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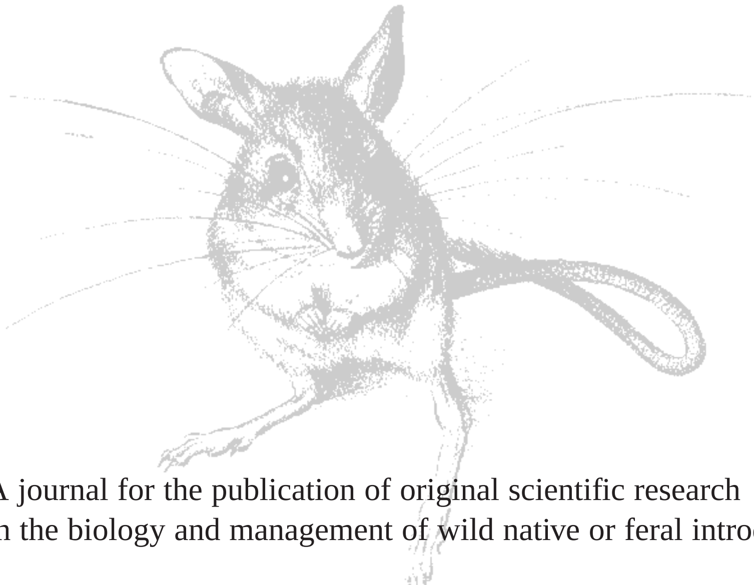

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Academy of Science

 Wildlife Research, 1999, **26**, 341–349

Influence of shade covers on pitfall trap temperatures and capture success of reptiles and small mammals in arid Australia

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Abstract

Shade covers for pitfall traps can be used to reduce the amount of solar radiation penetrating to the bottom of pitfall buckets, thereby reducing the number of captured animals dying from heat-stress. We tested the effectiveness of a variety of shade covers for reducing temperatures in pitfalls and trap mortality of small vertebrates, and examined the effect of one cover design on trap success in arid landscapes. Shade covers made of insulation foil were found to reduce core pitfall temperatures by 20–22°C compared with uncovered buckets, which reached temperatures greater than 66ºC. Other cover types tested (plastic lid or cardboard) were found to be less effective: core bucket temperatures still reached 48–53ºC. While foil covers do reduce temperatures and therefore the probability of heat-stress-related mortality, above-ground foil covers also influence trap success. Traps with above-ground foil covers caught 39–43% fewer small vertebrates and 7–42% fewer species than uncovered traps. Above-ground foil covers had the greatest influence on the sampled abundance of scincid lizards (reduced by 50–52%), reduced the sampled abundance of most other lizard families and mammals, but increased capture success for snakes. If shade covers are required to minimise heat stress and mortality in pitfall buckets we recommend foil covers placed inside the bottom pitfall buckets as they significantly reduce pitfall temperatures and are likely to have minimal influence on trap success. However, regular checking of traps is still one of the most reliable ways to reduce heat-stress-related and other deaths in pitfall traps.

Introduction

Small vertebrates, particularly reptile species, are a prominent component of the ground-dwelling fauna in arid-zone habitats of Australia (Pianka 1986; Morton and James 1988). Pitfall trapping has proved to be an effective technique for surveying small terrestrial vertebrates (Braithwaite 1983; Friend 1984; Mengak and Guynn 1987; Morton *et al.* 1988; Friend *et al.* 1989; Hobbs *et al.* 1994). The design of pitfall trap systems influences capture rates and species composition (Friend *et al.* 1989; Hobbs *et al.* 1994) and determination of the most efficient design for different species and habitats is ongoing. Morton *et al.* (1988) and Hobbs *et al*. (1994) have shown that large-diameter pitfall traps (with drift fences) result in significantly more captures of reptiles in arid environments. However, large-diameter pitfall traps allow more sunlight to penetrate to the bottom of the traps during the middle of the day in summer, thereby increasing temperatures within the traps.

Greer (1989) reported a range of critical maximum body temperatures for several Australian reptile species and families (e.g. agamids 41.6–49.5ºC; pygopodids 41.4–46.4ºC; scincids 36.3–46.3ºC). Air temperatures frequently exceed 40ºC during summer in Australia's arid zone, with soil surface temperatures that can exceed 80ºC (see Table 1). Reptiles and small mammals normally avoid these highly lethal conditions by seeking shade and retreating to burrows (Heatwole and Taylor 1987). However, there may be no escape from direct solar radiation and/or lethal temperatures if animals are trapped within an uncovered pitfall trap. Death from such exposure is an undesirable aspect of fields surveys both because of the effect on local populations and as an ethical issue (NHMRC *et al.* 1990).

The purpose of this research was to test the influence of a variety of types of shade cover on pitfall temperatures and to identify which types were likely to reduce the number of heat-stress-

10.1071/WR98032 1035-3712/99/030341

related deaths in traps. Further, we test the influence of shade covers on capture success of pitfall traps in arid-zone habitats.

Materials and Methods

Assessing temperatures in pitfall buckets and the soil surface

Six 20-L pitfall buckets (29 cm in diameter and 38 cm deep) with east–west-oriented drift fence lines were established within an unshaded area of an open woodland site 8 km south of Alice Springs, central Australia. One bucket was not covered ('no cover') and covers were constructed on the remaining five buckets as follows:

- a lid from a bucket (30 cm diameter) was propped against the northern side of the drift fence line ('lid north');
- lid from a bucket (30 cm diameter) was propped against the southern side of the drift fence line ('lid south');
- a square piece of brown cardboard (25 × 25 cm), folded to about 90º, was placed in the bottom of a bucket ('card');
- a circular piece of double-sided building insulation foil (25 cm in diameter) was placed on a 5-cm-high wire frame in the bottom of a bucket ('foil base'); and
- a piece of double-sided building insulation foil (100 × 50 cm) was placed over the drift fence line directly over the bucket and secured using soil or rocks ('foil top', see Fig. 1).

The temperature of the base of each bucket (central core and extremes), bare soil surfaces at fixed points 1 m from each of the buckets (then averaged), and soil extremes within 3 m of the trapline, were measured hourly using an infrared radiation probe from 0800 to 1800 hours on a summer day (30 January 1998).

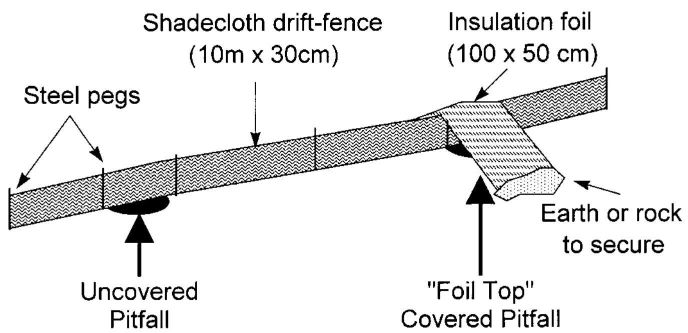

Fig. 1. Pitfall trap system design used during field surveys.

Influence of foil covers on captures of small vertebrates

The influence of above-ground foil covers (i.e. 'foil top' design) on pitfall trapping success was tested during surveys of small vertebrates on two arid landscapes in Western Australia in November 1995. The first survey was located on Boologooro Station, 60 km north of Carnarvon (23º40′S, 113º47′E) with a winter-dominated mean annual rainfall of ~227 mm. Two landscape components were sampled: an acacia shrubland on sand dunes and sand sheets, and chenopod-dominated duplex soils. The second survey was located on Arubiddy Station, 43 km north of Cocklebiddy on the Nullarbor Plain (30º12′S, 125º46′E) with a winter-dominated annual average rainfall of ~281 mm. Again, two landscape components were sampled: bluebush (*Maireana sedifolia*) rises and slopes with calcareous earths, and saltbush (*Atriplex vesicaria*) depressions with calcareous duplex soils.

Each site contained three sets of traplines on two landscape components with traplines spaced approximately 50 m apart. Sites were located at six distance zones from a central artificial waterpoint (ranging from 0.5 to ~9 km), totalling 36 pitfall trap systems per landscape component. Each trapline consisted of a pair of 20-L plastic buckets buried so that the top of each was flush with ground level (see Fig. 1). Drift fences were constructed of shadecloth fabric 10 m long by 30 cm high with the bottom edge buried approximately 3 cm into the ground. Each drift fence was held upright by steel pegs about every 2 m. Fencelines were placed to bisect the opening of each bucket.

One of each pair of pitfall buckets was shaded with double-sided insulation foil 100 cm long and 50 cm wide draped across the drift fence and with the ends secured against wind with earth or stones as per the 'foil top' design of the temperature experiment (see Fig. 1). Traplines were opened for seven days and checked at least twice daily, with all captured animals identified, marked by paint pens and released.

The abundance of each individual species, taxonomic families and all vertebrates, and tallies of species richness, were calculated for each site and design. The capture success of the covered pits at each site was calculated as a percentage of the abundance or species richness of the uncovered pits at the same site. Chi-square tests were conducted to determine the influence of shade covers on the capture success for family and total abundances.

Results

Temperatures in pitfall buckets and the soil surface

Temperatures were taken on a hot summer day with clear skies and light winds. The maximum air temperature on that day was 39ºC after an overnight minimum air temperature of 20ºC. Average soil surface temperatures rapidly increased from 38ºC at 0800 hours to over 70ºC at midday and remained over 70ºC until well past 1500 hours (see Table 1, Fig. 2). At 1300 hours the highest surface recording was 84ºC amongst humus-rich patches (Fig. 3) with the coolest surface temperature of 51ºC beneath dry grass tussocks (Fig. 4).

The temperature within all but the foil-covered buckets altered greatly throughout the day depending on the amount of solar radiation penetrating to the bottom (see Figs 2–4). The centre or core of the uncovered ('no cover') bucket reached a maximum temperature of 66ºC compared with 44–53ºC for the covered designs. The lid of the 'lid north' design was placed on the northern side of the drift fence to provide the greatest shading effect to the base of the pitfall bucket, and yet portions of this bucket reached temperatures of 66ºC. The 'lid south' design was up to 5ºC less effective than the 'lid north' design in reducing core temperatures. During the hottest part of the day the greatest range in bucket temperatures at any one time occurred in the uncovered (52–72ºC), 'lid south' (45–68ºC) and 'lid north' (45–66ºC) buckets. The card-covered bucket ranged from 45 to 52ºC, the 'foil base' bucket ranged only 1ºC (46–47ºC) and the 'foil top' bucket varied less than 1ºC from 44ºC (Table 1).

Influence of foil covers on captures of small vertebrates

The two surveys resulted in the capture of 204 individual reptiles and small mammals (130 from Arubiddy, 74 from Boologooro) representing 9 families and 33 species. Skinks were the most abundant group followed by geckoes for the Arubiddy sites and geckoes followed by skinks for the Boologooro sites (Table 2). There were no heat-stress-related mortalities of small vertebrates in pitfall traps in this experiment so we cannot provide figures on the effectiveness of covers in reducing heat-stress-related mortality.

The relative capture success of most species of lizards, and all species of mammals, were reduced by the presence of above-ground foil covers ('foil top' design) on pitfall traps (Table 2). The trend was stronger on the chenopod-dominated sites of the Nullarbor Plain (Arubiddy sites) than on the mixed acacia/chenopod shrubland of the Boologooro sites. Three of the four snake species were captured only in foil-covered pitfall traps. The sampled abundance of all the most commonly captured species, including *Morethia adelaidensis* (skink), *Underwoodisaurus milii* (gecko), *Ctenotus schomburgkii* and *C. uber* (skinks) at Arubiddy sites, and *Lerista muelleri* (skink), *Diplodactylus pulcher* (gecko) and *Ctenophorus reticulatus* (dragon) at Boologooro sites, were lower by 20–75% in foil-covered pitfall traps. Generally, abundant species fall into both covered and uncovered pitfall traps but the number of captures in uncovered pits is usually higher than in covered pits (see Table 2).

The sampled abundances of all lizard families and mammals were reduced by the presence of above-ground foil covers at the Arubiddy sites (Table 3). The most notable reductions were in

Table 1. Comparisons of soil surface, uncovered and covered pitfall bucket temperatures

Measurements taken on a summer day with a maximum air temperature of 39°C. Highest temperatures are underlined

Time	Soil Surface			No Cover			Lid Cover North			Lid Cover South			Card Cover			Foil Base Cover			Foil Top Cover		
	Mean	Min	Max	Core	Min	Max	Core	Min	Max	Core	Min	Max	Core	Min	Max	Core	Min	Max	Core	Min	Max
0800	38	33	45	34	34	36	34	34	35	34	34	35	34	34	35	34	34	35	35	34	36
0900	46	39	55	36	35	36	35	35	36	35	35	36	36	36	37	36	36	36	36	35	36
1000	55	44	66	39	38	40	39	39	40	39	39	40	38	38	38	38	38	38	39	39	40
1100	63	50	73	42	40	56	41	40	42	41	40	51	40	39	44	40	38	40	39	38	39
Noon	70	50	82	53	45	64	46	43	48	50	43	65	46	41	46	44	41	44	41	40	41
1300	73	51	84	56	50	66	48	43	63	50	43	67	49	45	51	45	44	45	41	41	42
1400	73	49	82	66	52	72	48	45	66	53	45	68	52	45	52	46	46	47	44	44	44
1500	71	48	78	51	49	56	46	44	46	47	45	53	46	44	47	44	44	45	43	42	43
1600	66	50	78	47	47	50	44	44	45	45	44	46	45	44	46	45	44	45	42	41	42
1700	59	48	66	45	44	46	43	42	44	44	44	45	44	44	45	43	43	44	42	41	43
1800	50	44	56	44	43	44	41	40	42	42	41	43	43	42	44	42	41	43	41	41	41

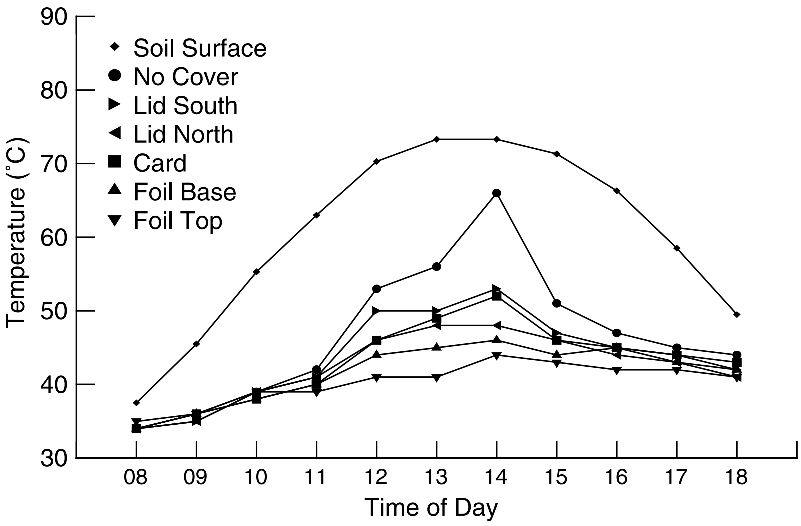

Fig. 2. Mean soil surface, uncovered and covered pitfall bucket core temperatures on a summer day in central Australia.

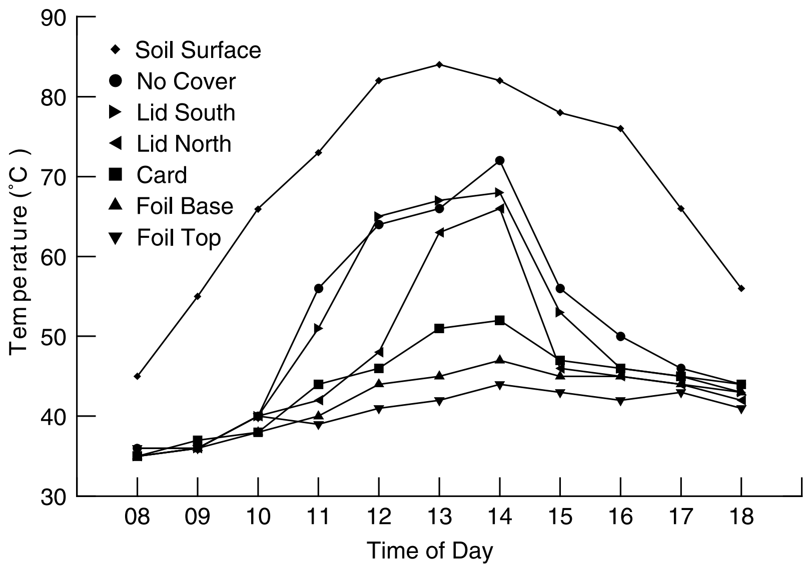

Fig. 3. Maximum soil surface, uncovered and covered pitfall bucket temperatures on a summer day in central Australia.

the sampled abundance of skinks (–52%), total mammals (–100%) and total small vertebrates (–43%) at the Arubiddy sites. The trend was similar, but reduced, at the Boologooro sites where there were marked reductions in capture success for total mammals (–100%) and total vertebrates (–39%). Above-ground foil shade covers also reduced sampled reptile (–36%), mammal (–100%) and total vertebrate (–42%) species richness at the Arubiddy sites, but covers had less influence on species richness values at the Boologooro sites (Table 3).

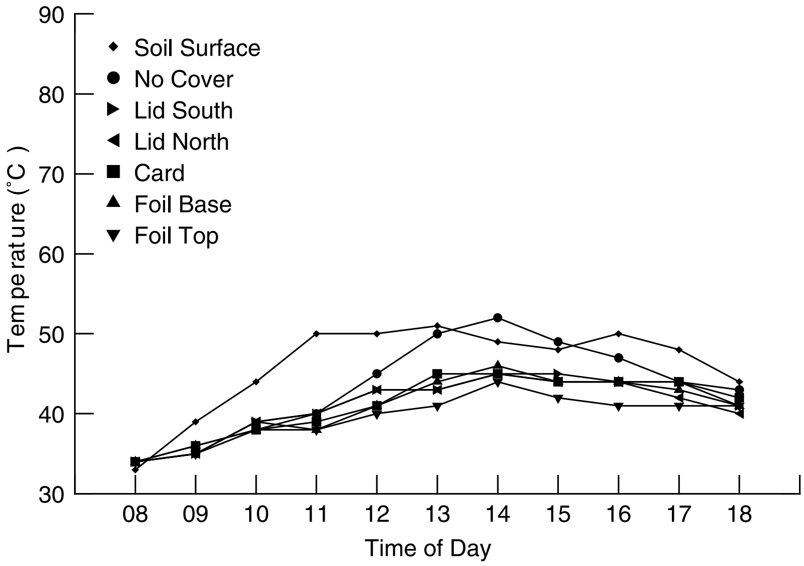

Fig. 4. Minimum soil surface, uncovered and covered pitfall bucket temperatures on a summer day in central Australia.

Discussion

Most small vertebrates of the Australian arid zone that are trapped and contained within a pitfall bucket where temperatures exceed 40–45°C will suffer heat stress (Heatwole and Taylor 1987; Greer 1989). Prolonged exposure may result in their untimely death. The use of shade covers is one approach to reducing pitfall bucket temperatures and consequent mortality of animals, particularly when frequent checking and release of captured animals is not possible. On a hot summer day (39ºC maximum air temperature) different designs of covers can reduce core bucket temperatures by 13–22ºC compared with uncovered pitfalls (see Table 1; Fig. 2). The method of propping a bucket lid against a drift-fence line to shade the inside of a bucket can reduce core bucket temperatures by 13–18ºC in the hottest part of the day but is less or non-effective when the sun is not at its zenith. In the 'lid' designs the situation of the bucket lid can have a substantial influence on pitfall bucket temperatures – in our tests the 'lid south' design was up to 5ºC less effective at reducing core temperatures and up to 17ºC less effective at reducing maximum temperatures than the 'lid north' design (see Table 1; Figs 2, 3). Cardboard covers placed in the bases of buckets to block solar radiation also reduced maximum bucket temperatures (Fig. 3). However, plain brown cardboard absorbs much of the incoming radiation, heats up and radiates heat into the bottom of the bucket, making it less effective at reducing core bucket temperatures than the 'lid north' design. Conversely, the insulation foil in the 'foil base' and 'foil top' designs reflect most of the incoming solar radiation and therefore those buckets stay cooler than all 'lid', 'card' and uncovered designs. Foil covers (i.e. 'foil base' and 'foil top') provide the greatest reduction in core temperatures (20–22ºC) and maximum temperatures (39–42ºC) compared with uncovered designs. The 'foil top' is slightly more effective than the 'foil base' design in reducing pitfall bucket temperatures.

Foil covers greatly reduce pitfall bucket temperatures and are therefore likely to reduce heat-related mortality. Our two surveys in arid Western Australia resulted in no data to test the effectiveness of above-ground foil covers on trap mortality. Regular checking of traps during the day (particularly around noon) is an effective technique to reduce such deaths, but is usually impractical for logistic reasons and may reduce capture success from excessive human

Table 2. Numbers of small vertebrates captured in two surveys testing the influence of shade covers on pitfall-trap capture success

% Diff. = Difference between capture success of foil-covered and uncovered pitfall buckets expressed as a percentage of uncovered pitfall-trap captures. Note that values of ±100% difference are used for species encountered only at either covered or uncovered buckets

Species	Arubiddy Sites			Boologooro Sites		
	Uncovered	Covered	% Diff.	Uncovered	Covered	% Diff.
Lizards						
Agamidae						
Ctenophorus maculatus	–	–	–	1	0	–100
Ctenophorus reticulatus	–	–	–	5	4	–20
Ctenophorus scutulatus	–	–	–	0	1	+100
Pogona minor	–	–	–	0	1	+100
Tympanocryptis lineata	6	4	–33	–	–	–
Gekkonidae						
Diplodactylus conspicillatus	–	–	–	2	1	–50
Diplodactylus granariensis	6	7	+17	–	–	–
Diplodactylus pulcher	–	–	–	8	2	–75
Diplodactylus squarrosus	–	–	–	3	2	–33
Diplodactylus strophurus	–	–	–	2	0	–100
Gehyra variegata	3	0	–100	1	1	0
Heteronotia binoei	–	–	–	0	1	+100
Nephrurus levis	–	–	–	0	5	+100
Underwoodisaurus milii	18	14	–22	–	–	–
Pygopodidae						
Pygopus lepidopodus	2	0	–100	–	–	–
Scincidae						
Ctenotus leonhardii	–	–	–	0	1	+100
Ctenotus schomburgkii	11	3	–73	–	–	–
Ctenotus uber	10	9	–10	–	–	–
Lerista connivens	–	–	–	0	1	+100
Lerista dorsalis	2	0	–100	–	–	–
Lerista macropisthopus	–	–	–	3	0	–100
Lerista muelleri	–	–	–	9	4	–56
Lerista uniduo	–	–	–	4	2	–50
Morethia adelaidensis	18	8	–56	–	–	–
Tiliqua occipitalis	1	–	–100	–	–	–
Varanidae						
Varanus eremius	–	–	–	2	0	–100
Snakes						
Elapidae						
Demansia psammophis	0	1	+100	–	–	–
Suta punctata	–	–	–	0	1	+100
Typhlopidae						
Ramphotyphlops bituberculatus	0	1	+100	–	–	–
Ramphotyphlops grypus	–	–	–	1	1	0
Mammals						
Muridae						
Mus musculus	6	0	–100	–	–	–
Pseudomys hermannsburgensis	–	–	–	4	0	–100
Dasyuridae						
Sminthopsis macroura	–	–	–	1	0	–100
Total No. of Reptile Species	10	8	Both 12	12	15	Both 17
Total No. of Vertebrate Species	11	8	Both 13	14	15	Both 19

Table 3. Differences between the numbers of small vertebrates captured and species richness for vertebrate groups in foil covered and uncovered pitfall-trap systems

% Diff. = Difference between capture success of foil-covered and uncovered pitfall buckets expressed as a percentage of uncovered pitfall trap captures. Note that values of ±100% difference are used for species encountered only at either covered or uncovered buckets. Chi-square statistics for total abundance are given, including significance levels where * = $P < 0.05$,** = $P < 0.01$ for 1 d.f.

	Total Abundance [36 traplines]							
	Arubiddy Sites				Boologooro Sites			
Species Group	Uncovered	Covered	% Diff.	χ^2	Uncovered	Covered	% Diff.	χ^2
Agamidae	6	4	–33	0.40	6	6	0	0.00
Geckonidae	27	21	–22	0.75	16	12	–25	0.57
Pygopodidae	2	0	–100	2.00	0	0	–	–
Scincidae	42	20	–52	**7.81	16	8	–50	2.67
Varanidae	0	0	–	–	2	0	–100	2.00
Lizards	77	45	–42	**8.39	40	26	–35	2.97
Elapidae	0	1	+100	1.00	0	1	+100	1.00
Typhlopidae	0	1	+100	1.00	1	1	0	0.00
Snakes	0	2	+100	2.00	1	2	+100	0.33
Total Reptiles	77	47	–39	**7.26	41	28	–32	2.45
Total Mammals	6	0	–100	*6.00	5	0	–100	*5.00
Total Vertebrates	83	47	–43	**9.97	46	28	–39	*4.38

	Mean Species Richness (± s.d.) [6 sites]					
	Arubiddy Sites			Boologooro Sites		
Species Group	Uncovered	Covered	% Diff.	Uncovered	Covered	% Diff
Reptiles	5.50 (±0.84)	3.50 (±1.52)	–36	4.00 (±1.79)	4.17 (±2.14)	+4
Mammals	0.50 (±0.55)	0.00 (±0.00)	–100	0.50 (±0.55)	0.00 (±0.00)	–100
Vertebrate	6.00 (±0.89)	3.50 (±1.52)	–42	4.50 (±1.98)	4.17 (±2.14)	–7

disturbance of the local fauna. Either type of foil cover used in this study is likely to reduce mortalities where access or logistics result in infrequent checking and clearing of pitfall traps.

Above-ground foil covers, while effective in reducing pitfall bucket temperatures, reduced the total numbers of reptiles and mammals caught by 39–43% and reduced species richness by 7–42% during our surveys. These covers had the greatest influence on the abundance of scincid lizards (reduced by about 50%) and reduced the sampled abundance of other lizard families and mammals. Our limited data also suggest that covers may increase capture success for snakes. Of the greatest concern is the fact that diurnal scincid lizards are likely to experience the highest risk from heat-stress and mortality, and yet their sampled abundance is most reduced by these covers. Although the trend of reduced capture success resulting from the use of shade covers on pitfall traps is consistent across the Arubiddy and Boologooro surveys, the results are more pronounced for the Arubiddy sites. This difference may stem from fewer captures, greater shrub cover or less wind at the Boologooro sites (i.e. less movement in foil covers), or the differing behavioural characteristics of the two suites of species.

It is desirable that wildlife survey techniques have minimal impact on the health and well-being of the animals being investigated while being as efficient as possible. Any modification of a survey technique should be of concern for surveyors because relatively subtle changes (from a human perspective) in trapping designs may significantly influence the capture success. In arid environments, when temperatures and solar radiation are high, foil covers for pitfall traps can greatly reduce heat stress and presumably mortality in captured animals; however, above-ground cover designs can also significantly reduce trapping success and we cannot recommend their use for this reason. Covers placed within pitfall buckets are likely to have less influence on capture rates than highly visible above-ground covers. Foil covers placed in the base of pitfall buckets were very effective at reducing bucket temperatures and we suggest that they are less obvious or distracting to wildlife than above-ground foil covers. If covers are required to minimise heat-related mortalities in pitfall traps we suggest the use of insulation foil placed on a 5-cm-high frame in the bottom of a pitfall buckets.

Acknowledgments

Thanks to Kevin Jones for the early design and testing of the shade covers used in this study and for the labour of installing pitfall buckets in extremely hard and rocky ground. We thank Alex Drew, Carolyn Maxfield, Hugh Pringle, Jacqui Stol, John Stretch and Rosemary Buxton for their help during the study. The hospitality and assistance of Barbara and Peter Brown (Arubiddy Station), staff of Agriculture WA, Carnarvon, and Jo and Bob Symonds (Boologooro Station) are greatly appreciated. Thanks to Steve Morton and Julian Reid for their comments on the draft manuscript. Fauna surveys reported in this study were done under WA CALM license number SF001662.

References

Braithwaite, R. W. (1983). A comparison of two pitfall trap systems. *Victorian Naturalist* **100**, 163–166.

Friend, G. R. (1984). Relative efficiency of two pitfall–drift fence systems for sampling small vertebrates. *Australian Zoologist* **21**, 423–432.

Friend, G. R., Smith, G. T., Mitchell, D. S., and Dickman, C. R. (1989). Influence of pitfall and drift fence design on capture rates of small vertebrates in semi-arid habitats of Western Australia. *Australian Wildlife Research* **16**, 1–10.

Greer, A. E. (1989). 'The Biology and Evolution of Australian Lizards.' (Surrey Beatty and Sons: Sydney.)

Heatwole, H. F., and Taylor, J. (1987). 'Ecology of Reptiles.' (Surrey Beatty and Sons: Sydney.)

Hobbs, T. J., Morton, S. R., Masters, P., and Jones, K. R. (1994). Influence of pit-trap design on sampling of reptiles in arid spinifex grasslands. *Wildlife Research* **21**, 483–490.

Mengak, M. T., and Guynn, D. G. (1987). Pitfalls and snap traps for sampling small mammals and herpetofauna. *American Midland Naturalist* **118**, 284–288.

Morton, S. R., and James, C. D. (1988). The diversity and abundance of lizards in arid Australia: a new hypothesis. *American Naturalist* **132**, 237–256.

Morton, S. R., Gillam, M. W., Jones, K. R., and Fleming, M. R. (1988). Relative efficiency of different pit-trap systems for sampling reptiles in spinifex grasslands. *Australian Wildlife Research* **15**, 571–577.

NHMRC, CSIRO, and AAC (1990). 'Australian Code of Practice for the Care and Use of Animals for Scientific Purposes.' (Australian Government Publishing Service: Canberra.)

Pianka, E. R. (1986). 'Ecology and Natural History of Desert Lizards.' (Princeton University Press: Princeton.)

Manuscript received 28 April 1998; accepted 6 November 1998