VERTEBRATE SURVEYS IN SEMI-ARID WESTERN AUSTRALIA

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Abstract

The role of surveys within the Western Australian Museum is examined with particular reference to the semi-arid areas of Western Australia.

Two major types of field studies are detailed. These are: (1) broad scale biological surveys to document the fauna of particular areas of the State; and (2) often arising from (1) ecological studies pertaining to inter alia habitat utilization, conservation and life history strategies. The efficacy of several sampling methods used in biological survey work of the semi arid areas of W.A. are discussed. Considerable trapping bias is demonstrated.

INTRODUCTION

Collections are the cornerstones of Natural History Museums. The curation of these collections, therefore, is a prime responsibility of most museums. The more comprehensive and better documented these collections are the more useful they are or become.

The Western Australian Museum has extensive collections of the State's fauna. These collections result from regular excursions by its staff to various parts of the State and from specimens sent in by the public and government departments. The collections include irreplaceable 'type' specimens as well as representatives of rare and extinct forms.

Involvement in faunal surveys by the WA Museum has been guided by its traditional responsibilities; these being to (a) collect, document and describe the fauna; (b) evaluate the distribution, variation, biogeographical affinities and ecology of species, and (c) make information available on the content and status of the fauna to the public, government, private industry and for education and research.

The importance of museum specimens, for identification of species and studies on systematics, distribution, biogeography, diversity and conservation is widely acknowledged, although the role of traditional museum research in these areas is the subject of recent debate (Ricklefs 1980, Olson 1981, Schwaner 1982). Schwaner (1982) has pointed out the need for museums to be 'continuously receptive to new types of collections and new methods of preservation' so that they may adequately fulfil their traditional roles and responsibilities in the future. The use of living tissue for karyological research (King 1977) and frozen tissue for biochemical and immunological studies (Baverstock et al. 1982) are of increasing importance in the study of systematic zoology. It is essential that museums maintain collections suitable for the application of these methods, thus necessitating a change in collecting and preservation methods for several groups.

This paper will examine the objectives and design of field studies of terrestrial vertebrates by the Western Australian Museum and evaluate some of the current techniques employed, placing particular emphasis on studies within the arid and semi-arid regions of the state.

APPROACH TO FIELD STUDIES

The approach of the Western Australian Museum to field faunal studies encompasses both faunal surveys and detailed ecological studies. These aspects are complementary in that the subjects of ecological studies often arise from information acquired on broad scale surveys; while the design and methods of surveys often benefit from the results of ecological studies.

Involvement by the Museum in terrestrial surveys over the last 10-15 years has frequently been in cooperation or collaboration with other government departments. Although the primary responsibilities of these departments are often different, the unifying purpose is to ensure that species and communities are adequately documented and well represented and managed in nature reserves.

Faunal Surveys

The objectives of faunal surveys determines their scope and design. Surveys range from broadscale ones that aim to document an array of taxa and communities over a large geographical area, occasionally assessing seasonal variation, to smaller scale and more intensive fauna surveys designed to document specific taxa and their biology.

For most of the last 13 years the WA Museum has concentrated on broadscale biological surveys. These have documented the vertebrate fauna of two major regions, the semi-arid Western Australian Wheatbelt and the semi-arid and arid Eastern Goldfields (Fig. 1).

The survey of the Wheatbelt commenced in 1971 with the prime objective of recording the species of vertebrate fauna and flora in the region, to document their distribution and abundance, assess their zoogeographic affinities, study aspects of basic biology, provide information for management of reserves in the region, and provide base-line information to enable the assessment of future changes in the fauna (Kitchener 1976). Representatives of numerous nature reserves throughout the region were selected for survey on the basis of their size and geographic position.

The survey of the Eastern Goldfields has taken five years and covers an area somewhat larger than Victoria. The project was initiated in cooperation with the Wildlife Research Center of the WA Dept. of Fisheries and Wildlife, the WA Herbarium and the WA National Parks Authority. The objectives were to document the flora and fauna of the region over the mosaic of landforms and soil types that occur. These data will be used to evaluate the existing or proposed reserves in the area for conserving representative communities and species.

Less extensive surveys were conducted by the WA Museum on the Northern Swan Coastal Plain (NSCP) and the Mitchell Plateau. The NSCP study (WAM 1978) documented the vertebrates and aquatic invertebrates of the area over an 18 month period with a view to evaluating the possible consequences of an artificially lowered water table on these faunal groups. The Mitchell Plateau, in the northwest Kimberley, was the focus of numerous brief or specialised collecting trips culminating in a major biological survey in late 1976. This survey (WAM 1981) examined most terrestrial and many aquatic and marine taxa.

Regional surveys of specific taxa, such as birds (Storr 1980) and reptiles (Storr *et al*. 1983) have been published with information gained from collecting trips, published data, unpublished field notebooks and the Museum collections. Examples of general and local faunal surveys can be found for Kalbarri (Bannister 1969), Cape Le Grande National Park (Kitchener *et al*. 1975) and Cockleshell Gully Reserve (Chapman *et al*. 1977), and for specific vertebrate taxa (mammals) on the Ord River (Kitchener 1978).

Ecological Studies

Modern research on systematics of animals often requires an integrated study of variation in fields as diverse as morphology, karyology, biochemistry, physiology, reproduction, habitat preferences and ecology.

There have been several major recent ecological initiatives from the Museum; the studies emanating from the survey of the WA Wheatbelt will be discussed later, while those arising from the survey of the Mitchell Plateau, Kimberley, will be briefly considered here.

The survey of the remote and relatively undisturbed Mitchell Plateau showed the comparative richness and abundance of mammal species and the diversity of habitats they occupied (Kitchener et al. 1981). It also highlighted several unresolved taxonomic problems, suggested periods when breeding of mammals was reduced or ceased, and indicated seasonal shifts in habitat utilization by some species. In an endeavour to examine these factors an intensive 18 month study was initiated with the objectives of:

1. Determining the taxonomic affinities of small mammals in the region.
2. Determining changes in abundance, distribution, physiology, morphology, genetic structure, pathology and demography of species both within and between habitats during different seasons.
3. Comparing the variation in life history strategies of these tropical populations with conspecifics in northern Australia and congeners in temperate Australia.

The approach and rationale of this study will be outlined by Bradley et al. (1984). Basically eight discrete habitats were trapped in five seasons over 18 months. Of the 19 small terrestrial mammal species captured, six had populations of adequate densities to allow an examination of the major survey objectives. Most information is yet to be analysed but some important secondary findings have been published on the natural history of Salmonella sampled from the mammals of a relatively pristine area (How et al. 1983). The findings showed the importance of surveying for these organisms over a variety of hosts and in different seasons; it also showed the prevalence was higher in marsupials than eutherians, higher in carnivores than other trophic types and highest in the wet season and lowest at the end of the dry in most hosts. Hence we have a detailed ecological study providing survey data on non-target organisms.

Data Presentation

Information gathered during field studies is enhanced in value by the degree of its availability to research workers and to management and conservation authorities. We have adopted a tiered approach to publications of field faunal studies.

The documentation of the rationale and methods used in long-term biological surveys are an important forerunner to any data presentation (see Kitchener, 1976). More recently, the objectives, design and methods used in the integrated survey of the Eastern Goldfields has been outlined by the Biological Surveys Committee of WA (1984). The baseline data gathered during surveys is generally published in a single report or series of reports documenting species present and landform, soil or habitat type in which they occurred. It is the intention to publish the information from the 12 Eastern Goldfield study areas in separate reports which will include data on climate, landform, soils, vegetation structure, flora, vertebrate fauna and discussions on the biogeographic affinities and adequacy of conservation reserves in each area.

From baseline survey data it is possible and often important to analyse the information on basic biology of species or taxa. Single species studies may, for instance, be crucial in determining the effects of habitat fragmentation on rare or endangered taxa. The discovery of populations of the rare marsupial, Phascogale calura (the Red-tailed Wambenger) on several reserves in the WA Wheatbelt allowed Kitchener (1981) to document aspects of its biology, present distribution, habitat preferences and probable reasons for its decline. These data have in turn led to more intensive studies on its ecology and physiology by Bradley (1983). The gecko Oedura reticulata was considered rare before the survey of the Wheatbelt, but is now recognized as a moderately common habitat specialist occurring only on smooth barked eucalypts in the semi-arid region of Southwestern Australia. A detailed study of its demography and habitat preferences has shown that it persists in dense populations even in tiny (1 ha) patches of woodland provided the composition and structure of the trees remains suitable (How & Kitchener 1983). In realising the importance of broad scale survey data in providing the only information available on habitat preference of rare or uncommon species, Humphreys (1983) developed a species habitat utilisation index in order to overcome problems associated with both differential trapping effort and distribution of individuals between habitats.

The major analyses of data from the survey of the WA wheatbelt resulted in the numerous papers by Kitchener and his colleagues examining the relationships between faunal richness and measures of habitat area and heterogeneity. These publications have examined the data in the light of island biogeographic theory, in which the isolated reserves studied were considered as islands in a 'sea' of wheat, as well as assessing the information for effective conservation and management of the flora and fauna. Papers, dealing with reptiles (Kitchener et al. 1980a), mammals (Kitchener et al. 1980b) and birds (Kitchener et al. 1982) examined the importance of reserve size to the persistence of most taxa. They noted that many medium sized mammals had disappeared from the region in historic times and a group of habitat specialist passerine birds were numerically depleted. These papers determined that the smallest reserves examined (30 ha) were important for conservation of vertebrates but in general larger reserves were better.

In a later paper Kitchener (1982) divided vertebrates into two groups, those that were recorded only in undisturbed vegetation and those that occurred in both disturbed and undisturbed vegetation. He determined that species that occurred only in undisturbed vegetation were most influenced by the size of reserves, while the species occupying both natural and disturbed vegetation were most influenced by floristics and structure of the vegetation. He concluded that a better understanding of a species' biology and habitat preferences was essential to formulate adequate conservation and management measures.

Humphreys and Kitchener (1982) examined these categories further and concluded that the group most in need of conservation (those species that occur only in undisturbed vegetation) were proportionally under-represented in reserves less than 600 ha. This group is threatened by widescale habitat alteration and fragmentation and they showed, that for a given reserved area, more of these species should be retained by fewer but larger reserves. In an attempt to determine the importance of areas smaller than those examined in the reserves study, Kitchener and How (1983) studied the lizard fauna on patches of woodland between 0.5 and 18 ha in area. Their study supported the findings of Humphreys and Kitchener (loc cit) that the more generalised species predominated in very small isolates; they also concluded that small patches in the Wheatbelt had similar numbers of lizard species to similar sized islands off the WA coast.

EVALUATION OF METHODS

In the remainder of this paper we intend to document and evaluate the trap types and techniques used by the Museum's survey team in vertebrate surveys of the arid and semi-arid region of Western Australia. In the interests of spatial constraints only those methods and techniques used to document the terrestrial mammals, reptiles and amphibians will be discussed; information on bird sampling techniques and effectiveness will be presented by McKenzie (this publ.).

Sampling Methods for Mammals

Surface traplines of 20 metal traps (alternating Elliott aluminium live traps and 'Selfset' snap traps baited with peanut paste, rolled oats and bacon) were systematically used to trap small mammals in the Western Australian Wheatbelt (Kitchener 1976).

The relative efficacy of these two metal trap types is evaluated from data on the number of species and individuals caught in the Wheatbelt and during other WA Museum surveys of south western Western Australia (Table 1). This evaluation was undertaken to determine if snap traps could be eliminated from future surveys since they afforded no opportunity to release specimens of adequately documented species while those specimens collected were frequently damaged and of little value to techniques employed in modern studies of systematics.

Eight marsupials and four native rodents were trapped using this systematic method (Table 1). Equal numbers of species were captured by each trap type but significantly ($p<0.001$) more individuals were caught in snap traps. The rodents Rattus fuscipes, Notomys mitchelli, Pseudomys occidentalis and P. albocinereus were all ($p<.001$) more frequently caught in snap traps but there was no significant difference in trap preference amongst marsupials. Table 1 excludes information on the introduced Mus musculus which were analysed in detail by Chapman (1981); he concluded that Elliotts were more effective than snap traps under both plague (92%) and non-plague (84%) situations. Incorporation of Chapman's data for Mus musculus would reverse the findings on capture of individuals by different trap types, but not the finding that four rodents were preferentially caught by snap traps in the Wheatbelt.

An interesting dichotomy is apparent from Table I; rodents, despite being represented by fewer species were captured more frequently

($p<0.001$) than marsupials in both types of traps. This difference may indicate avoidance of surface metal traps but could also reflect lower densities as the marsupials are mostly carnivores.

The Eastern Goldfields survey used two sampling techniques to systematically document the small mammal fauna. The more conventionally used surface traplines were supplemented by fenced pitfall traplines in all major habitats and in all 10 vertebrate survey areas within the region (Fig. 1).

For the first two trips to nine survey areas and the second trip to the tenth, three types of pitfall traps were used which varied in shape, depth and aperture width; two were conical in shape and one cylindrical. The smaller cone was 300 mm deep with a 162 mm diameter aperture, the larger cone was 450 mm deep with a 175 mm diameter aperture, and the cylinder was 600 mm deep with a diameter of 150 mm. These pitfall traps were sited under a 50 m long by 30 cm high flywire mesh drift fence that was embedded 5 cm into the substrate. Ten pit-traps were placed per line generally in the ratio of five small cones: three large cones: two cylinders. Surface traplines consisted of nine Elliott live traps (33 x 10 x 10 cm), nine Selfset snap traps and three Tomahawk cage traps (66 x 22.5 x 22.5 cm); the latter never caught mammals.

Both types of traplines were set for 5 or 6 days in a minimum of 5 sampling sites at each of the ten vertebrate survey areas examined by the Museum team. After two trips had been made to most survey areas (between November 1978 and October 1980) a comparison was made of the efficacy of the three pitfall traps and two metal traps in habitats where all five had been used (Table 2).

Sixteen small mammal species were caught, these comprised nine marsupials, six rodents, a rabbit and a bat (Table 2). Despite the expectation that individuals would be caught in proportion to the number of traps set, higher ($p<0.001$) numbers were caught in large cones and cylinders and fewer ($p<0.001$) in small cones and snap traps, than expected. When data are examined on a taxonomic basis small cones caught fewer ($p<0.05$) marsupials and fewer ($p<0.001$) eutherians, large cones more marsupials ($p<0.001$), cylinders more marsupials ($p<0.001$) and more eutherians ($p<0.001$), snap traps fewer marsupials ($p<0.001$) and Elliott traps fewer marsupials ($p<0.001$) but more eutherians ($p<0.001$) than would be expected if traps were equally effective in relation to trapping effort.

It is apparent from these data that large cones and cylinders are the most effective traps overall. However, when these two are compared, cylinders are more ($p<0.001$) effective at catching eutherians but equally as effective for marsupials. Some field observations are pertinent to explaining these differences. Both *Mus* and *Notomys* have been observed to jump out of large cones, and *Mus* have been observed jumping to within 2 cm of the top of cylinders. Evidence from faeces in pits and tracks adjacent to them suggest that *Notomys* spp are capable of escaping from cylinders. It is thus apparent that both types of cone are of inadequate depth for some rodents while even cylinders may not be deep enough to trap and contain all species. A comparison of Elliott and snap trap results from the Eastern Goldfields showed that snap traps catch significantly fewer ($p<0.001$) individuals; the converse to the Wheatbelt survey. *Mus musculus* and *Pseudomys hermannsburgensis* were both ($p<0.01$) trapped more in Elliotts, while *Notomys alexis* ($p<0.05$) was more frequently caught in snap traps.

Surface traplines caught only 44% of the small marsupial species recorded in the Eastern Goldfields.

In our evaluation of the effectiveness of various trap types there appeared to be a change in the relative response of small mammals to sampling techniques along a latitudinal gradient in the Eastern Goldfields. To examine this gradient we partitioned the ten survey areas into three regions which correlated to rainfall, latitude and to a lesser extent principal vegetation and soil type. The southwestern region comprises three survey areas (LC, MR, WL of Fig 1), is dominated by woodlands and mallees, lies between latitudes 31°30'S and 33°S and has an annual precipitation of between 260-300 mm falling principally in winter. The central region of four survey areas (MJ, BH, GG, BS of Fig 1) has vegetation types characteristic of both the Austin and Coolgardie Botanical Districts (Beard 1980), lies between 29°30'S and 31°30'S and has an annual precipitation of 230-260 mm that is spread relatively evenly throughout the year. The northern region of three areas (YM, BW, YY of Fig 1) is typical of the Austin District with mulga (*Acacia aneura*) predominating, lies between 27°30'S and 29°30'S, has an annual precipitation of 200-225 mm which is irregular but frequently heavier in summer.

The number of individual marsupials and eutherians caught by each method and the trapping effort in each region is given in Table 3. Although surface traplines captured marsupials and eutherians differentially from pitfall traplines, they indicate no difference in the trap proneness between regions ($p < 0.9$). However, the pitfall traplines in the northern region capture marsupials more than expected ($p < 0.05$) from the distribution of captures and trapping effort. Comparison of trapping within regions shows that pitfall traplines captured significantly more marsupials than eutherians in only the central and northern regions, while surface traplines captured more eutherians than marsupials in all three regions.

Comparison within taxa and techniques shows that surface traplines capture marsupials or eutherians with similar efficiency/trap effort in the three regions. Drift fenced pitlines captured eutherians with equal efficiency through the three regions but marsupials were caught less in the southwest ($p = 0.05$) and more in the north ($p = 0.0005$) than expected. This latter trend suggests that either marsupials are in denser populations in more arid areas, or they behave differently, moving greater distances in the arid and hence are more likely to be caught; we intend to examine this trend further when data from all Eastern Goldfield sites are available.

Sampling Methods for Reptiles

Systematic collections of reptiles, amphibians and invertebrates were also made using material from fenced pitfall traplines in the Eastern Goldfields. This technique was the only objective method used for reptiles. All other collecting procedures for these groups relied on opportunistic sampling by collectors with differing collecting prowess and interests.

Table 4 (compiled from Appendix I) provides information on the number of species and individuals in each reptile family recorded by the three types of pitfall trap. In habitats where all trap types were used there is no difference in the relative efficacy of different pit types for total number of individuals caught. Examined at the familial level, only for Varanids was any pit type significantly more effective in catching individuals; in this instance cylinders were more effective ($p < 0.01$) than other trap types. The importance of pit diameter to reptile capture will be evaluated elsewhere after consideration of both the SVL's and hindleg length of individuals caught.

Pitfall traps in the more arid regions of the Eastern Goldfields caught a greater proportion of the known reptiles in a specific habitat than they did in less arid areas:

$\mathrm{Sin}^{-1}/Y = 92.6 - 0.18X$ where Y = proportion of known reptile fauna and X = mm annual rainfall. ($N = 67$ $t_3 = -2.73$ $p = 0.008$)

The concomitant analysis of the effectiveness of opportunistic sampling showed that opportunistic collecting recorded a similar proportion of the reptile fauna throughout the Eastern Goldfields.

Evaluation of the efficacy of the technique on the basis of the vegetation structure in each of the 67 habitats documented shows a significant overall trend ($F_{5,61} = 2.61$; $p = .033$) with woodlands [$X \pm$ S.D(n)] 40.55 ± 13.14(15), being least well collected by this technique followed by mallees 42.15 ± 12.45(15), heaths 44.79 ± 15.96(5), shrublands 45.04 ± 22.85 (17), *Triodia* grasslands and dunes 59.10 ± 9.45(7) and samphire salt complexes 61.51 ± 21.27(8) being the best documented.

DISCUSSION

In faunal surveys the constraints imposed by methods on the data are seldom examined. In our surveys we used three trap types - snap traps, live surface metal traps and pit traps with drift fences. These trap types vary in effectiveness both by region and by taxa.

The two trapping methods captured marsupials and eutherians in opposite proportions. Such bias is most important in attempting to make objective assessments of areas. Additionally, one method maintained uniform selectivity throughout the area while pitlines exhibited differential capture success in different regions. While it is easy to have subjective views as to which method is most representative, only with more detailed work involving capture-mark-release methods can an objective interpretation be placed on the data.

In Queensland rainforests Fox and Posamentier (1976) found snap traps caught more individuals of small mammals than surface live traps but both caught all species. Having similar results from other sites in eastern Australia they recommended snap traps for faunal surveys if specimen quality was unimportant. Our data show that snap traps were more effective in catching rodents in the WA Wheatbelt, but both traps were relatively ineffecti in trapping marsupials. In the Eastern Goldfields *Mus musculus* and *Pseudomys hermannsburgensis* were caught most often in Elliott live traps whereas *Notomys* were caught more frequently in snap traps; marsupials were poorly represented in both surface trap types.

Snap traps have no applicability to studies on the dynamics of small mammal species; they are also of little use in fauna surveys if fresh tissues are required.

Pitfall traps have been used for small mammals in Australia since the mid 1970's and have greatly extended our knowledge of the biology and distribution of many species, particularly marsupials (Aitken, 1977, Cockburn *et al*. 1979, McKenzie and Youngson 1983).

Cockburn *et al*. (1979), in a study of vertebrates in the Big Desert Victoria, used standard 20 litre drums (*c*. 29 cm x 35 cm) under a drift fence and showed more species were collected by this technique than by the use of conventional live traps. The marsupials *Cercartetus concinnus*, *C. lepidus* and *Ningaui yvonneae* were captured only in pitfall traps while *Notomys mitchelli* was captured only in Elliotts. In the Great Sandy Desert, W.A., surface metal traplines caught fewer individuals and only six (55%) of the 11 species recorded from fenced pitfalls (McKenzie and Youngson 1983). This study also showed that more individual marsupials and rodents were caught by pitfalls in habitats on sandier surfaces but our data in the Eastern Goldfields showed more marsupials were caught by pitfalls in arid regions while rodent captures remained unchanged over the environmental gradient.

There is wide agreement on the utility of pitfall trapping, especially for small marsupials, but few assessments of the various methods. Pitfalls beneath metal lids, or under short drift fences recorded the same vertebrate faunal components but with different effectiveness (Braithwaite 1983).

The type of pit traps used is frequently governed by availability of suitable containers and they are, with the possible exception of those used by McKenzie and Youngson (1983) and Hopper (1981), generally of insufficient depth to catch and hold all small mammal species in an area.

Pitfall trapping for reptiles and amphibians has been used widely in surveys of northwestern Victoria (Mather 1979, Cockburn *et al*. 1979, Menkhorst 1982) resulting in large extensions of the known ranges of several species. Pit traps used in these studies varied in shape and dimensions so the data are not directly comparable. Extrapolation from the efficacy of our three pit trap types would suggest, however, that traps were of sufficient depth to catch most of the smaller and more dominant reptile species. The study by Mather (1979) of Wyperfeld National Park, recorded 27 reptiles and three amphibians, and Menkhorst (1982) recorded 21 reptiles in the Big Desert. Both reported dominance (60%) of individual numbers by three to five species and that sandy sites with Triodia irritans were richest in both species and individuals.

Our data indicate that pitfall traplines become more effective (measured by the proportion of the known herpetofauna they collect) in habitats of the arid areas and we suggest that this may be accounted for by the trend for greater efficiency in structurally less complex habitats.

Pitfall trapping has become a major technique for vertebrate survey in Australia within only the last 10 years. Design of drift fences and choice of pit traps are largely intuitive and there is a need for published information on comparisons between different designs and pit types, especially in different environments. Critical appraisal of the efficiency and bias of the methods is needed if faunal surveys are to be comparable and cost effective. It is also preferable that individuals be live trapped in the interests of both conservation and to facilitate the collection of material of use for modern systematic studies.

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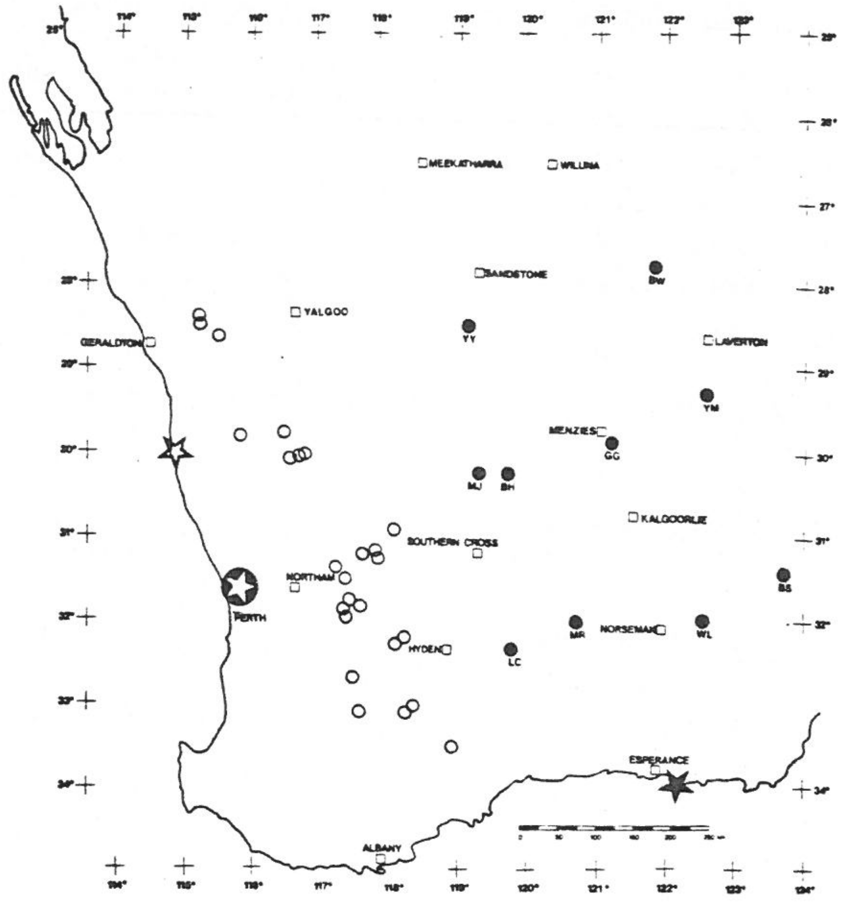

Figure 1. Locations in southwestern Australia surveyed by the Western Australian Museum since 1971.
Closed star - Cape Le Grande National Park;
open star - Cockleshell Gully Nature Reserve;
circled star - Northern Swan Coastal Plain;
open circles - Wheatbelt;
closed circles - Eastern Goldfields.
(letters referring to specific sites Codes).

APPENDIX I

The number of individuals of each species of reptile caught in different pitfall trap types between November 1978 and October 1980 in the Eastern Goldfields of Western Australia.

	Small Cones	Large Cones	Cylinders
GEKKONIDAE			
D. conspicillatus	10	7	5
D. elderi	6	4	1
D. granariensis	3	4	1
D. intermedius		1	
D. maini	6	5	
D. pulcher	10	8	1
D. squarrosus	4	5	3
D. strophurus	2	1	1
Heteronotia binoei	1	2	1
Nephrurus laevissimus	19	9	5
N. vertebralis	1	4	2
Oedura reticulatus	1		
Rhynchoedura ornata	12	3	4
Gehyra variegata	15	12	2
PYGOPODIDAE			
Delma australis	4		
D. nasuta	12	8	2
Lialis burtonis	5		
Pygopus nigriceps		3	1
AGAMIDAE			
Ctenophorus cristatus		1	
C. fordi	36	23	13
C. inermis	4	3	
C. isolepis	4	1	1
C. reticulatus	5	4	1
C. salinarum	4	8	
C. scutulatus	4	3	
Diporiphora reginae	3		
Moloch horridus	4		1
Pogona minor	4	5	2
Tympanocryptis adelaidensis		1	
T. cephala	1		

SCINCIDAE			
Cryptoblepharus plagiocephalus	4	2	
Ctenotus atlas	16	16	3
C. brooksi	6	1	3
C. calurus			1
C. greeri	2	2	2
C. helenae	1	4	2
C. leonhardii	9	7	4
C. pantherinus	3		2
C. quattuordecimlineatus	5	5	4
C. schomburgkii	37	31	11
C. uber	4	3	2
C. xenopleura	8	5	3
Egernia carinata	1		
E. depressa	1	4	
E. inornata	2	5	
E. multiscutata	1	2	
E. striata	1	1	
Hemiergis initialis			1
H. millewae			1
Lerista desertorum	1		
L. muelleri	18	6	1
L. picturata	3	1	
L. terdigitata	3	1	
Menetia greyii	10	2	
Morethia butleri	1	1	
Omolepida branchialis	2	1	
Tiliqua occipitalis		1	
T. rugosa			1
VARANIDAE			
Varanus caudolineatus	2	3	2
V. eremius		2	1
V. gouldii			1
V. panoptes			2
TYPHLOPIDAE			
Ramphotyphlops bituberculatus	1		
R. hamatus	5	1	
R. waitii	3	3	

ELAPIDAE			
Pseudonaja modesta		2	
P. nuchalis			1
Rhinoplocephalus gouldii	1		
R. monachus		1	1
Vermicella bertholdi	1	1	
V. fasciolata		1	
V. semifasciata	3	3	

Table 1. Number of individuals of each small mammal species (excluding Mus musculus) caught in surface traplines (Elliott traps and snap traps) during the vertebrate survey of the Western Australian Wheatbelt.

Species	Elliotts	Snaptraps
DASYURIDAE		
Dasyurus geoffroii	0	1
Phascogale calura	6	8
Sminthopsis carssicaudata	0	2
S. granulipes	5	11
S. murina	9	5
PERAMELIDAE		
Isoodon obesulus	1	3
BURRAMYIDAE		
Cercartetus concinnus	1	0
TARSIPEDIDAE		
Tarsipes rostratus	1	0
MURIDAE		
Notomys mitchelli	10	50
Pseudomys albocinereus	39	67
P. occidentalis	3	32
Rattus fuscipes	117	189

Table 2. The number of individuals of small mammal species caught in different trap types from pitfall traplines and surface traplines in the Eastern Goldfields of Western Australia.

Technique :	Pitfall Traplines			Surface Traplines	
Trap type :	Small Cone	Large Cone	Cylinder	Snaptraps	Elliotts
No. of trap nights :	4690	2806	1284	4311	4311
Species	Individuals				
DASYURIDAE					
Sminthopsis crassicaudata	8	13	5	1	3
S. granulipes	1	4	-	-	-
S. hirtipes	-	-	5	1	-
S. macroura	-	2	1	-	1
S. murina	-	18	8	5	2
S. ooldea	3	9	4	-	-
Ningaui ridei	9	16	8	-	-
N. yvonneae	-	2	1	-	-
BURRAMYIDAE					
Cercartetus concinnus	2	2	2	-	-
VESPERTILIONIDAE					
Nyctophilus geoffroyi	1	-	-	-	-
MURIDAE					
Mus musculus	-	2	4	8	41
Notomys alexis	-	1	3	11	3
N. mitchelli	-	2	1	4	1
Pseudomys albocinereus	2	2	11	3	2
P. hermannsburgensis	1	12	3	5	22
LEPORIDAE					
Oryctolagus cuniculus	-	1	-	-	-
TOTAL	27	86	56	38	75

Table 3. Number of individual small mammals caught and the number of Trap Nights for each sampling technique in the southwestern, central and northern regions of the Eastern Goldfields.

		No. Individuals Caught (Trap Nights)		
Sampling Technique		Southwest	Central	North
	Marsupials	17	44	68
Pitfall traplines		(1851)	(3895)	(3034)
	Eutherians	9	24	15
		26	68	83
	Marsupials	3	6	4
Surface traplines		(2070)	(3942)	(2610)
	Eutherians	24	46	30
		27	52	34

Table 4. Number of reptile species and individuals caught in three different pitfall trap types used in the Eastern Goldfields.

	No. species (No. Individuals)			
Trap type :	Small Cones	Large Cones	Cylinders	Total
Trap nights :	4936	2959	1378	9273
Family				
GEKKONIDAE	13(90)	13(65)	11(26)	15(181)
PYGOPODIDAE	3(21)	2(11)	2(3)	4(35)
AGAMIDAE	10(69)	9(49)	5(18)	12(136)
SCINCIDAE	23(139)	21(101)	15(41)	28(281)
VARANIDAE	1(2)	2(5)	4(6)	4(13)
TYPHLOPIDAE	3(9)	2(4)	-(-)	3(13)
ELAPIDAE	3(5)	5(8)	2(2)	7(15)
TOTAL	53(335)	54(243)	39(96)	73(674)

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