Postgraduate research in the Simpson Desert: the pitfalls of a PhD

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ABSTRACT

The biota and ecological processes of the Australian arid zone remain relatively unstudied. Australian deserts are remote from population centres and are subject to unpredictable rainfall, making it difficult to plan and execute time-limited research projects. Desert research is expensive; the lack of basic infrastructure, i.e. roads, and the remoteness from major service centres means that vehicle and fuel costs are high. Increasingly, research funding is being directed to universities for postgraduate research projects, instead of more long-term, expensive projects in research centres and government departments. Postgraduate research is strictly time- and cost-limited, which can constrain research effort in desert systems where stochastic conditions prevail. However, steps can be taken to ensure that short- to medium-term desert research projects are viable and successful. Combining different approaches and methods of data collection ensure that a project can become 'desert-proofed' when unfavourable conditions occur. I discuss a variety of different research projects and the need to reconsider our approach to desert research, giving emphasis to the study of functions and systems instead of a single, elusive species.

Key words: Australian deserts, postgraduate research, arid zone ecology, dasyurids

Introduction

Most ecological research projects in Australia are focussed on the biota of temperate and tropical coastal areas, where the majority of Australians live. There are clear advantages in conducting research close to home; field sites are readily accessible and can be visited frequently, travelling times are relatively short, and research expenses generally are lower. Conversely, the extensive arid zone of Australia, the 'neglected 70%', attracts comparatively few researchers; field sites are remote and at times inaccessible, and often lack basic infrastructure. Accordingly, fieldwork in desert regions is frequently difficult, sometimes impossible, and always expensive. But the uniqueness of Australian deserts combined with our scant knowledge of many basic aspects of desert systems provide rich research opportunities for motivated ecologists.

In the current political and economic climate, many government agencies and departments have reduced their research programs considerably, and most funding for ecological research is now directed to universities. As such, most short to mid-term research projects are carried out by postgraduate students in fulfilment of Masters and Doctoral degrees, who must adhere to strict time (two years for MSc, three years for PhD) and budget constraints. In this paper, I will explore the difficulties that postgraduate (and other) researchers face when conducting research in Australian deserts, and discuss ways in which projects may be designed to overcome some of the problems that are likely to be encountered. Some of my observations will be applicable to many field-based research projects, but it is not my intention to trivialise the general difficulties that all field researchers encounter, rather to highlight the more specific difficulties that researchers face when working in a remote area. To this end, I will draw from my own experiences gained while studying the ecology of dasyurid marsupials for a PhD in the Simpson Desert in south-western Queensland.

Climatic unpredictability of Australian deserts

It is well known that Australian deserts are different from those in other continents; rainfall events are sporadic and unpredictable, many areas are extensively vegetated, and the fauna and flora are diverse and unique (Whitford 2002). Whereas deserts elsewhere may, on average, be drier than Australian deserts (e.g. Atacama, Namib), they have a more regular and predictable pattern of precipitation. In Australia, huge seasonal and annual fluctuations in rainfall can result in periods of prolonged drought which sometimes last for years, interspersed with periods of higher rainfall that can occasionally cause severe flooding.

Obviously, the timing of any research project may coincide with adverse weather or other extreme environmental conditions. In Australian deserts, however, significant delays can be encountered from events that would not necessarily cause great problems in other regions. Flooding, sometimes resulting from surprisingly little rainfall, may prevent access to a study site for prolonged periods as unsealed roads quickly become impassable (Fig. 1*a*). Flooding may also drown burrow-dwelling study animals or initiate dispersals amongst some species into or out of the study region, so changing the abundance and the composition of faunal communities. Conversely, drought (Fig. 1*b*) may cause such a decline in productivity

Pp 76 - 81 in the *Animals of Arid Australia: out on their own?* 2007, Edited by Chris Dickman, Daniel Lunney and Shelley Burgin. Royal Zoological Society of New South Wales, Mosman, NSW, Australia.

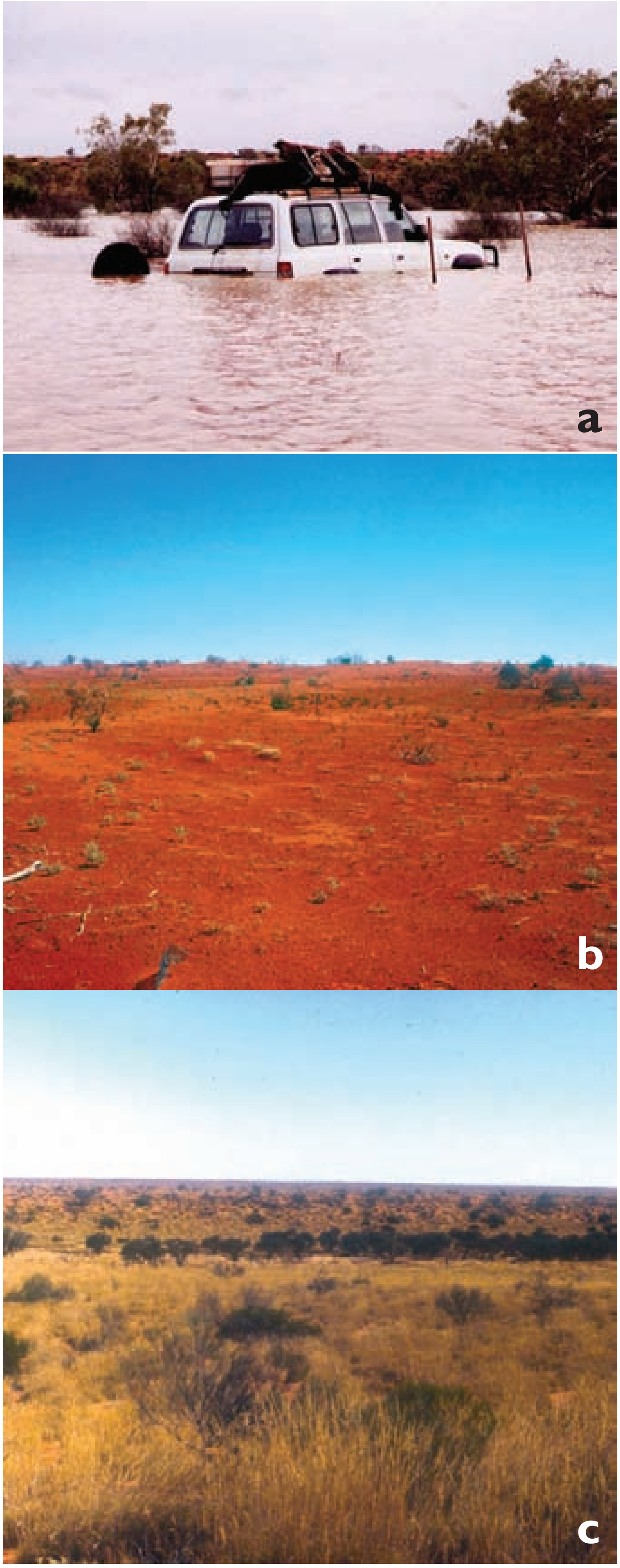

Figure 1 Variable and unpredictable rainfall produces a range of research opportunities: (a) floods delay fieldwork for months; (b) drought and fire destroy most vegetation; (c) 'ideal' conditions (abundant vegetation, roads open). Photos: B. Tamayo.

that some species cannot survive in adequate numbers to be studied or, in the case of nomadic or widely dispersing species, may disappear from a study site altogether. Evidently, the intrinsic processes that drive desert ecosystems (especially rainfall and its effect on primary and secondary production) can adversely affect a project in progress. Rarer 'cataclysmic' events can also have a huge effect for an unlucky researcher; for example, wildfires can destroy huge tracts of vegetation, killing or displacing many animals. On the brighter side, these events also provide opportunities for researchers who can retain flexibility in their projects. For example, Mike Letnic (2003) was able to incorporate the effects of a vast wildfire into his doctoral study on the effects of patch burning and rainfall on small mammals in the Simpson Desert.

Usually there are extensive periods between extreme weather events that are favourable for fieldwork (Fig. 1*c*), but the stochastic nature of rainfall events means that researchers must attempt to retain as much flexibility in fieldwork schedules, and perhaps in research topic, as possible. This can make funding a desert project quite difficult. For example, Martin Predavec (1994) was able to study rodent population dynamics in the Simpson Desert during a population irruption for his PhD. These irruptions occur on average once or twice a decade only, and follow major rainfall events that result in high levels of seed production in desert plants (most desert rodents are omnivorous, with seed comprising a large part of the diet). As these major rainfall events are unpredictable and their effects short-lived, Predavec was fortunate that funding from a large desert research grant already held by his supervisor could be made available at short notice. Predavec was successful also in applying for smaller grants (e.g. Ethel Mary Read Grant from the Royal Zoological Society of NSW) to assist with research expenses.

With the exception of surveys, most research projects are designed to adhere strictly to the hypothetico-deductive paradigm. Observations are made, models or theories are developed, hypotheses are predicted, and a series of experiments or analyses is designed to test whether these hypotheses are supported. In desert ecosystems, this can be a complete waste of time if adverse environmental conditions prevail and the study species cannot be captured. For his honours research, for example, Brad Murray was going to study predation risk behaviour in rodents in response to the presence or absence of artificial illumination in the Simpson Desert. Unfortunately, few rodents were captured at the study site for the next three years; this was probably due to increased predation by red foxes (whose numbers greatly increased in response to a rodent population irruption following above average rainfall), and declining food resources. Instead, Murray studied granivory in rodents, using samples that had been collected by Predavec and others in the previous couple of years when they had been abundant (Murray and Dickman 1994*a*,*b*).

Investigators must be prepared to take full advantage of the research opportunity as it arises, and ensure that adequate funding and infrastructure are available for the project. However, applying for and securing a research grant, usually from the Australian Research Council (ARC), is a long process as only one round of applications is considered each year. In order that funds are available for research opportunities as they arise, investigators may apply for funding for a larger-scale project covering a variety of research goals over a more substantial period of time (5 years). This effectively limits most desert research funding to established laboratories or arid zone research centres.

The tyranny of distance – the infrastructure and logistics of desert research

Most Australians live in towns and cities within 200 km of the coast. With the exception of those based in inland towns such as Alice Springs, many desert researchers have to travel long distances to reach their study site, which can often take several days if the unsealed roads are in a poor state (how we may envy desert biologists working in Israel and the south-western US who live less than 20 km from their field sites!). In my own case, travelling the 2000+ km to the north-eastern Simpson Desert from Sydney usually took 2.5 days. When flooding caused extensive detours, the trip took >3 days which then resulted in less time being available for actual fieldwork.

There are many logistical problems associated with any field-based project, but some problems can be difficult to overcome when working in remote areas with little infrastructure. Firstly, reliable transport is vital; four-wheel drive vehicles are essential for accessing study sites (Fig. 2), but even minor mechanical problems can result in major delays. Simple precautions, such as carrying an extra spare tyre, can prevent a car from being stranded for hours on a distant desert track. Safety is obviously a primary concern, and all vehicles must be well-maintained and well-equipped, with adequate training provided to researchers (remote area first-aid certificate, advanced driving certificate). Communications (satellite phone, high-frequency radio) are also of great importance, but cannot always be relied upon; poor weather can compromise their effectiveness, extreme heat can warp the electrical components, and antenna cables can fray and break. All equipment and food must be carried in, and water extracted from bores (useful skills such as starting a diesel bore are quickly learnt, see Fig. 3).

At Ethabuka station where I conducted most of my research, the University of Sydney main camp consisted of a shady clearing amongst gidgee trees, a couple of fuel drums and a pile of field equipment under a tarpaulin. Everything else (food, more field equipment, camping gear) had to be brought in on each fieldtrip, which required extensive planning and too many lists. To maximise opportunities for data collection and guard against equipment failure, I had to ensure that not only did everything work before we left for the field, but that backups or alternatives were available (e.g. radio-tracking equipment). As the nearest shop/fuel station was a 270 km return trip away, nothing could be left to chance. On each trip, I was assisted by 2-4 volunteers, and I was fortunate that I was able to draw on the expertise of seasoned technical staff and colleagues to help me with various aspects of fieldwork. This illustrates the amount of 'prior preparation and planning' required to 'prevent poor performance' in order to collect data at a remote site. It is obviously time-consuming and expensive, but these costs can be offset partially by combining fieldtrips with other researchers (usually from the same laboratory) and sharing resources.

Figure 2 Appropriate vehicles are essential when accessing remote sites, particularly after rain. (Photo by Bobby Tamayo).

Figure 3 Starting a diesel-powered water bore (Photo by Bobby Tamayo).

Case study: investigating the ecology of dasyurids in the Simpson Desert

The focus of my own research project evolved over some time. Initially, I was to investigate facilitation effects between central-netted dragons *Ctenophorus nuchalis* and the lesser hairy-footed dunnart *Sminthopsis youngsoni*. Dunnarts use burrows during the day when sleeping, but do not excavate their own burrows; they had been observed using *C. nuchalis* burrows, as well as spider and scorpion holes. Perhaps dunnart abundance was at least partially dependent upon dragon abundance? Funding for this project had been secured already by Chris Dickman, and I was fortunate to be offered this research opportunity. However, shortly before I started the project, *C. nuchalis* populations decreased sharply when spinifex density rapidly increased. Indeed, by the time I started fieldwork, the spinifex-averse *C. nuchalis* was virtually absent at the study site, whereas its spinifex-loving congener *C. isolepis* (military dragon) was abundant (Dickman *et al*. 1999). As dunnarts do not appear to shelter in *C. isolepis* burrows, the original project was no longer possible, so instead I investigated foraging behaviour and habitat use in *S. youngsoni* (thankfully still abundant!). This project evolved further to investigate the factors affecting distribution and abundance of all sympatric dasyurid species in this part of the Simpson Desert (Dickman *et al*. 2001; Haythornthwaite and Dickman 2006a).

Between March 1996 and April 1998, I conducted 11 field trips to the Simpson Desert to study aspects of the distributional ecology of up to 8 sympatric dasyurid species. Trips were planned every two months between late February and late November (the summer months were too hot for rigorous fieldwork), although extensive flooding in the Channel Country and Simpson Desert in March 1997 caused a trip to be cancelled. Each trip lasted approximately 18 days, and was timed so that most trapping sessions (for nocturnal mammals) occurred at low levels of lunar illumination, i.e. new and quarter moons. When preparation and clean-up times were added, each trip took 3 weeks in total, resulting in a '3-week on, 5-week off' regime for most of the year. I quickly became adept at balancing part-time work, research, and social and family commitments (as did my partner).

The scale of my research project, from landscape-scale population studies down to nightly movements amongst individuals, meant that my study site covered a considerable area (approx. 5600 km^2). This area covered the greater parts of three cattle stations in the north-eastern Simpson Desert (Ethabuka, Carlo, Cravens Peak), on which Chris Dickman and an army of researchers and volunteers had established > 50 trapping grids at 12 different sites since 1990. Each site therefore consisted of between 2-12 grids, spaced ≥1 km apart. I was extremely fortunate that the grids were well established by the time my project began, as 'digging in' a 1 ha grid of 36 pitfall traps is expensive, labour-intensive, time-consuming and not much fun. I had the benefit of also being able to use the trapping data from those grids from 1990-2000, into which I incorporated my own data set when investigating the life histories of sympatric dasyurid species. On each field trip, I would trap a maximum of 5 grids per night (180 traps) at one site for 3-5 days, and then move onto another site for the remainder of the trip. Occasionally, a third site would be trapped too. Traps were checked early each morning, and all vertebrates (except elapids) were identified, weighed, measured, clipped and released.

In common with many desert research studies, I found that variation in the daily 'catch' was huge. High capture rates of small mammals were always desired but rarely achieved, with fewest dasyurids being captured in the winter months. At times (mostly in winter), low capture rates prevented radio- and pigment-tracking and experiments from being run. This variation in captures, although extremely interesting from a research point of view, affected trapping regimes and trapping effort. In winter, (when reptiles are not abundant) all traps generally could be checked and cleared within 2-3 hours, thereby minimising the incidence of hypothermia in small mammals. In warmer weather, however, trap checking could sometimes take >4 hours: in hot weather, reptiles are abundant and very active, and comprise a large proportion of the 'catch', and all have to be processed (weighed, measured, identified, etc.); during population irruptions following good rains, hundreds of rodents (*Notomys alexis*, *Pseudomys hermannsburgensis*, *P. desertor*, *Rattus villosisimus*) may be captured in one day; and following overnight rain, the record for desert spadefoot toad (*Notaden nichollsi*) captures in one trap stands at 16 (60 in one grid in one night). While every attempt is made to clear the traps as quickly as possible, in hot weather (e.g. >30^{o}C at 8.00 am), animals can quickly become heat-stressed and die. Accordingly, the number of trapping grids that could be open at any one time was limited, and data collection was sometimes necessarily constrained.

To investigate macrohabitat use and long-distance movements in *S. youngsoni*, I radio-tracked 15 adult dunnarts. In common with many other studies, radio-tracking was at times problematic. Once I had overcome basic 'challenges' such as recharging receivers (from the car battery) and finding butane-powered soldering irons for activating the transmitters, I found that desert environments were well-suited to radio-telemetry. The lack of a complex tree canopy meant that excellent line-of-sight could be obtained, and dune ridges provided convenient locations from which to take fixes. Similarly, I obtained good results from fluorescent-pigment tracking (Haythornthwaite 2005a), as the dry climate preserved powder tracks well.

I also conducted two feeding experiments to investigate how *S. youngsoni* selected foraging sites in different microhabitat types, and what effect predation risk had upon foraging behaviour. The first experiment involved the construction of 3 10 x 10 m enclosures, built from star pickets, wire netting and fencing wire, with fences lined with plastic sheeting up to 1 m high. This represented a significant effort from very inexperienced fencers! Vegetation (i.e. spinifex) cover was selectively removed from each enclosure to result in densely-, medium- and sparsely- vegetated enclosures. After two feeding stations (plastic dishes and mealworms) had been set up in each enclosure, an adult dunnart (tagged with a chemoluminescent tag) was introduced to each enclosure, and its behaviour and habitat use recorded at hourly intervals from dusk to midnight. Traps within the enclosures were opened at midnight so that subjects could be removed the next morning, and released at their original point of capture. On some occasions, capture rates of dunnarts were so low that no suitable animals were available for the enclosure experiment (the same problem existed with radio-tracking). Additionally, I was unable sometimes to re-capture and remove dunnarts from the enclosures, preventing another run of the experiment with a different animal that night. However, I reliably obtained good data from this experiment and showed that dunnarts changed foraging behaviour in response to perceived predation risk (Haythornthwaite 2005b).

In the second feeding experiment (Haythornthwaite and Dickman 2000), I established 12 feeding stations (containing mealworms) on a sand-dune to cover three different dune zones (top, side and swale), with each station having feeding dishes in two different microhabitats (near spinifex, and in open areas), and provided illumination at half the feeding stations to simulate lunar illumination and hence predation risk. Sand around each feeding dish was smoothed to record small mammal tracks. In the morning, the number of mealworms eaten and the type and number of tracks around the feeding dishes were recorded to provide a measure of foraging activity. This free-ranging experiment reliably provided data at times when capture rates of dunnarts on the trapping grids were low, and provided valuable insights to dunnart foraging behaviour. Despite some equipment concerns (the gas lanterns, used as the illumination source, were bulky to transport, and the glass lanterns and mantles were fragile and constantly needed replacing), I found this type of experiment to be both robust and reliable.

This approach of using long-term data sets combined with trapping, tracking and experimental techniques ensured that I was able to gain adequate data from two seasons of fieldwork, despite the inherent obstacles of working in a remote desert environment.

Where future research should be directed

There are numerous, virtually open-ended research opportunities in Australian desert ecosystems, but which projects should be considered by postgraduate students? Without stating specific aims, we can identify common aspects to most projects that may assist when deciding future directions in desert research.

Given time, cost and environmental limitations, research should obviously be directed towards areas where most benefit is gained for the effort expended. This means that opportunities for data collection by researchers should be maximised, and projects 'weather-proofed' by relying on different sources for data. For example, vegetation data are often collected by zoologists to determine habitat for study animals, with plants frequently assessed only by their structure. However, if plants are identified to species and sampled appropriately, then not only is the data set more robust when habitats are being quantified, but a plant database is compiled that may be of use to future researchers. This practice can be extended to trapping records where all captures (not just target species) are identified and measured, invertebrate sampling, seed sampling and other field observations. In my own work, I certainly benefited from such practices and was able to access a 10-year data set of mammal captures to determine population dynamics among dasyurids, and was able also to identify changes in vegetation over this time. If such resources are readily available to postgraduate students, then the complete reliance on field data gathered only during their candidature is eased. Similarly, projects that make use of museum or historical records can provide similar benefits. This ensures that all is not doomed when a field site becomes inaccessible for six months.

Another approach to making projects more desert-tolerant is to shift the focus of research projects away from the study of single species, instead studying functional groups or processes. This removes the need of having to capture one particular species whose abundance may fluctuate under different environmental conditions (e.g. frogs, rodents, agamid lizards, dasyurids, birds). If functional groups are studied instead (e.g. granivores, insectivores), then researchers are much more likely to make captures and gain appropriate data. Experiments can also be designed to obviate the need to capture target species first. For example, feeding experiments can be designed to evaluate the effect of water on seed foraging behaviour in free-living birds and rodents (Kotler *et al.* 1998), or study the effects of predation risk on foraging behaviour in free-living dasyurids (Haythornthwaite and Dickman 2000). Yet another approach is to combine field and laboratory experiments in one study, so reducing the reliance and frequency of field trips. For example, Silvia Ricci (2003) used field observations and laboratory experiments to investigate seed selection and foraging behaviour in desert rodents, and the effects of different food resources on reproduction.

Some field studies, however, are perhaps best suited to desert conditions. For example, radio-tracking animals in sand-dune habitats is much easier than in other habitats; there are no obstructions, triangulation points are easy to find, and the sand dunes provide good line-of-sight for both bearings and direct observations. Provided the study species is relatively easily captured, then some valuable insights into habitat use and movements of individuals can be gained (Haythornthwaite and Dickman 2006). Similarly, I found that fluorescent-pigment tracking worked very well in the sand-dune habitats. However, there are usually some disadvantages with most field techniques; in the case of radio and pigment-tracking, following highly mobile dunnarts all night produced some excellent data, but sleeping in 50°C temperatures the next day was impossible. I reached a compromise and tracked dunnarts for half the night only, at the sacrifice of some data. As with all fieldwork, the spirit is usually willing, but physical limitations often prevail.

The future of postgraduate desert research

Assuming that funding is available for desert research, there will always be interest amongst some postgraduate researchers in studying desert ecosystems. The difficulties and expenses of fieldwork in remote areas will remain, but robust projects can be designed to suit prevailing conditions. If researchers can adapt their approach so they can take advantage of the climatic fluctuations inherent in Australian deserts, then they have a far greater chance of successfully completing a project. However, it would be extremely difficult for a postgraduate researcher to undertake such a project without the support and expertise of an established arid-zone research facility.

There are many aspects of Australian desert systems that are worthy of greater research effort. They present unique opportunities to potential postgraduate researchers, whose efforts will lead us all to gain a better understanding of these remarkable places.

Acknowledgements

Thanks to technical staff and fellow researchers in Chris Dickman's lab at the University of Sydney. I appreciate the assistance of many volunteers with fieldwork, and thank the Smith, Jukes and McDonald families for providing hospitality and access to study sites. Thanks to Bobby Tamayo for sharing his extensive photo collection. Chris Dickman provided witty (but constructive) comments on the manuscript.

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