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HABITAT USE IN A LARGE RAINFOREST PYTHON (*MORELIA KINGHORNI*) IN THE WET TROPICS OF NORTH QUEENSLAND, AUSTRALIA

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***Abstract.*—We examined habitat use in the Scrub Python, *Morelia kinghorni*, a species of large tropical boid present on the Atherton Tablelands, North Queensland, Australia. Radio transmitters were surgically inserted into six individuals (3 male and 3 female) who were then followed for varying lengths of time over 2.5 years. Our results show that this snake specializes in closed forest habitats with 82% of sightings in this habitat type. During the coldest part of the year, the snakes used large epiphytic ferns in tall forest trees presumably as basking platforms above the shaded forest floor. We observed that 81% of snakes in epiphytes were in large (> 1m) *Drynaria rigidula* ferns. During the study, Tropical Cyclone Larry, a category 2–3 cyclone, passed through the study area and substantially impacted the vegetation. However, the three individuals that were being tracked at the time all survived. When collected for transmitter removal 6–10 months after the cyclone, the snakes had gained weight and mass and were in good condition. We do not consider *M. kinghorni* to be threatened but do conclude that it has disappeared from many areas of the Atherton Tablelands as a result of deforestation.**

Key Words.—closed forest; deforestation; epiphytes; habitat use; *Morelia kinghorni*, Scrub Python

INTRODUCTION

The Amethystine or Scrub Python (*Morelia kinghorni*; Fig. 1) is the largest snake in Australia (Torr 2000). It is also the largest carnivore in the wet tropics of North Queensland and arguably the largest terrestrial carnivore in Australia. Despite being a large, charismatic species, surprisingly we know little about its ecology in the wild. Most accounts of this species involve one-time observations of feeding behavior (Fearn and Sambono 2000a; Turner 2001; Fearn 2002a; Murphy et. al. 2004), combat behavior in males (Sues and Shine 1999; Lloyd and Fearn 2005) or notes on the large size attained by some individuals (Fearn and Sambono 2000b; Fearn 2002b). Although these observations are valuable (Bury 2006; McCallum 2006; Green and Losos 1988), they do not contain the detail needed to understand this species' ecology.

Few ecological studies exist and the first significant research on the ecology of this species in the wild only appeared in 2005 (Fearn et. al. 2005). That study examined the thermal biology and reproductive ecology of a population of Scrub Pythons in the Tully River Gorge on the Wet Tropics lowlands. In contrast to our study, Fearn et. al. (2005) did not use radio telemetry to follow individual pythons, thus limiting their findings on habitat use in this species.

The present study was an attempt to elucidate habitat use by this species on the Atherton Tablelands using radio telemetry in an area where the variety of habitat types that are found on the Tablelands are accessible. The study was complicated by Tropical Cyclone Larry, a Category 2–3 cyclone when it crossed the Atherton Tablelands on 20 March 2006, severely damaging the study area.

FIGURE 1. A large male (left) and female (right) Scrub Python (*Morelia kinghorni*) from the Atherton Tablelands, North Queensland, Australia. (Photographed by A. Freeman)

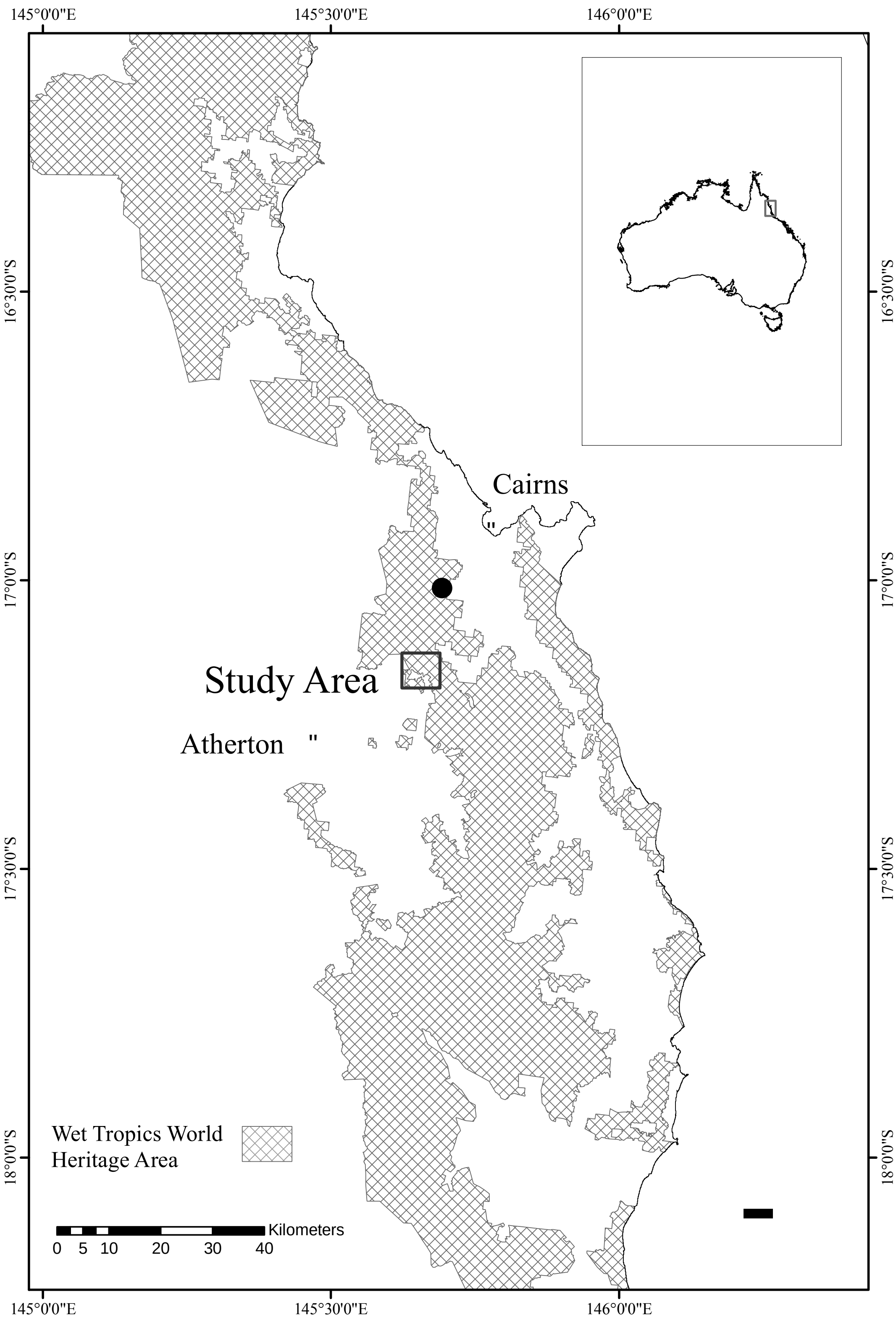

FIGURE 2. The study area located south west of the city of Cairns in North Queensland, Australia (17⁰ 12' 21"; 145⁰ 40' 48") where Scrub Pythons (*Morelia kinghorni*) were radio-tracked.

TABLE 1. Categories used to classify habitat of Scrub Pythons (*Morelia kinghorni*) at the Atherton Tablelands in North Queensland, Australia.

Habitat	Description
Grassland	Open areas dominated by introduced pasture species. Vegetation varies in height and can grow as high as 1m. Where it is not grazed it forms a dense ground cover.
Plantation	Planted tree crop. On the Atherton Tablelands, plantations are usually composed of Hoop Pines (*Araucaria cunninghami*) and *Eucalyptus* sp.
Rainforest	Closed forest type (70–100% canopy cover of tallest stratum) that remained uncleared over the past 50 years; fragments >10 ha in size. A complex structure and largely continuous canopy with emergent trees up to 55 m tall typify the rainforest communities of the study area. Epiphytes are common, and climbing rattans (*Calamys* sp.) and lianas proliferate in disturbed areas.
Regrowth	Closed forest type (70–100% canopy cover of tallest stratum) and often dominated by *Acacia* sp. that had been cleared and left to regenerate in the last 50 years. Simpler in structure without the density of epiphytes and lianas in the rainforest vegetation.
Sclerophyll	Open forest/woodland (< 70% canopy cover of tallest stratum) often with grassy understorey. *Eucalyptus* sp., *Syncarpia glomulifera, Corymbia intermedia*, and *Allocasuarina torulosa* comprise the tree layer. Corridors of vine thickets in steep gullies intersect the woodland.
Urban	Built environment including houses, sheds, roads, and railroad tracks.

MATERIALS AND METHODS

Study area.—The Atherton Tablelands is a mid-elevation plateau (700–900 m), situated south-west of the city of Cairns in North Queensland, Australia (Fig. 2). Prior to European settlement the region was largely covered by upland rainforest interspersed with areas of more open sclerophyll forest (Winter et al. 1987). Large-scale clearing for agriculture began in the early part of the 20th century and continued for a number of decades (Winter et. al. 1987). Logging was in decline by the time most of the remaining rainforest was incorporated into the Wet Tropics of Queensland World Heritage Area in the late 1980's. Today the area is a mosaic of pasture, crops, and small towns. Interspersed with this are rainforest fragments ranging in size from a few trees to patches of 600 ha, many dissected by major and minor roads. Small areas of secondary growth are common, particularly along riparian corridors. Large areas of continuous forest are confined to the hill slopes that surround the Tablelands. Our study area was situated on the eastern edge of the Tablelands centred on The School for Field Studies, Centre for Rainforest Studies. In the immediate vicinity are all the main habitat types of the eastern Atherton Tablelands from cattle pasture to World Heritage rainforest that has never been cleared, although it has been selectively logged.

Field methods.—We captured snakes by hand when we incidentally encountered them in the study area. A qualified veterinarian surgically implanted temperature sensitive radio transmitters (Sirtrack™, Havelock North, New Zealand) weighing between 16–21 g into the peritoneal cavity of the snake (Pearson and Shine 2002; Pearson et. al. 2005). The mass of these transmitters was < 0.008% of the body mass of the smallest python used (2,700 g) in the study. We released transmittered snakes at the site of capture within 24 h. We tracked pythons on foot using a three-element Yagi antennae (Sirtrack Ltd. Havelock North, New Zealand) and receiver (TR 4 Telonics™, Mesa, Arizona, United States). When not sighted, we estimated a snakes' location using triangulation, the approximate distance from the receiver using signal strength, and determined if it was moving using signal oscillation. After approximately 9–11 mo, we recaptured the pythons and removed or replaced the transmitters. We checked the locations of snakes twice a week. On each occasion we took detailed notes on weather and the snakes' location, posture, and habitat use. We recorded the pulse interval of the telemetry signal for temperature analysis. We recorded the exact locality of each sighting using a handheld Garmin™ geographic positioning system (GPS) with an accuracy that varied from 15 to 50 m (a conservative estimate from manufacturer's rating). On the few occasions when we could not get a GPS reading, the animals' position was estimated using digital maps of the study area in the Arc View 3.2™ Geographic Information System.

When we located an individual, we recorded the macrohabitat in which it occurred based on vegetation

TABLE 2. Sex, size, and dates of radio-tracking of individual Scrub Python, *Morelia kinghorni*, followed at the Atherton Tablelands in North Queensland, Australia.

Animal No.	Sex	SVL (cm)	Tail (cm)	Mass (kg)	Date Released	Final Date Monitored	Duration of tracking (days)
13	M	267.0	49.0	3.758	12-Apr-04	9-Sept-06	880
19[1]	M	316.0	48.0	6.526	12-Apr-04	6-Dec-04	238
40	M	261.6	45.0	3.759	9-Feb-06	8-Jan-07	333
14	F	270.3	43.0	3.645	12-Jun-04	28-Nov-05	534
30s[2]	F	295.4	32.0	6.410	12-Feb-05	6-Oct-05	236
42	F	265.8	46.5	2.670	12-Feb-06	8-Jan-07	330

[1] Snake that died during course of study (see above)
[2] Snake "lost" part way through study probably due to transmitter failure

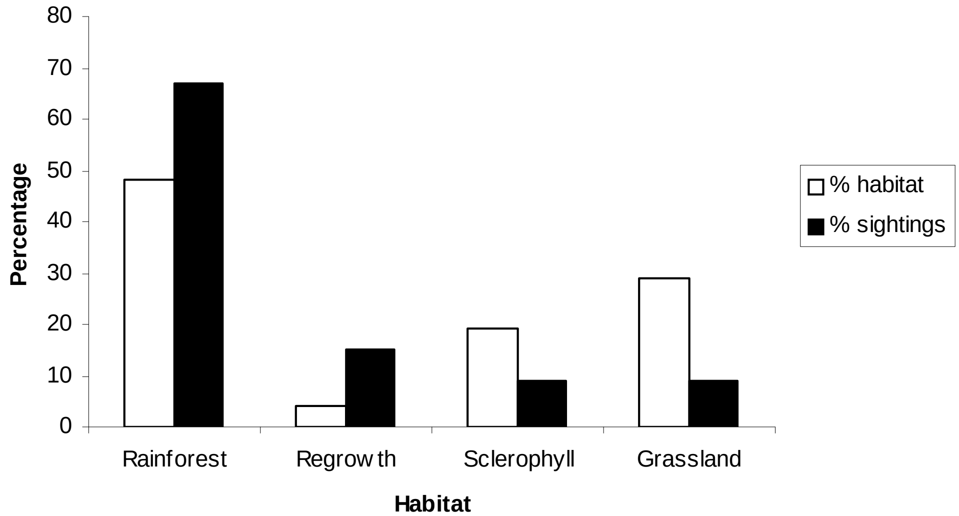

FIGURE 3. Comparison of the percentage of sightings of Scrub Pythons (*Morelia kinghorni*) in each of the four main habitats on the Atherton Tablelands, North Queensland, Australia.

type, canopy cover, vegetation structure, and the time since the forest was cleared (Table 1). We classified observations associated with houses, sheds, roads, or other human structures as "Urban" (Table 1).

When we observed animals in forest, the micro-habitat in which each snake occurred was allocated to one of five categories (Ground, Understorey, Sub Canopy, Canopy, Emergent). For animals above the ground, the height above the ground was measured in metres using a Bushnell™ laser rangefinder. If foliage prevented a reading, we estimated the height. When a snake was in an epiphyte, we recorded the species of epiphyte. We mapped all positions with Arc View 3.2™ Geographic Information System. We also calculated home range with the Animal Movement extension to Arcview™ ver. 1.1 (Hooge and Eichenlaub 1997).

We determined habitat availability with Regional Ecosystem vegetation maps (Stanton, P., and D. Stanton. 2005. Vegetation mapping of the wet tropics. Wet Tropics Management Authority, Cairns, Australia. Available from http://www.wettropics.gov.au/map/map _vegetation.html). These maps use a combination of aerial photography analysis and ground truthing, and cover the entire Wet Tropics region at a 1:50,000 scale. In the Arc Map 8.0™ Geographic Information System, we placed an eight-kilometre grid divided into 500 m^2 squares over a map of the study area. We centered this grid on the School for Field Studies property, where we captured five of the six snakes. At each point where grid lines intersected, we determined the vegetation using the digital Regional Ecosystem vegetation map. We allocated the vegetation types of the 289 data points to one of the general habitat categories used in the current study. The extent of the grid was 4 km on either side of the centre point of the study area. Four km was the longest straight line distance that any of the pythons moved during the course of the study.

RESULTS

Between April 2004 and January 2007, we radio-tracked six *Morelia kinghorni* (three males; three females) for various lengths of time (Table 2). We observed feeding by all snakes over the tracking period and we noted no ill effects that could be directly attributed to the insertion or presence of the transmitters. One animal died during the course of our study. This was an individual that we tracked for over seven months prior to its death. The cause of death was unknown and there was no indication that it was from the radio-tracking.

Overall pattern of habitat use.—Pythons occurred most frequently in closed forest habitat with 67% of all sightings in rainforest (n = 432) and 15% (n = 94) in regrowth, a total of 82% of sightings in closed habitat. Grassland at 10% (n=61) and sclerophyll forest at 8% (n=55) of sightings were used far less. All grassland sightings were near (< 30 m) the edge of rainforest or regrowth either in forest clearings or on the edge of pasture. The pythons used habitat in proportions that differed significantly from habitat availability ascertained from GIS (χ^2 = 348.569, df = 3, P = <0.01); the percentage of sightings in rainforest and regrowth habitat occurred at a rate higher than its availability (Fig. 3). The use of habitat varied little between individual animals. Mean percentage (+/-SE) use of rainforest was 73.0 (6.9); regrowth 17.5 (4.7); sclerophyll 3.7 (3.3); grassland 5.8 (3.4).

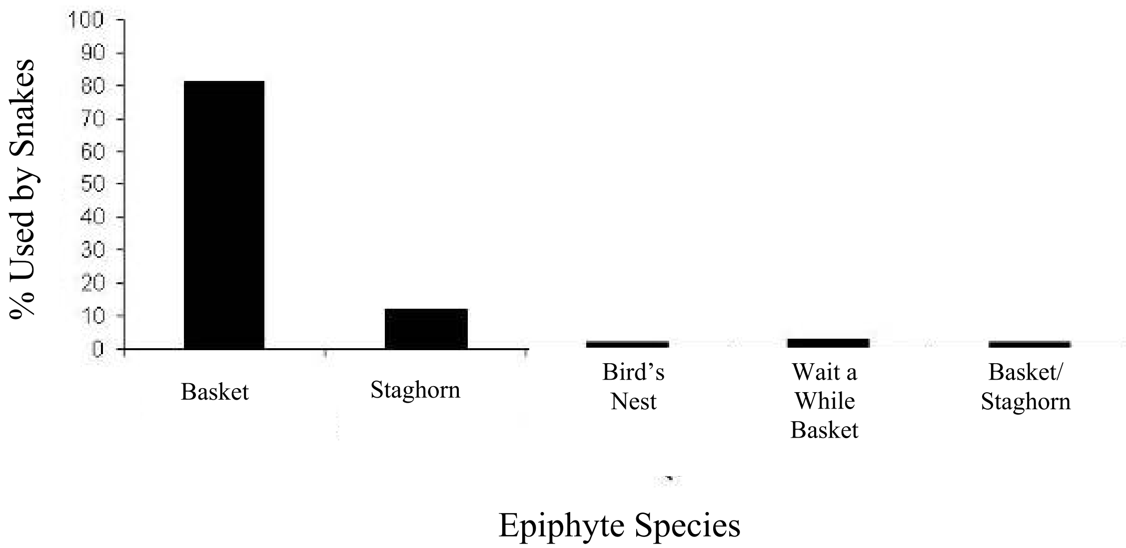

FIGURE 4. Epiphyte species (N = 65 epiphytes) used by radio-tracked Scrub Pythons (*Morelia kinghorni*) on the Atherton Tablelands, North Queensland, Australia (Basket Ferns, *Drynaria rigidula*; Staghorn, *Platycerium bifurcatum*; Birds Nest Ferns, *Asplenium* sp.; Wait a While Ferns,*Calamus* sp.).

Use of Epiphytes.—Forty-six percent of all locations were in epiphytic vegetation. The epiphytes used by snakes were restricted to rainforest vegetation and were mostly large (> 1 m circumference) Basket Ferns (*Drynaria rigidula*; Fig. 4) in the emergent and canopy layers of the forest (Fig. 5). The height of epiphytes used by snakes varied from 17–40 m with a mean of 21.7 m +/- 0.54 m (SE). Epiphytes were most often used by snakes from April to September with a peak in July and August. This peak coincided with the coldest time of the year (Fig. 6). The low number of sightings in epiphytes during May was an artefact of sampling being skewed by a very small sample size.

The most time that we continuously recorded a snake in the same epiphyte was 66 days (22 June – 26 August 2006). Although we do not know if the snake spent all of this time in the epiphyte, or if it moved off and returned to the epiphyte between tracking sessions, this type of behavior appeared to be uncommon in this study. We only observed snakes on the ground twice in between two sightings in the same epiphyte. Instead, most snakes did not return to the previous epiphyte. However, it was not uncommon for the snakes to use the same epiphytes multiple times over the course of the study. Five of the six snakes that were tracked made multiple use of the same epiphyte. This varied from No. 13 using five epiphytes on multiple occasions to No.s 19, 30s, and 40 using one epiphyte on multiple occasions. Sometimes they returned to the same site months after it was last used. For example, one epiphyte was used on three separate occasions between 18 July 2004 and 27 June 2006 by the same animal (No. 13).

Outside of using epiphytes, the snakes seldom used the emergent, canopy or subcanopy layers in the forest. Less than 2% (n = 6) of sightings in closed forest habitat in these layers were of snakes not associated with epiphytes. *Morelia knghorni* occurred in grassland in the cooler months; however, they were invariably close to the forest edge with no sightings further than 20 m from the edge of rainforest or regrowth habitats. These snakes appeared to be using this habitat for basking with 90% (n = 55) of sightings in grassland habitat occurring in the cool season (April – September).

During the cooler season, two of the three males used steep rocky country in sclerophyll forest, at lower altitudes over the edge of the escarpment. One of the males (No. 13) was in this habitat two years in succession. The reason for this behaviour is unknown but may be related to thermoregulatory and/or reproductive behavior (Barker and Barker 1994).

Post Cyclone Larry.—The impact of Cyclone Larry on vegetation in the study area was patchy but severe. Large areas of rainforest become unrecognisable within the study area. Eleven of the 34 epiphytes that were used by snakes prior to the cyclone were relocated after the cyclone. Of these, four (36%) had survived intact or were slightly damaged. The other seven were on the ground.

Unfortunately only one (No. 13) of the three snakes that were being radio-tracked after the cyclone had been followed for a significant period of time prior to the cyclone. Therefore, it was not possible to ascertain if there were significant changes in habitat use that could be attributable to the cyclone. Interestingly, all three snakes had gained in length and mass and were in good condition when they were captured for transmitter removal in September 2006 (No. 13) and January 2007 (No.s 40 and 42), which would indicate that the individuals concerned were not negatively affected by the cyclone.

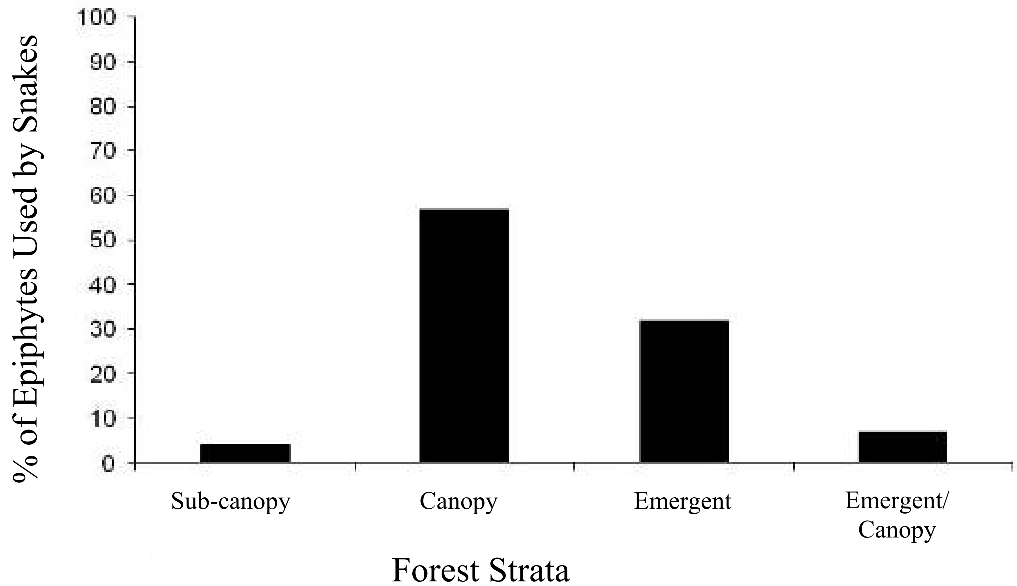

FIGURE 5. Strata in the forest of epiphytes used by radio-tracked Scrub Pythons (*Morelia kinghorni*) on the Atherton Tablelands, Australia (n = 68).

DISCUSSION

Our results show that within the study area, *M. kinghorni* is primarily a species of closed forest habitats (rainforest and regrowth). Similar results were found in a previous study that examined habitat use of *M. kinghorni* on the Atherton Tablelands using road kill and incidental data (Freeman and Bruce 2007). Other habitat types were used but less frequently. For example, snakes used grassland during the cool season when the lack of shaded cover provided basking opportunities. The shift to grassland habitats during the cool season is likely to be a strategy to cope with the relatively cool winters of the Atherton Tablelands.

The use of sclerophyll habitat is less straightforward. Two males used this habitat in the cool season when the open habitat had ample basking opportunities similar to those in epiphytes and on grassland edges. However, in early September 2004 one of these snakes (No. 19) was found with fresh injuries on the neck after going missing for 15 days. The type of injury resembled those made by male *M. kinghorni* during intra-specific fighting (Lyall Naylor pers. com.; Lloyd and Fearn, 2005). This agonistic behavior between male snakes is thought to lead to greater mating success for the victors of such combat bouts (Shine 1978; Fearn et. al. 2005). The other male (No. 13) that occurred here during three separate time periods over two years showed no obvious signs of male-induced injuries during this period. However, 15 months after we removed its transmitter, this snake was recaptured within the study area with horizontal "fighting" wounds identical to those documented by Lloyd and Fearn (2005), a strong indication that it had at least attempted to reproduce in the 2007 breeding season after tracking was completed.

The only other published account of a radio-tracking study of this species is of a single *M. kinghorni* that consumed a radio-collared Bennett's Tree-kangaroo (*Dendrolagus bennettianus*). The tree-kangaroos were part of a study on the ecology of this species in Far North Queensland (Martin 1995). In contrast to our study, over a period of 44 days, this snake divided its time equally between open and closed forest (Martin 1995). The relatively short duration of the observation may be the reason for this difference. Martin's study site was in the drier, north-western fringe of the wet tropics where much of the rainforest is in small patches surrounded by open woodlands dominated by *Eucalypt* species (Martin 1995; Alastair B. Freeman, *pers. obs*.). In this area, the use of the open forest habitat by *M. kinghorni* may reflect the overwhelming availability of this habitat as much as it does a preference on the part of the snake. Others suggest that large *M. kinghorni* are primarily terrestrial in habit (Barker and Barker 1994). However, all six of the snakes we radio-tracked spent much time (nearly 50%) in epiphytes in the canopy and emergent layers of the forest. Similar behavior was observed on the Atherton Tablelands in the late 19th century (Lumholtz 1889). Lumholtz describes how in winter, his Aboriginal guides would climb high into ferns to catch pythons for food (Lumholtz 1889). While he refers to these snakes as *Morelia spilota*, judging by their size they could only be *M. kinghorni*. Carl Lumholtz observed, "*During winter it seems to prefer staying in the large clusters of ferns found on the trunks of trees*." (Lumholtz 1889). This passage is also accompanied by a drawing of an Aboriginal hunter removing a snake from a large epiphytic fern that, judging by its size, is most likely a *Drynaria rigidula* (Pp. 316; Lumholtz 1889).

Our study supports the use of large epiphytes by *M. kinghorni*, which are found in the rainforest during the

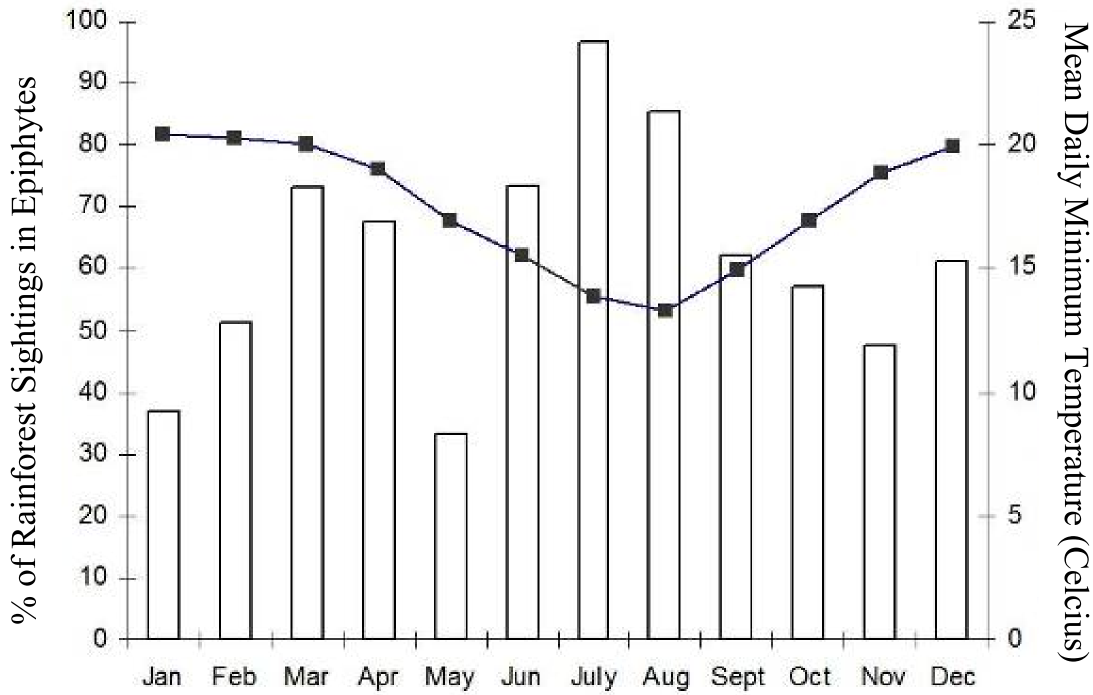

FIGURE 6. Percentage Scrub Pythons (*Morelia kinghorni*) sightings in epiphytes recorded in rainforest of North Queensland, Australia compared to mean daily minimum temperature as recorded at the study site. Sighting data is all snakes combined from April 2004 to December 2007. Temperature data was combined from September 2004 up to December 2007.

cool season (July and August), usually occurring in epiphytes in the canopy and emergent layers of the forest. Similar behaviour has been observed in *M. spilota* in northern New South Wales (Shine and Fitzgerald 1996). Here, Carpet Pythons (*M. spilota*) moved high into trees during the winter to bask in, or just below, the canopy foliage. The re-use of specific epiphytes by individual snakes suggests that these individuals may preferentially return to suitable epiphytes. Fitzgerald et. al. (2002) observed the arboreal snake *Hoplocephalus stephensii* re-using specific retreat sites in tree hollows and suggest that this selection may be made from memory rather than by any visual or olfactory stimuli present at the time the retreat is encountered. We speculate that a similar situation may apply to *M. kinghorni* in relation to its re-use of epiphytes.

In tropical rainforest the maximum, mean, and diurnal range of temperatures are significantly higher within or above the canopy than below it (Madigosky 2004). The large epiphytes in these layers of the forest therefore provide basking sites for *M. kinghorni* above the shade and coolness of the forest floor (Madigosky 2004). These basking sites probably become more important for this large reptile where it is close to its altitudinal limit, as it would appear to be on the Atherton Tablelands (Freeman and Bruce 2007). Although this species commonly occurs between 700 and 800 m on the Atherton Tablelands, it is rare above elevations of 800 m (Freeman and Bruce 2007; Alastair B. Freeman, unpubl. data). At higher altitudes, large, "python friendly" epiphytes may be an important microhabitat that restricts this species of snake to certain forest types that have an abundance of these epiphytes. The lack of suitable winter basking sites may partially explain why *M. kinghorni* does not occur in seemingly suitable habitat elsewhere on the Atherton Tablelands (Freeman and Bruce 2007; AlastairB. Freeman, unpubl. data).

Conservation.—This study adds to previous work (Freeman and Bruce 2007) on *M. kinghorni* on the Atherton Tablelands. It demonstrates that this species prefers closed forest habitat. While *M. kinghorni* is not of major conservation concern, it has disappeared from substantial areas of the Atherton Tablelands as a result of land-clearing. Today, major forest clearance is no longer a significant threat as it has largely ceased on the Tablelands with the remaining substantial areas of forested habitat now in protected areas. However, with local urbanization and rural residential development on the Atherton Tablelands, it is unlikely that the situation for *M. kinghorni* will improve substantially in the near future.

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ALASTAIR FREEMAN besides being a senior technical officer with the Threatened Species group, Department of Environment and Resource Management, in North Queensland, is also a research fellow at The School for Field Studies, Centre for Rainforest Studies, on the Atherton Tablelands. His main research interests revolve around herpetology, in particular the biology and conservation of freshwater and marine turtles, the impacts of forest fragmentation on lizards and snakes, and the ecology of boids. He is a current member of the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group. (Photographed by ??)

AMANDA FREEMAN really prefers bird-watching but will often make an exception and turn her hand to bird's scaly cousins for the sake of marital harmony. Her research interests have encompassed a variety of subjects from seabird-fishery interactions off the coast of southern New Zealand to the impacts of cyclones and fragmentation on bird faunas in tropical rainforest. Currently Amanda is working on bird communities in restored and regrowth forests and the ecology and diet of a population of Tooth-billed Bowerbirds (*Ailuroedus dentirostris*) on the Atherton Tablelands in North Queensland. Until recently, she managed The School for Field Studies, Centre for Rainforest Studies, on the Atherton Tablelands, far north Queensland, but now spends most of her time caring for toddler Tessa. (Photographed by ??)