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OBSERVATIONS ON THE ECOLOGY OF *VARANUS* IN THE GREAT VICTORIA DESERT

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During late 1978 and early 1979, I was fortunate to be able to make a number of ecological observations on several species of *Varanus* (mostly on *eremius, gouldii,* and *tristis,* but also on *giganteus* and *gilleni*) primarily at two study sites in the western part of the Great Victoria Desert. One of these areas, the "L-area", is located about 40 km. east of the town of Laverton, W.A. at latitude 28° 31' S. and longitude 122° 45' E.; the other site, "Red Sands", is approximately 10 km. west southwest of the new Yamarna Homestead, or about 7 km. west of Point Salvation, at about latitude 28° 13' to 15' S. and longitude 123° 36' E. The present note should be considered an addendum to or a sequel to several earlier papers (Pianka 1968, 1969*a*, 1970, 1971).

Australian *Varanus* are exceedingly wary, essentially unapproachable lizards which are difficult to observe. Fortunately, however, they leave fairly conspicuous tracks and one may deduce quite a lot about their biology from careful study of this spoor. The largest species, *V. giganteus,* reaches two metres or more in total length, whereas some of the smaller "pygmy goannas", such as the ubiquitous and very important lizard predator *V. eremis,* achieve lengths of less than half a metre. Two other species, *V. gouldii* and *V. tristis,* are intermediate in size. All these *Varanus* consume very large prey items, particularly other vertebrates (especially lizards). Three species (*V. eremius, V. gouldii* and *V. giganteus*) are terrestrial, whereas *V. tristis* is semiarboreal.* Each of these four monitor species leaves its own distinct track: individuals of all range over extensive areas with daily forays typically covering a distance of a kilometer or more.

Although the entire genus *Varanus* is classified as "endangered", the desert species discussed here would certainly seem to be in no danger whatsoever. Not only are these monitors abundant throughout literally millions of square kilometres, but their habitat is safer, simply by virtue of its vastness and remoteness, than that of the majority of lizards anywhere on the globe. Even once widespread and common species of lizards in the Brazilian tropical rainforest or the North American deserts could vanish due to excessive habitat destruction, but the enormous untouched extent of the Australian sandy deserts virtually assure that these desert *Varanus* may be among the last of Earth's wild creatures.

VARANUS EREMIUS

Judging from the frequency of its unique and conspicuous tracks, *V. eremius* must be quite common in Australian sandy deserts. Unlike the larger goannas, it is active all year long. This beautiful little red *Varanus* is extremely wary and hence very seldom seen, however. Nevertheless, a great deal about its activities can be inferred from its tracks: statements to follow are based upon impressions gained while following hundreds of kilometres of *eremius* tracks. Individuals usually cover great distances when foraging and I have often followed a fresh track for distances of up to a kilometre. Tracks indicate little tendency to stay within a delimited area; if there is a "home range", it must be extremely large.

These small goannas are attracted to fresh holes and diggings of any sort and almost invariably will visit any recent excavation within a day or two after it is made. In contrast to *V. gouldii* (below), *V. eremius* seldom do any digging for their prey, but rather seem to rely almost entirely upon catching it above ground. More than once I have noted an *eremius* track intercept the track of another smaller lizard with evidence of an ensuing tussle. One *eremius* was actually observed to attack another lizard from ambush: on this occasion, a large *eremius* leapt out of a loose *Triodia* tussock when a small blue-tailed skink *(Ctenotus calurus)* came within a few centimetres of the edge of the tussock. Stomach contents reveal that other lizards comprise about half the prey items and represent over 70% of the *eremius* diet by volume (Table 1).

* Two other poorly known small species, *V. caudolineatus* and *V. gilleni*, are also climbers.

Table 1. Summary of stomach contents of 60 *Varanus eremius* with food (39 other stomachs were empty). Frequencies based on 60 stomachs.

Food Item	Number	Volume, cc.	% of Total Number	% of Total Volume	Frequency
Centipedes	1	0.5	1.3	0.5	1.7
Scorpions	3	2.7	4.0	2.9	5.0
Grasshoppers	27	16.5	36.0	17.4	41.7
Cockroaches	3	3.0	4.0	3.2	5.0
Caterpillars	1	0.1	1.3	0.1	1.7
Unidentified Insects	4	2.4	5.3	2.5	6.7
Lizards	36	68.8	48.0	72.6	53.3
Unidentified Partially Digested Material	—	0.75	—	0.8	
Totals	75	94.8	99.9	100.0	

Large grasshoppers plus an occasional large cockroach or scorpion constitute most of the remainder. Nearly any other lizard species small enough to be subdued is eaten (60 stomachs with food contained 36 individual lizard prey representing some 14 other species). In addition to the 11 prey species listed in Pianka (1968), *eremius* collected during the present expedition had eaten *Lerista bipes, Ctenotus dux* and *Ctenotus schomburgkii.* In a typical foraging run, an individual *eremius* usually visits and goes down into several burrows belonging to other lizard species (especially the complex burrow systems of the nocturnal skink *Egernia striata*). These activities could be in search of prey, related to thermoregulatory activities, and/or simply involved with escape responses. Certainly an *eremius* remembers the exact position of burrows it has visited, since it almost invariably runs directly to the nearest one when faced with an emergency.

Only one female collected on the present trip contained enlarged eggs: this animal, collected at Red Sands on 20 November 1978, had four yolked ovarian eggs 5-6 mm. in diameter. Mean clutch size among eight gravid females is 4.1 eggs (range = 3 to 6). Two females collected in the late 1960's had shelled eggs in their oviducts: total clutch volumes were 8.0 cc. and 5.7 cc. — ratios of clutch volume/female weight are .161 and.177.

VARANUS GIGANTEUS

The perentie has been assigned a most appropriate scientific name: it is Australia's largest lizard, and second in size among all extant lizards only to the Komodo dragon *Varanus komodoensis* (Auffenberg 1978). As indicated above, these enormous varanids are reputed to reach a total length of over two metres. During my first intensive investigations of lizard ecology in the Great Victoria Desert in 1966-68 (Pianka 1969*b*), I found little reason to challenge the commonly held view that perenties require rock outcrops (Cogger 1975; Houston 1978; Stirling 1912). I encountered only two live * specimens of these gigantic *Varanus* in the late 1960's — one at the edge of breakaway country a few kilometres east of the L-area (latitude 28° 27' S. by longitude 122° 52' E.) and the other at a tor area about 70 km. south southwest of Wiluna (latitude 27° 05' S. by longitude 119° 37' E.); in many months of work at sandy desert sites, I saw no perenties and found no tracks in sandplain or sandridge habitats.

Returning to the same areas a decade later, extensive field work during October, November and December of 1978 also failed to produce any evidence of perenties. However, in January of 1979, tracks of these huge lizards appeared, both on the L-area and at Red Sands. After some weeks of work, including unsuccessful attempts at noosing, digging, and much wasted stalking, etc., I finally managed to track down and exhume a large adult male on Red Sands on February 3rd. This magnificent beast measured about 68.7 cm. snout to vent and weighed well over 2.5 kg. Its tail length was 95.0 cm., for a total length of 1.64 metres. The animal's stride was approximately 30-40 cm. This perentie had been underground for nearly a week (probably longer); when extracted, it was some 7 or 8 metres inside a long and deep tunnel at a depth of over a metre. The animal obviously knew the location of this burrow as it had wandered several kilometres but then headed directly towards one of the very few large burrows in the area. Other tracks displayed the same phenomenon. This massive lizard was extremely docile, almost to the point of feigning death, until allowed to stand on its own feet (Iwas holding on to his tail) at which point it became very pugnacious, lunging with an open mouth in a rather impressive escape effort. After measuring, weighing and

* Skulls were also taken from two dead perenties found alongside tracks: one near Atley Homestead (about latitude 28° 27' S. and longitude 119° 05' E.), and the other well into the southern part of the Great Victoria Desert at about latitude 28° 19' S. by longitude 124° 50' E.

photographing this monitor, it was released the next day some 4 or 5 km. south of the point of capture. Interestingly enough, it set out on a long-distance trek northwards, almost directly towards the area where it was originally captured. I tracked it down a second time several kilometres away from the point of release and obtained an active body temperature measurement of 38.8° C. (air temperature was only 28.3° C.). Body temperature of another active perentie (mentioned above) collected near the L-area on 10 March 1967 was 37.6° C. (air temperature 24.8° C.).

Existing published range maps (Cogger 1975: p. 234 and Houston 1978: p. 66) are somewhat misleading: Houston suggested two disjunct populations and neither authority realized the southern extent of the geographic distribution throughout the region of the Great Victoria Desert. The discovery of *V. giganteus* well out into these southern sandy deserts implies that a population may occur virtually across the entire vast interior (see also Burbidge *et al* 1976) — if so, even perenties should probably not be considered "endangered".

Another, slightly smaller, perentie was encountered nearby on 7 March 1979 at the Reetz Creek Billabong (Latitude 28° 09' S., Longitude 123° 50' E.). This perentie exploited the muddy water of the billabong for escape and seemed very much at home in the tepid water, acting more like an aquatic monitor such as *Varanus mertensi* or *Varanus niloticus* than like a desert lizard.

My experiences with all *Varanus*, particularly with these perenties, have greatly impressed me with their mammalian-level intelligence.

VARANUS GILLENI

Only one specimen of this uncommon arboreal pygmy varanid was encountered in the Great Victoria Desert during my 1966-68 studies, and only one additional animal was discovered during 1978-79. This, the second record of this species of climbing monitor from the western part of the Great Victoria Desert, establishes the species on Red Sands, and represents a further range extension to the west of over 100 km. A large adult male (186 mm. snout-vent length, 65 grams) was found by following its very *tristis*-like track to a dead but still standing marble gum *(Eucalyptus gongylocarpa)* tree near the crest of a sandridge. Upon felling the dead tree, the *gilleni* emerged, shaken up. This pygmy varanid's body temperature was 36.4° C (the body temperature of the *gilleni* collected in 1967 was 38.4° C.). Its stomach was nearly empty, but contained what appears to be one of the pincers from the foreleg of a large scorpion.

VARANUS GOULDII

This terrestrial monitor appears to find most of its prey (predominantly lizards and reptile eggs) by digging; *V.gouldii* appear to have very keen powers of olfaction. Examination of the stomach contents of 15 *gouldii* with food collected during the present expedition adds four more lizard species to the list of seventeen species of lizard prey recorded earlier (Pianka 1970): these are *Ctenotus ariadnae, Ctenotus grandis, Lerista bipes,* and *Moloch horridus.* The proportion of lizard prey in these new stomachs is high, and when added to the data previously summarized (Pianka 1970) lizard food constitutes a full third of the *gouldii* diet by volume (Table 2).

Table 2. Summary of stomach contents of 63 *Varanus gouldii* with food (23 other stomachs were empty). Frequencies based on 63 stomachs.

Food Item	Number	Volume, cc.	% of Total Number	% of Total Volume	Frequency
Centipedes	8	23.6	2.8	4.7	12.7
Spiders	15	25.2	5.3	5.0	14.3
Scorpions	9	26.0	3.2	5.2	14.3
Wasps	1	0.5	0.4	0.1	1.6
Grasshoppers	28	32.5	9.8	6.5	20.6
Cockroaches	10	16.3	3.5	3.2	14.3
Phasmids	1	0.9	0.4	0.2	1.6
Beetles	48	45.3	16.8	9.0	22.2
Moths	2	3.0	0.7	0.6	3.2
Caterpillars	11	14.4	3.9	2.9	7.9
Unidentified Insects	9	5.3	3.2	1.1	6.4
Lizards	38	175.9	13.3	34.9	44.4
Birds	2	12.0	0.7	2.4	1.6
Reptile Eggs	96	110.6	33.7	21.9	22.2
Mammals	1	5.0	0.4	1.0	1.6
Bones	4	3.5	1.4	0.7	6.4
Unidentified Vertebrates	2	4.0	0.7	0.8	3.2
Totals	285	504.0	100.2	100.2	

As reported earlier, *V. gouldii* hibernate during the wintertime: at emergence in September-October, most animals are thin and their fat-bodies are tiny, but they rapidly fatten up during October and November.

At Red Sands, on two separate occasions a few days apart, a large adult male with enlarged testes was discovered in very close proximity to (essentially touching) an adult gravid female: these apparent mating pairs were found on 17 and 21 November 1978. Both pairs were tracked down; one pair was inside a *Triodia* tussock with their tails protruding —the other pair were dug up together in the same burrow. A total of six of the female *gouldii* encountered on this trip had large yolked ovarian egg follicles: clutch sizes were 4, 5, 6, 7, and 8 (two clutches of 8). Based on data from both my visits, overall average clutch size of all 11 gravid female *V. gouldii* from the Great Victoria Desert is 6.35 eggs. Two females, apparently almost ready to ovulate as evidenced by enlarged oviducts and extremely large ovarian eggs (about 8-9 cc. each), had clutch volume/body weight ratios of .119 and.159. Two recently hatched juvenile *gouldii* (snout-vent lengths of 130 and 133 mm.) were collected: one on 21 January 1979, the other on 11 February 1979.

VARANUS TRISTIS

V. tristis also consumes other lizards as well as baby birds (and probably bird eggs); its very distinctive track typically runs more or less directly from tree to tree (presumably the monitors climb most of these trees looking for food). *V. tristis* activity is also highly seasonal and the animals seem to rely on building up fat reserves during times of plenty to get them through lean periods. On the present expedition, I was able to supplement my previous sample of 23 *tristis* (Pianka 1971) with an additional 63 animals (see Acknowledgments).

Other lizards are the major prey of *Varanus tristis*, constituting some 71.4% of its diet by volume (Table 3). Probably individuals of almost any other lizard species small enough to be subdued are eaten: the list of prey species I have recorded include *Amphibolurus minor, Moloch horridus, Ctenotus brooksi, C. colletti, C. grandis, C. helenae(?), C. pantherinus, C. quattuordecimlineatus, Lerista bipes, Gehyra variegata*, and *Varanus caudolineatus*.

Table 3. Summary of stomach contents of 64 *Varanus tristis* with food (22 other stomachs were empty). Frequencies based on 64 stomachs.

Food Item	Number	Volume, cc.	% of Total Number	% of Total Volume	Frequency
Spiders	1	2.0	0.8	0.5	1.6
Ants	5	0.5	4.1	0.1	1.6
Grasshoppers	42	42.9	34.7	10.6	35.9
Cockroaches	7	6.2	5.8	1.5	9.4
Phasmids	2	2.0	1.7	0.5	3.1
Beetles	1	3.0	0.8	0.7	1.6
Cicadas	1	1.0	0.8	0.3	1.6
Caterpillars	3	3.0	2.5	0.7	1.6
Unidentified Insects	16	18.0	13.2	4.5	25.0
Lizards	32	288.7	26.5	71.4	46.9
Birds	3	31.7	2.5	7.8	3.1
Reptile Eggs	6	4.0	5.0	1.0	3.1
Bones	2	1.1	1.7	0.3	3.1
Totals	121	404.1	100.1	99.9	

On 15 November 1978 at Red Sands, a large adult male and a gravid female that had both been active in the same general area were tracked down to the same dead marble gum hollow log. This female and ten others collected between 28 October and 19 November 1978 contained very large shelled eggs in their oviducts (Table 4). In addition to these eleven gravid females and the one reported by Pianka (1971), a further seven females collected during late October and early November on the present expedition contained enlarged yolked ovarian egg follicles. Clutch sizes of these females number 5, 8, 9, 9, 10, 10 and 12, giving a mean clutch size among all 19 gravid females of 10.2.

Table 4. Data on eleven egg bearing female *Varanus tristis* with shelled eggs in their oviducts collected in late October and November of 1978.

Date	Clutch Size	Total Volume of Ova, cc.	Body Weight grams	Ratio of Clutch Volume to Female Weight
28 October*	8	24	199	.121
3 November	14	38	231	.165
4 November	11	27	185.5	.146
7 November*	8	24.5	205	.120
11 November*	11	44.5	214	.208
12 November*	8	34	215	.158
15 November	8	30	182	.165
16 November	10	40	282	.142
17 November	15	54	298	.181
19 November	17	64	317	.202
19 November	10	33	185.5	.178
Means	10.9	37.6	228.6	.162

SOME COMMENTS OF A COMPARATIVE NATURE

Reproductive Effort. Female investment in reproduction, as reflected in ratios of clutch volume to body weight, is not too divergent in *V. eremius*, *V. gouldii* and *V. tristis* (average ratios are about 17%, 14% and 16% respectively). Clutch sizes differ substantially more among these three species, averaging 4.1, 6.4 and 10.2 respectively. Individual eggs are relatively small in the rather fecund *tristis* but comparatively larger in *eremius*.

Fat-bodies. Stirling (1912) was struck by the size of fat bodies in two emaciated captive perenties. I have been equally impressed with the volumes of fat-bodies in some *gouldii* and *tristis*. In all *Varanus*, fat-bodies are probably exceedingly important, varying seasonally. They doubtlessly allow *Varanus* to weather out food shortages imposed by droughts and hence facilitate the use of unpredictable desert habitats.

* From the L-area (all others from Red Sands)

Body Temperature. Aside from the somewhat aberrant *V. tristis*, these desert *Varanus* seem to have remarkably similar thermal requirements, with average active body temperatures varying only from 37.4° C. to 38.2° C. (Table 5).

Table 5. Statistics on body temperatures recorded from active *Varanus* in the field belonging to six different desert species.

Species	Body temperature			Slope of Regression	Correlation Coefficient
	X	SD	N		
caudolineatus	37.8	3.45	10	0.71	0.71
eremius	37.5	3.04	53	0.24	0.46
giganteus	38.2	—	2	—	—
gilleni	37.4	—	2	—	—
gouldii	37.5	3.46	67	0.49	0.62
tristis	34.8	2.72	38	0.34	0.60

Prey Size. Except for the diminutive *V. brevicauda*, Australian desert *Varanus* seem to rely largely upon other lizards for food. But prey sizes, particularly those of the largest items eaten, vary considerably among species (Table 6). As might be expected, larger species tend to consume bigger prey

Table 6. Frequency distributions of estimated sizes of intact prey eaten by six species of Australian desert *Varanus*.

Size Category, cc.	*brevi-cauda*	*caudo-lineatus*	*gilleni*	*eremius*	*tristis*	*gouldii*
0.1	5	2		9	7	9
0.2	3	4		4	2	6
0.3	0	3		7	3	6
0.4	1	5		2	8	7
0.5	1	2	1	7	16	37
0.6	0	0	1	1	0	11
0.7	0	1	1	3	3	10
0.8	0	4	1	4	3	4
0.9	0	0	0	1	0	2
1.0	2	2	0	5	20	88
1.1— 2.0	1	3	2	15	21	64
2.1— 3.0		2	1	7	8	20
3.1— 4.0			1	3	6	7
4.1— 5.0				1	7	13
5.1— 6.0					1	4
6.1— 7.0					2	2
7.1— 8.0						1
8.1— 9.0						0
9.1—10.0					3	2
over 10.0				1	9	3
Total Number	13	28	8	70	119	296
Mean Volume	.41	.75	1.60	1.32	3.40	1.60

than smaller ones. The observed graded sequence of prey size distributions (Figure 1) is reminiscent of the plot of food weights among three species of accipiter hawks presented by MacArthur (1972).

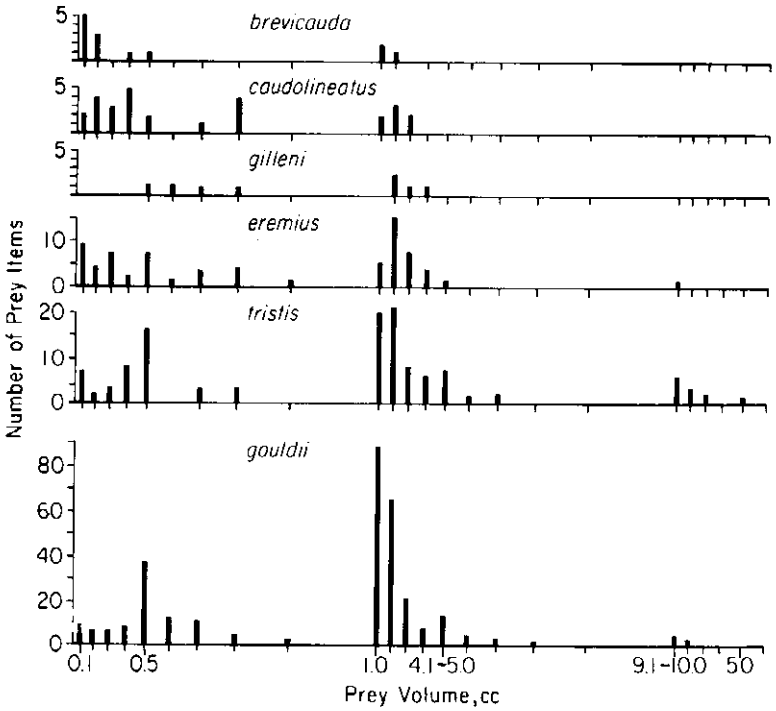

Figure 1. Frequency distributions of prey volumes among six species of Australian desert *Varanus* (semilogarithmic plot).

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