

Daily Distance Travelled and Foraging Areas of *Varanus gouldii* (Reptilia: Varanidae) in an Urban Environment

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Abstract

The foraging areas of *Varanus gouldii* were monitored by the spool-and-line technique over 51 consecutive days during October and November 1990 in Karrakatta Cemetery, Perth, Western Australia. The daily distance travelled by lizards varied markedly. The mean distance travelled was 111.6 m for days that varanids moved from their burrows. There was a weak positive correlation between the daily distance travelled and the maximum daily temperature and hours of daily sunshine. Some varanids moved their foraging areas from open unshaded sections of the cemetery into a more heavily treed area in November. The size of the daily foraging area for small varanids (<600 g) was extremely variable (estimated median 300 m²); areas were greater in November than October. Some varanids moved to different foraging areas every few days.

Introduction

There are few published data on the spatial area occupied, or daily distance travelled, by Australian varanids (Stebbins and Barwick 1968; Green and King 1978) and none on size of foraging areas in an urban environment.

Numerous approaches have been adopted to describe the spatial area occupied by varanids. Auffenberg (1981, p. 90) used the term 'activity range' to include the scavenging and foraging areas, of which the former is much larger for *Varanus komodoensis*. In the latter, he included a core area, where most activity occurred. He reported that *V. komodoensis* has a mean foraging area of 4.2 km². Auffenberg (1988, p. 134) later used the same terms to describe the spatial area occupied by *Varanus olivaceus* and defined activity range as 'the total area in which an individual is likely to be found'. *V. olivaceus* is reported as having an annual activity range of 1.48 ha (Auffenberg 1988). Stanner and Mendelssohn (1987) and Green and King (1978) reported home-range areas of *Varanus griseus* and *Varanus rosenbergi*, respectively. Both used radio-telemetry and the convex polygon method, with Green and King (1978) defining home range as 'the area traversed by an individual in its normal activities'. *V. griseus* has a reported home range of 200-500 ha (St Girons and St Girons 1959; Stanner and Mendelssohn 1987), while *V. rosenbergi* has a home range of 19.44 ha (Green and King 1978); this was later corrected by Christian and Waldschmidt (1984) to 7.8 ha. Green and King (1978) also reported activity areas for *V. rosenbergi* (1.39 ha) and *Varanus gouldii* (1.37 ha), defining this space as 'the area utilised by an animal during its daily activities'. There is a paucity of data on daily distance travelled by varanids (Stebbins and Barwick 1968; Pianka 1970, 1971, 1982; Auffenberg 1981; Vernet *et al.* 1988) and these recordings show considerable variation.

This study determined the foraging areas and daily distances travelled for *V. gouldii* in a section of the Karrakatta Cemetery in the metropolitan area of Perth, Western Australia, over 51 consecutive days in October and November 1990.

1035-3712/92/060743\$05.00

Materials and Methods

Study Area

Karrakatta Cemetery has 53 ha allotted to burial plots and 43 ha to roads and ornamental beds (Coleman 1979). Graves are arranged in rectangular plots (approximately 100 × 100 m) separated by gravel or bitumen roads. Monitors were abundant in the cemetery, although difficult to find and capture given their wariness and the type of available cover. *V. gouldii* were caught in a 7-ha section in the south-eastern part of the cemetery (Fig. 1). Most of the graves have a granite or concrete covering and, because of soil subsidence, there is often a space between the soil and the grave covering. Cracks and holes in, or erosion around, the base of the grave coverings provide access to the space underneath. It is in this space that many of the monitors shelter or dig burrows.

Present vegetation in the study area has been planted and includes peppermint gums, callistemons, box gums, camphor laurels, ghost gums, wandoos, flooded gums and jacarandas. On the southern periphery of the burial plots there is a treed section with substantial ground cover of indigenous and non-indigenous grasses and leaf litter (see Fig. 1). Leaf litter has been allowed to accumulate in some areas (particularly adjacent to some large trees; see Fig. 1), but not in others.

Study Period

Varanids were captured and their behaviour monitored between 29 September and 19 November 1990, a period of 51 consecutive days. The varanids were first seen after their winter inactive period by cemetery ground staff on 19 September 1990.

The daily maximum and minimum temperatures, as recorded by the Bureau of Meteorology for Perth, are reported with the hours of sunshine (sun not blocked by cloud cover) for each day of the study period.

Capture and Release

The varanids were generally captured with a noose in the morning as they emerged from their overnight resting burrow, or soon after emergence. Occasionally, animals were noosed or caught in mist-nets later in the day. Animals were released at the place of capture and on almost all occasions retreated into the nearest burrow, which was generally less than 5 m from the point of release. Most lizards reappeared from their burrow within 20 min. While I captured the lizards only within the study area I often followed their movements beyond the study-area boundaries.

Lizards were weighed and individually numbered on their abdomen with a black felt-tipped pen when caught. The reported weight is the one taken closest to the middle of the study period.

Tracking Technique

Two spools of white, 10-denier double-stranded nylon thread (Penguin Thread Co., Vic.) were joined and enclosed in the barrel of a 10-mL Terumo syringe, and attached to the side of the tail of each lizard with 18-mm polyvinylchloride electrical insulating tape. The syringe barrels were attached at a position along the tails where tail depth exceeded the syringe-barrel diameter to minimise the possibility of the syringe impeding the animal's movement by getting caught as it entered a hole or crevice. At the point where the animal was released, the free end of thread was tied to a fixed object. As the animal moved away from this point the thread pulled away from the centre of the bobbin, leaving a white nylon thread on the ground indicating the path the animal had taken. Two nylon spools released 420–460 m of nylon thread. After the nylon spool ran out, the animal was either recaptured (and the spool replaced) or the insulation tape and the empty syringe barrel generally came away within a further 2–4 days. During the first 15 days of the study, varanids had only one nylon spool attached to their tails. A second spool was added after this date as it doubled the possible tracking distance and appeared not to hinder or alter the animal's behaviour. For three large males (#13, 960 g; #14, 637 g; #16, 1330 g), four nylon spools were attached. Two nylon spools encased in the syringe barrel weighed 13 g, which is less than 8% of the smallest animal's mass.

The varanids' daily movement patterns were most often recorded early the next morning by retrieving the nylon thread, noting where the animal had gone and measuring the length of nylon-thread trail. The thread was most often retrieved early in the morning to minimise any presence in the area when the varanids were active. On a limited number of occasions, the movements of selected varanids were

observed from a distance for several hours to monitor their behaviour. When the nylon spools either broke or ran out the trail was lost. Nylon spools were replaced when the animals were recaptured or, if they could be caught at the time when the nylon spool was about to run out. The varanids were handled and disturbed as infrequently as possible. There was no evidence to suggest that the distance travelled on the day of capture was different to that of any other day.

Foraging Areas

In the present study, foraging area is defined as the area enclosed by the trail of thread left by an individual varanid while foraging. It was assumed that a *V. gouldii* effectively forages over an area 0.5 m each side of the thread trail, an area that has been included in all calculations of foraging area. The 0.5 m each side of the nylon-thread trail was chosen as foraged area on the basis of observations of how far each side of their nylon-thread trail these lizards actively searched for food in the leaf litter. Foraging, defined as food-searching behaviour, was identified from the particular pattern of nylon-thread trail left by the lizard. It could generally be distinguished by the nature of the thread trail from two other patterns of behaviour, namely basking and directed movement from one location to another (which could have incorporated 'patrolling' territory, seeking a mate). Foraging animals generally moved up and down between adjacent graves, often in a zigzag pattern through the leaf litter, and frequently left a long trail of thread in a small area. Foraging areas are reported for only those varanids that were monitored for a minimum of four consecutive days.

Estimation of Foraging Areas

The boundary of the area foraged by an individual varanid (including the area 0.5 m each side of the trail of thread) was transcribed onto a plan of that section of the cemetery. Where an animal was considered to be primarily moving from one location to another, these data were not included in the foraging-area calculations. The foraged area was then calculated by two methods: (A) cutting around the perimeter of the exact area and weighing the paper (a test-retest correlation of $r = 1.0$ was achieved when the procedure was repeated with a sample of 20); and (B) a repeat of (A) except that the perimeter of the smallest convex polygon was cut out to include the foraged area.

Mean and standard error (s.e.) are reported for distance travelled and foraging areas. Correlations between daily distance travelled and maximum air temperature and hours of sunshine were calculated with MINITAB software.

Results

In all, 15 *V. gouldii* (mean = 478.7 g, s.e. = ± 82.2 , range = 178–1330 g) were caught in the study area, and at least one nylon spool was attached to the tail of each lizard. The sex of the three lizards with a mass greater than 600 g could be confidently determined because on examination they (all males) completely evert their hemipenes; the sex of all smaller varanids was unknown. The movement behaviour of varanids with a mass less than 600 g appeared to be different from that of the larger varanids captured in the study area so the data for these two groups will be considered separately.

Daily Distances Travelled by Small Varanids (< 600 g)

The daily distances travelled varied considerably between animals and days (0 to more than 450 m). The total distance travelled by lizards on some days was unknown because the nylon thread was exhausted or broken. If data for only those days when the lizards actually moved away from their burrows and the complete distance travelled is unknown (i.e. where the thread did not break or run out) are included in the analysis, then the mean daily distance travelled was 111.6 m (s.e. = ± 11.3 , $n = 76$ lizard-days). However, the mean length of broken or run-out nylon thread trails retrieved was 180.5 m (s.e. = ± 19.4 , $n = 43$ lizard-days). Presumably, this is greater than the 111.6 m because of the increased propensity for a thread to break or run out the further a lizard travelled in a given day. Because the mean of the broken or run-out threads is greater than the mean for the known daily distance travelled, it can be assumed that the 111.6 m is an underestimate of the actual mean daily distance travelled by varanids smaller than 600 g.

Movements of the Three Large Males (>600 g)

The behaviour of the three large *V. gouldii* (>600 g) first seen in the study area early in November appeared different to the daily movement patterns of the smaller lizards monitored during October. A comparatively large male (960 g) *V. gouldii* (#13) was first caught in mid-afternoon on 4 November 1990 in section BC of the cemetery and travelled 98 m before going into a hole still in section BC. On 5 November it travelled 960 m (Fig. 1) before the nylon thread ran out at approximately 2 p.m. During this time it did not seem to be actively foraging for food. The same lizard was not seen again in the study area until it was recaptured on the morning of 10 November in section CC; it then moved 902 m before walking off its nylon thread in section AG, 700 m north of where it was captured. It was not seen again. Similarly, a 637-g male *V. gouldii* (#14) was caught in section BC at 11 a.m. on 6 November and travelled 430 m through five sections until it walked off its nylon thread at 2 p.m. in section CF. It was not seen again in the study area until

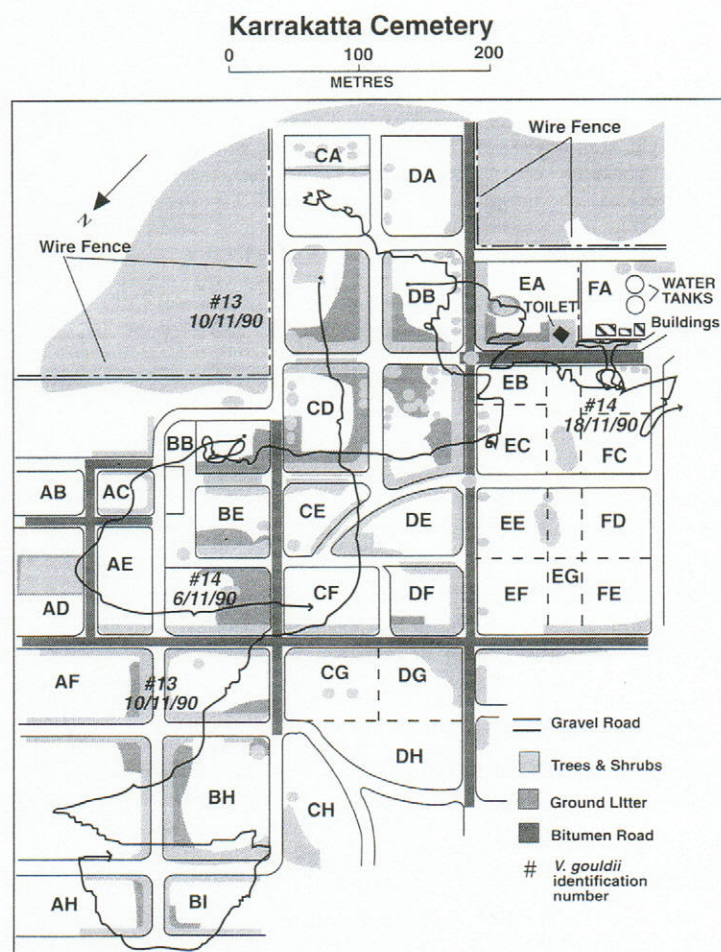


Fig. 1. The study site includes all of the burial plots within the rectangle having DA and AE in opposite corners. Nylon spool trails are shown for three large (>600 g) male *V. gouldii*.

18 November, when it was caught again in section DB; this time it travelled 980 m between 11 a.m. and 4 p.m. (Fig. 1). On this occasion it foraged for approximately 70% of the distance travelled. It was not seen again. On the 15 December a 1330-g male varanid was captured in section CC but its nylon thread broke after it had travelled only 101 m. It was not seen again in the study area.

These comparatively large male *V. gouldii* had not previously been seen in the study area prior to 4 November and they appeared to spend very little time actively foraging for food in the leaf litter (except on the second occasion for lizard #14).

Relationship between Daily Distance Travelled and Maximum Ambient Temperature and Hours of Sunshine

On eight occasions a lizard was active for several days and then on successive days did not emerge from its burrow, or remained at the entrance to the burrow during part of the day, for a number of days, even though the maximum ambient temperature and hours of sunlight were very similar to previous days when it was more active.

There was a weak positive correlation ($r=0.29$, $P<0.01$) between maximum daily temperature and the daily distance travelled (excluding data from days where the lizards did not move from their burrow and when the thread broke or ran out) by all lizards. Similarly, there was a weak positive correlation ($r=0.40$, $P<0.001$) between the hours of daily sunshine and the daily distance travelled by all lizards.

Daily Distances Travelled with the Onset of Summer

There was an increase in the daily distances (excluding data from days where the lizards did not move from their burrow and when the thread broke or ran out) travelled as the study progressed. The study period was divided into one 11-day and four 10-day periods. In the first period (30 September–9 October) the mean daily distance travelled by *V. gouldii* was 48.8 m, from 10 to 19 October it was 106.2 m, from 20 to 29 October it was 132.7 m, from 30 October to 8 November it was 140.9 and from 9 to 19 November it was 156.1 m.

Foraging Areas

Lizards smaller than 600 g were found foraging over areas of 50–1000 m², with a median area of approximately 300 m², per day. These estimates assume that *V. gouldii* effectively forages over an area of 0.5 m each side of the thread trail.

The location and foraging areas of each individual *V. gouldii* was known for a varying number of days. *V. gouldii* were often captured and their foraging area monitored for a number of days, then their subsequent whereabouts was unknown because the nylon-thread trail broke or ran out. Many of these varanids were subsequently recaptured and their foraging area was again monitored. Methods A and B were used to calculate the foraging areas of eight *V. gouldii*. The mean of 15 separate foraging areas (Table 1) calculated using method A (actual area) is 3103 m², whereas the mean calculated using method B (minimum convex polygon) is 5610 m².

The pattern and direction of foraging movement varied for individual *V. gouldii* (see Fig. 2 for examples). Some animals foraged in a small area and then moved to another area in an almost direct path. Others progressively increased their foraging area around a core zone, and some moved up to 100 m, foraged, and then moved to another area.

Discussion

This study analyses the movement patterns of medium-sized varanids by means of a spool-and-line tracking method. The results allow analyses of daily movements on a finer scale than in previous studies (e.g. by radio-telemetry). Estimates of daily foraging area tend to be smaller with the spool-and-line method than with periodic sightings and estimating activity areas by the minimum polygon method because the latter includes non-used areas.

Table 1. Foraging areas of *Varanus gouldii* between 30 September and 18 November 1990

See text for description of methods A and B to calculate foraging area

Lizard	Lizard mass (g)	Number of consecutive foraging days	Foraging areas (m ²)	
			Method A	Method B
#9	178	7	2474	2964
		6	1058	1109
#2	198	18	2408	3553
		5	6688	10184
#6	273	5	1280	2652
#11	382	7	3429	3816
		7	2835	6339
#5	437	5	693	1293
#7	460	4	2478	5101
		5	13097	28649
		4	1637	3511
#3	484	4	841	1065
		6	992	1043
		13	4038	4837
#8	515	8	2592	8039

Comparison with Distances Travelled by Other Varanids

The calculated mean daily distance travelled by small varanids was 111.6 m. However, this is certainly an underestimate of the distance travelled as the mean length of nylon threads retrieved on days where it broke or ran out was 180.5 m. Stebbins and Barwick (1968) report a 4.2-kg *V. varius* travelling a total distance of 2.9 km over five days in November. Vernet *et al.* (1988) report *V. griseus* in the north-western Saharan desert, covering between 0.1 and 2.5 km day⁻¹. Pianka (1970, 1971, 1982) reports following *V. gouldii flavirufus* for 'over a mile', *V. tristis* for 'nearly a mile' and *V. eremius* for 'up to a kilometre' in a semi-arid environment. Auffenberg (1981) reports the much larger *V. komodoensis* travelling as much as 10 km day⁻¹, with a mean of 1.8 km day⁻¹. *V. gouldii* with a mass less than 600 g at Karrakatta Cemetery during October and early November travelled an appreciably shorter distance per day than that reported for most other varanids. However, the three larger male *V. gouldii* (>600 g) travelled distances far greater than the mean daily distance travelled by the smaller varanids. Auffenberg (1981) reports that large male *V. komodoensis* travelled greater distances than smaller lizards of the same species. Given that these varanids were observed during their presumed breeding season (Pengilley 1981; Pianka 1982), it is possible that they had moved out of their normal daily foraging area in search of a mate.

There is a similarity between the behaviour patterns of *V. griseus* (Vernet *et al.* 1988) on the coastal plains of Israel and *V. gouldii* at Karrakatta Cemetery. Both would often stay in or around their burrows for a number of days and then travel considerable distances on other days, even though the environmental conditions appeared similar.

Environmental conditions, particularly ambient temperature and cloud cover, influence the behaviour of *V. komodoensis* and *V. olivaceus* (Auffenberg 1981, 1988). Therefore, I anticipated a correlation between maximum daily air temperature and hours of sunshine (no cloud cover) and the distance travelled each day by *V. gouldii*. The maximum daily temperature was significantly (but weakly) correlated with the daily distance travelled ($r=0.29$, $P=0.013$), and the daily hours of sunlight were also weakly correlated with distance travelled ($r=0.40$, $P<0.001$). The mean daily distance travelled also increased from late September to mid-November.

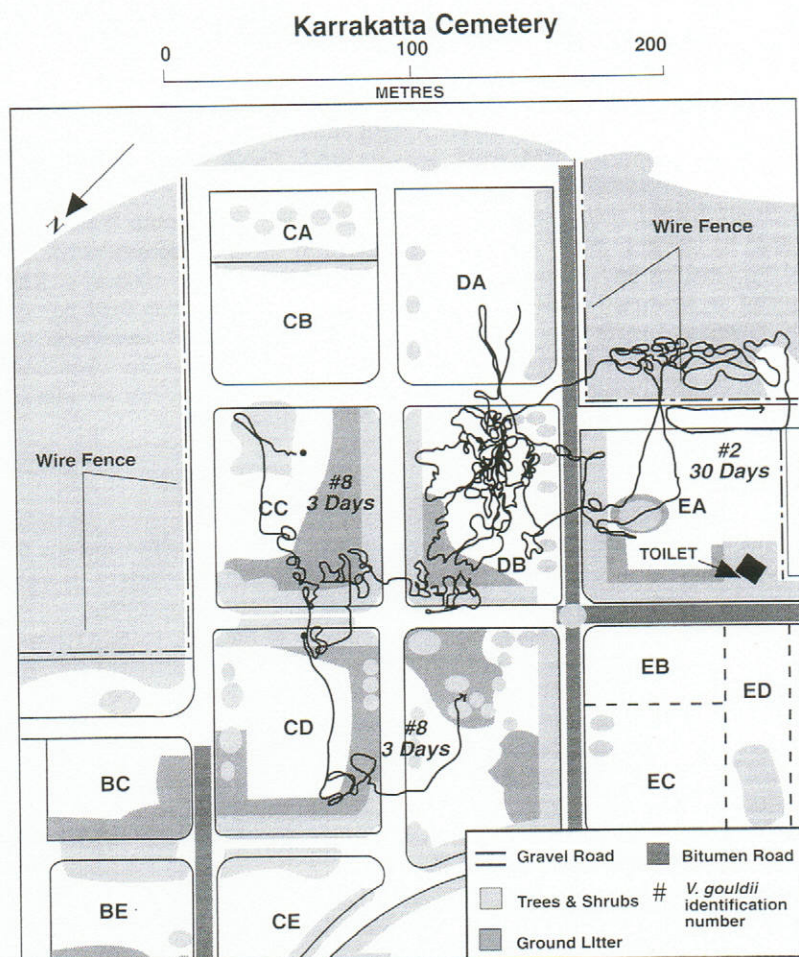


Fig. 2. Nylon spool trails are shown for two small (#2, 198 g; #8, 515 g) *V. gouldii* in a section of the study site.

Comparison of Foraging Areas with Other Studies

The foraging areas indicated in Table 1 for *V. gouldii* are overestimates due to the large number of graves (approximately 15% of the available surface area) in the study site. Many graves have no access under their cover, and concrete or granite grave surfaces do not provide suitable environments for typical varanid prey.

The foraging areas calculated using method A were 55.3% of those calculated using method B (the smallest convex polygon). The minimum convex polygon technique, now one of the most common methods of estimating the size of an animal's home range (Jennrich and Turner 1969; Rose 1982; Christian and Waldschmidt 1984), is based on estimating the home range of an animal from locational information derived from sightings or radio-telemetry fixes. One of the assumptions made when using this technique is that all of the area within the polygon is 'used' and forms part of the home range. This was clearly not applicable to *V. gouldii* at Karrakatta during the study period.

Size of Daily Foraging Areas of Varanids

The estimated median daily foraging area for *V. gouldii* smaller than 600 g was 300 m². Auffenberg (1988, p. 138) reported the mean (\pm s.e.) daily activity ranges of four *V. olivaceus* as 0.05 ± 0.004 ha and indicated that this relatively small area was due to the lizards finding a food tree and not leaving it until an alternative food source was required. Green and King (1978) reported daily activity areas for *V. rosenbergi* on temperate Kangaroo I., South Australia, of $0.67-2.43$ ha (mean 1.37 ± 0.54 , $n=3$) in December and for *V. g. flavirufus* in a semi-arid area at Calperum Station, New South Wales, in January of $0.61-3.25$ ha (mean 1.39 ± 0.48 , $n=5$), calculated by using the convex polygon method (modified by Jennrich and Turner 1969). The smaller *V. gouldii* (<600 g) at Karakatta Cemetery had an estimated daily foraging area ($0.005-0.1$ ha, median 0.03 ha) similar to that of *V. olivaceus* (Auffenberg 1988) but smaller than those of *V. rosenbergi* and *V. g. flavirufus* (Green and King 1978). Differences in the type and availability of suitable food, lizard size and density, vegetative cover and topography could collectively account for some of this variation in daily activity areas.

Shifts in Foraging Areas

Shifting foraging areas were evident for all lizards where foraging areas were monitored for more than 4 consecutive days. Generally, an individual *V. gouldii* would use the same one or two burrows for its nightly retreat while foraging in a particular area. It would then move to another foraging area and retreat to another one or two burrows.

Auffenberg (1981, 1988) describes a similar pattern of shifting foraging area for *V. komodoensis* (mainly males) and *V. olivaceus*, although over very different size areas and durations. Stanner and Mendelssohn (1987) report that female *V. griseus* remained confined to relatively small areas over a number of years whilst males tagged one year in a particular area were not observed a year later in that area. Such shifts in foraging areas could possibly be interpreted in terms of the 'Marginal Value Theorem' (Charnov 1976), where an animal remains in an area until its average foraging-return rate there falls to the average for the environment at large; it then pays to move to another more favourable patch where food is again in higher abundance.

Factors Influencing the Size of the Foraging Area

The size of the foraging area and the time spent in an area appeared to depend on the amount of leaf litter available. For example, 276 m of nylon thread was retrieved for lizard #11 on 3 November from within 300 m² (30×10 m) in section BC. Similarly, 252 m of nylon thread was retrieved for lizard #9 on the same day from within 680 m² (40×17 m) in sections EA and GA, and 105 m of thread was retrieved for lizard #8 from within 60 m² (20×3 m) in section DB on 22 October. In all three situations there was an extensive coverage of leaves, twigs and other debris on the ground. In other situations where the ground cover was much more sparse, *V. gouldii* foraged over much larger areas for the same distance travelled. Vernet *et al.* (1988) also found a correlation between the density of vegetation frequented by *V. griseus* and the level of activity.

Auffenberg (1981, 1988) reports a proportion of the populations of *V. komodoensis* and *V. olivaceus* studied to be transient lizards, most of these being males. Auffenberg (1981) also indicates that the resident *V. komodoensis* may use the same activity range for many years, whereas the transients move about over a much larger area passing through the activity ranges of other varanids within a period of weeks or months. Stanner and Mendelssohn (1987) indicate a considerable difference in the size (mean \pm s.e.) of home ranges for male *V. griseus* (98.4 ± 16.5 ha, $n=4$) and females (31.9 ± 18 ha, $n=5$), and males move longer distances during the courtship season. It is possible that the three large male *V. gouldii* caught late in this study either had a much larger home range than the smaller varanids and only infrequently visited this section of the cemetery or were transient

males perhaps in search of females. One large male *V. gouldii* (#13) on five occasions moved directly to holes known to have been occupied previously by other varanids, which may have indicated that it was searching for females or that it 'knew' the holes and routinely visited them.

Total Size of Foraging Areas

Auffenberg (1988, p. 136) describes the activity range of *V. olivaceus* (1.2–4.2 kg) in the Philippines as varying from 0.22 to 2.71 ha (mean 1.48 ± 0.21) and acknowledges that these areas are exceedingly small for a large reptile and are probably influenced by its omnivorous feeding behaviour. Activity ranges of *V. griseus* are reported as 200–500 ha (St Girons and St Girons 1959) in the Algerian desert, whereas they were much smaller (57 ha, range 14–116) on the coastal plains of Israel (Stanner and Mendelssohn 1987). For adult *V. komodoensis* (total length 2.1–3.0 m, $n=23$) the mean foraging area is 420 ha. Green and King (1978) found that the home range of *V. rosenbergi* on Kangaroo I. varied from 1.71 to 43.70 ha (mean \pm s.e.: 19.44 ± 4.58). This was subsequently reduced to 7.8 ha in a reanalysis of the data by Christian and Waldschmidt (1984), who made an alternative correction for the bias due to the number of sightings. The estimated activity areas for smaller (< 600 g) *V. gouldii* (Table 1) at Karrakatta Cemetery between 30 September and 19 November 1990 are generally much smaller than those reported for other larger varanids. It is highly probable, on the basis of the data available, that the size of foraging areas of *V. gouldii* would increase with a longer monitoring period and, as a consequence, are not directly comparable with the activity or foraging areas, or the home ranges cited above for long-term studies.

Movement into Areas of Increased Shade and Ground Cover

Prior to 6 November, all varanids foraged within the cemetery boundaries, mainly between graves in the leaf litter and occasionally in holes under the graves. After this time, several lizards increased their foraging range into the adjacent wooded areas. This area had a substantial ground cover of leaf litter and grasses, and also numerous large trees. This change in foraging area could have been due to a number of factors. The more dense ground cover presumably contained a greater quantity of prey items that could have attracted the varanids to this area. Secondly, varanids in the open area were harassed by adult red wattlebirds (*Anthochaera carunculata*) whose young were hatching. Those that moved to the wooded area avoided this harassment as they were much less conspicuous in the leaf litter and long grass than in the open areas. Why only some varanids moved to wooded areas is unclear.

Spatial Relationship

Within the 51-day study period, some *V. gouldii* constantly moved to new foraging areas and appeared to cover previously foraged areas on a random basis. If this pattern were to continue then an individual *V. gouldii* could progressively move from one site to another and, in its lifetime, forage over a very large area. Alternatively, this shifting foraging pattern could be contained within a defined home range and take a number of months, or seasons, for a lizard to progressively forage all of its area. Within the 51-day period there was considerable overlap in areas foraged by different *V. gouldii*. Small *V. gouldii* foraged in areas that had been previously foraged by other varanids days or weeks earlier. *V. griseus* on the coastal plains of Israel (Stanner and Mendelssohn 1987), *V. olivaceus* in the forests of the Philippines (Auffenberg 1988) and *V. rosenbergi* in the dry sclerophyll scrub of Kangaroo I. (Green and King 1978) are all similarly reported to have overlapping foraging areas. Auffenberg (1981) reported that core areas for *V. komodoensis* are mutually exclusive, but scavenging areas of males often overlap.

On no occasion were two *V. gouldii* found simultaneously in the same burrow although five were found to have remained overnight in burrows that had previously been used by other varanids during the study period. Green and King (1978) report finding burrows on Kangaroo I. containing two *V. rosenberg* on a number of occasions, and the same burrow being used by different animals on different nights.

Estimating Foraging Areas for V. gouldii

Some varanids in this study moved significant distances away from their nightly burrows to forage during the day before again returning to their burrows late in the afternoon. When estimating foraging area from sightings or radiotelemetry locational fixes, data would have to be collected at various times during the day to include these movement patterns. Similarly, if foraging areas change after several days, sightings or radiotelemetry fixes should be sufficiently frequent to include these changes in foraging areas.

The use of nylon spool-and-line trails provides a clear advantage over radiotelemetry or other methods of locating animals as it provides a continuous record of the exact movements of the animal. This is particularly useful in determining what parts of the habitat were most intensively used. Observations of intense use of an area covered with leaf litter or particular burrows provide important ecological information that is difficult to collect by other methods. The spool-and-line technique is also able to indicate vertical movement: on one occasion a *V. gouldii* (#1) climbed approximately 600 mm up the trunk of a small tree. This occurred adjacent to a gravel road, and whether this behaviour was normal or was caused by the lizard being disturbed is unknown.

The limitations of the spool-and-line method are the length of nylon thread that can be attached, and the necessity to frequently catch the animal. The spool-and-line method provides a good measure of movement on days of low-to-moderate activity for small-to-medium-sized monitors but it has not successfully measured activity on days of long-distance movements, particularly for the larger varanids.

Acknowledgments

Dr P. Withers, Dr D. King, Dr C. Dickman and two anonymous referees provided very useful comments and suggestions on drafts of this paper, resulting in significant improvements in the final copy. The assistance of S. and W. Thompson in catching varanids and winding up nylon thread was appreciated. The artwork for the two figures was done by Bill Adams of Edith Cowan University and was very much appreciated. Access to the Karrakatta Cemetery was approved by Mr Holman, Manager of Operations, and the assistance of Mr B. Poor and his staff in initially locating *V. gouldii* in the cemetery was very much appreciated. All lizards were caught under a licence issued by the Department of Conservation and Land Management. Animal experimentation was done with the approval of the Animal Welfare Committee of the University of Western Australia. Funding for this work was provided by Edith Cowan University and the University of Western Australia.

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