *V. prasinus* from Australia, but noted that the Cape York population is dark in color, while the animals from the Torres Strait Islands are green. At the same time, these authors mentioned that there had been a few sightings of green animals on Cape York, but they provided no further information. Also either ignoring or not being aware of Wells & Wellington (1985), Sprackland (1991) revised

the *V. prasinus* complex and redescribed the population of Cape York, based on the same specimens mentioned above, as a novel species, *V. teriae*. However, the older name *keithhornei* had to be given nomenclatorial priority (ICZN 2001) and Sprackland (1991) had omitted the Torres Strait Island populations of tree monitors.

In subsequent editions, Cogger (1992, 2000) mentioned, that the coloration of the Australian tree monitors is black or dark brown to bright emerald green, but made no distinction between the island taxon (*V. prasinus*) and the lizards described from the Iron Range (*V. keithhornei*), respectively. Similarly, Ehmann (1992) and Waldren (1996) only listed *V. prasinus* from mainland Australia. While the former author noted strikingly green-colored tree monitors next to deep blue-black specimens in the same area of Cape York, the latter mentioned that all specimens observed were melanistic. For the first time, Wilson & Swan (2003, also in the 2008 and 2010 editions, respectively) recognized both *V. keithhornei* and *V. prasinus*, probably biding the official ICZN (2001) decision about the taxonomic validity of Wells & Wellington's (1985) name for the mainland tree monitor population (see also Kaiser *et al.*, 2013).

In the most recent edition of his book on the amphibians and reptiles of Australia, Cogger (2014) also mentioned both tree monitor species, even though he again limited the distribution range of the green-colored *V. prasinus* to New Guinea and the Torres Strait Islands (thereby providing the first photographic record for little Daru Island), while *V. keithhornei* was restricted

to McIlwraith and Iron Ranges, although the area is incorrectly indicated on the map at Lakefield National Park about 100 km south of the actual distribution range.

## Methods

In order to evaluate the lasting rumors about the potential occurrence of *V. prasinus* on mainland Australia, we attempted to summarize and review all available anecdotal information about sightings of green tree monitors in the (non-) herpetological literature together with personal observations from the field communicated by several colleagues and friends. An online query of the Queensland Museum (QM) database revealed three *V. prasinus* specimens from Australia, two of which (QM J82370 and QM J82371), however, were confiscated by customs and the third originated from the Torres Strait Islands (QM J81737). In addition, the herpetological collections in London (BMNH) and Vienna (NMW) were consulted and relevant specimens examined. To better visualize the confirmed and unconfirmed occurrences of tree monitors on the Torres Strait Islands and mainland Australia, a map was created (Fig. 2).

## Results

### *Repeated independent sightings of Varanus prasinus on mainland Australia*

In the literature sightings of green tree monitor lizards on Cape York Peninsula have long been known and published, but so far there are still no documented proofs available such as photographs or voucher

specimens. To our best knowledge, the first reliable published sighting is by Christian (1981; reissued 1997), who saw one “emerald tree monitor ‘snaking’ its way through the tree tops” at the McIlwraith Range near Coen. On another occasion, he encountered two specimens that were “deep blue/black in colour.” Since *V. keithhornei* was not yet scientifically described at that time, both green and dark specimens he observed were assigned to *V. prasinus* (see, for instance, Cogger, 1992). Tucker (1988), a botanist, reported having seen “a small greenish goanna that climbed amongst the vines” in the area of the Claudie River near Lockhart River in the Iron Range (Fig. 2).

The first sighting of a tree monitor outside of the Iron and McIlwraith Ranges in mainland Australia was reported by Irwin (1996). He cited a personal observation and detailed description by M. White, who had spotted “a bright green specimen with wide black crossbands” dorsally about 6 km west of Somerset at Lockerbie Scrub, which is close to the tip of the Cape York Peninsula. This observation supports Günther’s (1877) historical report about *V. prasinus* among a collection of reptiles from Somerset and the Torres Strait Islands. Unfortunately, the collector, Rev. S. MacFarlane, provided no exact locality data for the specimen(s) (but see Günther, 1879). In his catalogue, Boulenger (1885: 322) merely noted “Islands of Torres Straits” for an adult specimen called “a” (BMNH 1877.3.3.16). Why this author restricted the locality to the Torres Strait Islands is unknown, but for the two new species described by Günther (1877), viz. *Carlia* (= *Lygisaurus*) *macfarlanei* and *Thecadactylus* (= *Pseudothecadactylus*) *australis*, these islands are also given as a rather vague type locality (Boulenger, 1885).



Fig. 4. Rainforest near the Cook’s Hut camping site at the Kutini-Payamu (Iron Range) National Park, where S. Sweet spotted *V. prasinus* in 2009. Photographed by Bernd Eidenmüller.



Fig. 5. The Iron Range, habitat of *V. keithhornei* and possibly also of *V. prasinus*. Photographed by Bernd Eidenmüller.



This is also evident in the name of *Peripia torresiana*, the third new species, which is considered a synonym of *Gehyra baliola* (Uetz *et al.*, 2016).

Recently, Lemm (2014) summarized the available evidence for the occurrence of *V. prasinus* on mainland Australia. Next to varanid biologists, he mentioned that many “birders [...] claim to have observed tree monitors that are green in color from the Cape York Peninsula.” In addition by referring to a personal communication with S. Sweet, he stated that emerald monitors were well-documented in an unpublished Queensland Parks and Wildlife report (Environmental Protection Agency, Borsboom 2007), but it remains unclear if this includes both the Torres Strait Islands and the Australian mainland. Also according to F. Parker (pers. comm., 2014 in Shea *et al.*, 2016) “anecdotal records unsupported by [voucher] specimens suggest that true *V. prasinus* may occur in the Iron Range.” In this regard, S. Sweet (pers. comm.) told us that he spotted a green tree monitor about 200 m west of Cook’s Hut camping area in the Kutini-Payamu (Iron Range) National Park in 1999 (Figs. 2 and 4). Being aware of the ongoing discussion about the occurrence of *V. prasinus* in Australia he confirmed that the specimen was typically green and not a pale grey one as is the case in *V. keithhornei*. Peter Krauss (pers. comm.) also observed tree monitors at this place but reported black specimens. Lastly, Patrick Couper (pers. comm.) recently informed us, that he is aware of sightings of *V. prasinus* on Cape York Peninsula, but unfortunately, no further details such as exact locality data were available to him.

## Discussion

### *Why have tree monitors in Australia been overlooked for so long?*

The independent observations of green tree monitors on mainland Australia as outlined above certainly warrant further investigations in the herpetofauna of Cape York. Although long-time residents and researchers doing intensive field work on the peninsula could not confirm the presence of *V. prasinus* in that area (Natusch and Natusch, 2011; D. Natusch; N. Weigner and D. Wilson, pers. comm.; Wilson and Heinsohn, 2007), such statements do not automatically prove its absence, and may simply be an indication of the elusiveness of the species (Covacevich *et al.*, 1982; Meiri, 2016). The scarcity of anecdotal reports surrounding the presence of *V. prasinus* on Cape York Peninsula may also be influenced by the arboreal nature of the species (but see,

*e.g.* Irwin [1996] and Sanders [2009] for *V. keithhornei* that appears to regularly visit the forest floor) and the inaccessibility of many areas of the rainforests of the Iron and McIlwraith Ranges (Fig. 5). In addition, their green and dark coloration provides excellent camouflage in the canopy of the rainforests making these enigmatic lizards nearly elusive in their habitat. Moreover, and despite their medium to large body size, the diversity of Australian monitor lizards seems to have been neglected in the past. Storr (1980), for instance, characterized two new species and three subspecies in his monograph about Western Australian goannas, and even today new species are regularly described (Aplin *et al.*, 2006; Maryan *et al.*, 2014), although most of these discoveries are based on intra-specific analyses merely representing differentiated parapatric populations of already well-known monitor species (Camina Vega & Koch, 2017).

In this context, it is noteworthy that about a hundred years prior to Czechura’s (1980) late discovery of tree monitors from Cape York, De Vis (1887) provided a description of an unidentified monitor lizard from Herbert River, North Queensland, which he considered “a local variety of *V. prasinus*”. The color pattern and the undifferentiated supraocular scales, however, do neither match *V. keithhornei* nor *V. prasinus*. Moreover, the locality is far out of the preferred habitats of tree monitors. Most probably, De Vis (1887) had an *Odatia* specimen at hand, presumably *V. semiremex* that is found along the East coast of Queensland (Pianka 2004; Tremul, 2017), but no clear determination is possible since the voucher specimen is no longer traceable in the collections of the Queensland Museum in Brisbane (P. Couper and A. Amey, pers. comm.). There, Charles W. De Vis (1829–1915, until 1882 Devis) was curator since 1882 and director from 1901 until his retirement in 1905. Notably, both the Australian dwarf monitors and the tree monitors were long jointly assigned to the subgenus *Odatia* due to their tail being round in cross section (see *e.g.* Günther, 1877; Mertens, 1942, 1963). This morphological character, however, is the result of convergent evolution. Instead, based on hemipenis morphology Böhme (1988) revealed the phylogenetic sister group relationship between tree monitors and Pacific or mangrove monitors, the *V. indicus* group, and classified them together in the subgenus *Euprepiosaurus* (Ast, 2001; Ziegler *et al.*, 2007). Recently, however, the tree monitors were transferred to their own subgenus, *Hapturosaurus*, due to their unique scale morphology in concert with their prehensile tail and other systematic evidence (Bucklitsch *et al.*, 2016).

### ***Facilitated colonization via Pleistocene sea level changes***

Of course, it cannot be excluded that the sightings of green tree monitors resulted from intentionally released individuals or single specimens of *V. keithhornei* with an aberrant (plesiomorphic) color pattern as is sometimes observed in *V. prasinus* specimens with a bluish-turquoise background coloration instead of the eponymous emerald green (Eidenmüller, 2016). Phylogenetically, the tree monitor lizards' common ancestor probably evolved a greenish coloration as an adaption to an arboreal lifestyle (see Ziegler *et al.*, 2007; Eidenmüller *et al.*, 2017). Notwithstanding, from a zoogeographic point of view a natural occurrence of *V. prasinus* on the Australian mainland seems plausible due to the existence of repeated land bridges connecting New Guinea and Australia during the Pleistocene. Hence, during the past 2,500,000 years, for the last time about 14,000 years ago, global sea levels were repeatedly up to 120 m lower than today (Jongsma, 1970; McCulloch *et al.*, 1999). At these occasions, when the shallow tropical waters surrounding the small Torres Strait Islands were dry land, faunal elements used the temporary land bridges of the Sahul shelf to colonize previously unoccupied areas. New Guinea and Australia remained largely connected via the emerged Torres Strait with sea levels as little as 10 m below present levels (Voris, 2000). Therefore, species naturally migrated from New Guinea to the various satellite islands finally reaching Northern Australia, and vice versa. Examples of squamates inhabiting both New Guinea and Northern Australia include, for instance, the snake genera *Acanthophis*, *Oxyuranus*, *Pseudechis*, and *Pseudonaja* as well as monitor lizards of the *V. indicus* species group (Kuch *et al.*, 2005; Wüster *et al.*, 2005; Ziegler *et al.*, 2007; Williams *et al.*, 2008). While these cases show only little or no (intra)specific differentiation between the allopatric populations on New Guinea and Northern Australia, tree monitors seem to represent an exception, since they developed into independent evolutionary lineages on both sides of the Torres Strait resulting in *V. keithhornei* on Cape York and *V. prasinus* on New Guinea (Ziegler *et al.*, 2007).

The fact that *V. prasinus* not only occurs in evergreen rainforests, but also inhabits tidal mangrove forests (e.g., Clarke, 2004), the predominant vegetation type on the Torres Strait Islands, makes it even more likely that this species repeatedly spread south during the Pleistocene and successfully colonized mainland Australia. There, they may have hybridized with the darker

mainland population of tree monitors. These repeated introgression events could represent an explanation if *V. keithhornei* should be revealed in the future to exhibit a higher degree of intraspecific variation in color pattern as currently known. The same scenario of a southward expansion applies to the ancestor of *V. keithhornei* which is the sister species to *V. beccarii* (Ast, 2001; Ziegler *et al.*, 2007) from the Aru Islands located west of New Guinea and likewise situated on the Sahul shelf.

### ***Are Varanus prasinus and V. keithhornei sympatric on Cape York?***

The area on Cape York, where a natural occurrence of *V. prasinus* would be most likely is at the northern tip of the peninsula at the Lockerbie Scrub. There, according to Irwin (1996) M. White had seen an emerald tree monitor. However, reports about *V. keithhornei* from this area are lacking. So far, the known distribution of the canopy goanna is limited to the Iron and McIlwraith Ranges on the east coast of North Queensland's Cape York Peninsula. Of all Australian varanids, it has one of the most restricted distribution ranges and is considered rare or insufficiently known (Covacevich *et al.*, 1982; Cogger *et al.*, 1999; Irwin, 2004). Currently, merely a dozen voucher specimens are deposited in the Queensland Museum collection (P. Cooper, pers. comm.). The three specimens of the type series were collected near Buthen Buthen mine (Fig. 2). In the meantime, further specimens have been observed north of the type locality. Hence, Irwin (1994) was able to catch four specimens near the Claudie River in the Iron Range, where Tucker (1988) had earlier observed a greenish tree monitor. On the way from the Claudie River to Weipa, just before reaching the main road, another specimen of *V. keithhornei* was discovered (Frisby & Gatehouse, 2009). Also the independent sightings by Christian (1981), S. Sweet, and Peter Krauss (see above) of green and dark tree monitors within the Iron Range suggest the sympatry between both tree monitor species in that area.

### **Conclusions**

The fact that green tree monitors were independently and repeatedly sighted on Cape York Peninsula by experienced herpetologists and laypersons who provided an exact description of *V. prasinus*, makes it very likely that mainland Australia could actually harbor two, probably sympatric tree monitor species. Since there are no other large green, arboreal lizard species in northern Queensland (Cogger, 2014; Wilson & Swan,

2003, 2008, 2010), confusion with another species can be excluded and we assume the sightings by non-herpetologists to likewise represent the New Guinea emerald tree monitor. This would form an exception since all other members of the subgenus *Hapturosaurus* are allopatrically distributed (Koch *et al.*, 2014; Ziegler *et al.*, 2007). The potential sympatry of *V. prasinus* with *V. keithhornei* would indicate an advanced speciation process and support the specific status of both taxa within this otherwise very closely-related group of tree monitors (Ziegler *et al.*, 2007).

Although we could not provide new evidence for the potential occurrence of *V. prasinus* on mainland Australia, the information we gathered allowed us to reach the conclusion that this scenario is very likely and we hope to stimulate further field work on Cape York Peninsula and the Torres Strait Islands to study the still partly unknown herpetofauna of this remote tropical region. Likewise, the polymorphism hypothesis of single greenish specimens of *V. keithhornei* exhibiting a plesiomorphic coloration deserves further investigations of this little known Australian monitor lizard.

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