

ENVIRONMENTAL VARIABLES AND THE BIOLOGY OF NATIVE AUSTRALIAN ANIMALS IN THE MULGA LANDS

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ABSTRACT

Many native animals in the mulga lands are able to live and breed successfully under relatively harsh conditions. Some of the ways they do this provide insights into the dynamics of the mulga lands which cannot be derived from studies of introduced animals.

Many of the successful organisms are generalised, adapted to survive a wide range of conditions, cold and wet as well as hot and dry; and, in the long-term sense, many organisms exhibit regular breeding seasons, implying recurring availability of resources.

Ecological studies of native animals in the mulga lands in Western Australia emphasise the importance of creek systems as areas of water concentration and storage, and therefore of food production. Low temperatures, flooding, and predator-prey relationships between plants and animals are suggested as important factors depressing productivity in years of heavy rainfall.

INTRODUCTION

Studies of the wildlife of inland Australia began almost as soon as explorers penetrated into the area. Gould (1863) published the observations of his collector, Gilbert, who gathered what information was available in the 1830's, and by the end of the nineteenth century the reports of some other expeditions specifically mounted to study natural history were available (e.g. Horn Expedition; North (1896); Spencer (1896)). Subsequently more intensive work was started with the publications of McGilp (1923), Whitlock (1910, 1923, 1924), and Wood-Jones (1923-25). Later Finlayson (1936, 1939; other references in Ride (1970)) began to make detailed accounts of native desert animals.

Studies on rabbit biology (summarised by Myers (1970)) are intentionally ignored since the rabbit is an introduced animal, and like the sheep, cow and dingo, such studies give the same kind of insights into the environment as those of other introduced animals.

The present paper aims to examine the insights into the dynamics of the mulga lands that may derive from studies of native animals, animals which have lived and bred successfully in them for millions of years.

Recent studies of the life history and physiology of frogs (Main, Littlejohn and Lee 1959), reptiles (Storr, 1963, 1964, 1965, 1966, 1967*a* and *b*, 1968*a* and *b*, 1969, 1971; Pianka, 1968, 1969, 1970*a* and *b*, 1971), birds (Immelmann 1963; Serventy 1971), small mammals (Griffiths, 1968; Main, 1968), and kangaroos (Ealey, 1967*a* and *b*; Ealey, Bentley and Main, 1965; Ealey and Main, 1967; Frith and Calaby, 1969; Kirkpatrick, 1965, 1966; Kirkpatrick and McEvoy, 1966; Newsome, 1971*a*; Russell, 1970, 1971) have given us a broad picture of the way native vertebrates come to terms with the environment of the mulga lands. From these three general points can be made.

Firstly the native fauna of mulga lands fluctuates in numbers without over-exploiting its resources or suffering rapid extinction, except when the environment is seriously degraded by man's activities or the activities of introduced animals (Newsome, 1971*b*).

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Secondly many of the abundant animals that occur in the mulga lands are not desert specialists, but rather generalised animals that can tolerate a wide range of climate and have a wide distribution. Many of them have behavioural responses that protect them from the extremes of heat and cold, aridity and humidity which occur in the region. Some of the highly specialised 'desert' forms are, in fact, rare and limited to specific habitats, e.g. marsupial mole (*Notoryctes typhlops*) (Ride, 1970).

Thirdly many authors (Finlayson, 1961; Immelmann, 1963; Keast and Marshall, 1954; Marshall, 1960; Serventy and Marshall, 1957) have stressed the irregular nature of breeding in the mulga lands. The emphasis on irregularity contrasts with observations in the Murchison District of Western Australia, where recurrence of reproduction is impressive in both plants and animals (Davies, 1968, 1970).

It appears that the discussion of breeding seasons (as defined for birds in Thomson (1964)) in arid zone organisms has been confused by two factors. First the uncritical acceptance of breeding records. For a breeding attempt to be successful in the long-term evolutionary sense, significant numbers of the offspring must survive and be capable of reproducing themselves. Most temperate zone birds start breeding during the medium length photoperiods and warm temperatures of spring, but these conditions are mimicked by autumn in certain years, and provided the species does not have a lengthy refractory period, there may be a recrudescence of breeding activity in autumn (Lofts and Murton, 1968). In arid zones dramatic temperature changes often accompany rain (Mott, 1972) and these may be the proximate factors that lead to the onset of breeding at unusual times of the year rather than the rainfall itself. Observations in Western Australia suggest that these breeding attempts rarely meet the criterion of success given above and the work of Serventy and Marshall (1957) contains examples of failure of autumn nesting attempts. The second point of confusion appears to stem from the use of the terms 'autumn' and 'spring' in the discussion of out of season breeding, without recognising that these seasons can only be defined in terms of a particular combination of photoperiod and temperature, which are, in fact, common to both. Relatively few of those species studied so far have been found to have an obligate requirement of 'short photoperiod' to break their refractory phase (Lofts and Murton, 1968), and none of these are native Australian species. Once breeding commences, changed environmental factors, notably temperature and the availability of food and cover, maintain its momentum and may control its termination (Lofts and Murton, 1968; Serventy and Marshall, 1957). Although there is evidence that some mammals are also sensitive to the initiation of reproductive physiology by photoperiod and temperature changes (Donovan 1967; Thorpe 1967), there is much published data suggesting that breeding is potentially continuous in the large kangaroos (Frith and Calaby, 1969).

Regular breeding seasons imply that there is a regularity in the availability of resources needed for breeding, in particular food for the young as they start an independent life. Continuous breeding implies that no such regularity exists. There is certainly a regular annual temperature pattern in the mulga lands, and in the southern part of the mulga lands in Western Australia there is, in addition, a regular rainfall if one's standards are set low enough (Davies, 1968). This standard may be too low for the large kangaroos, although it is adequate for emus and many other mulga land organisms.

BASIC LIFE HISTORY PATTERNS

The ways in which arid zone animals come to terms with their environment have been discussed at length in relation to overseas deserts (Buxton, 1923; Cloudsley-Thompson and Chadwick, 1964) and Keast, Crocker and Christian (1959) have given some examples from Australia. There are three strategies open to desert organisms. They may be *nomadic*, avoiding areas where conditions are harsh and concentrating in

localities where conditions are temporarily favourable. They may *avoid* the extreme conditions in some resting or inactive stage, or they may *remain* in one area, surviving the harsh conditions and exploiting the good seasons.

In the mulga lands the *nomads* are mainly birds, but species of fish, amphibia, reptiles, birds and mammals *avoid* the heat, cold and moisture stress by living deep in caves, in litter or in mud during waterless periods or when it is very cold, emerging to feed and breed whenever suitable conditions occur.

TABLE 1

Flowering and fruiting of ten shrubs at Mileura, Western Australia, expressed as a percentage of the sample of individually marked shrubs which flowered or fruited in the specified month during observations between 1960 and 1971. Percentages have been rounded to the nearest 10%.

Species	No. in sample	Percentage Flowering:											
		J	F	M	A	M	J	J	A	S	O	N	D
<i>Acacia aneura</i>	25		40	20	50	10	10	40	20	10	20		10
<i>A. pruinocarpa</i>	5											40	60
<i>A. tetragonophylla</i>	20					30	50	70	90	30	20	10	
<i>A. victoriae</i>	10									10		80	60
<i>Cassia desolata</i>	20		10				20	30	70	60	50	10	10
<i>C. sturtii</i>	15						10	30	50	60	40	10	
<i>Eremophila fraseri</i>	20	10	10	10	30	20	40	60	50	70	30	50	10
<i>Hakea suberea</i>	5				20	20	40	30	60	10			
<i>Santalum spicatum</i>	5		20	30	60	70	30						
<i>Scaevola spinescens</i>	5		50	10	50	80	60	10		20	40		10
		Percentage Fruiting:											
<i>Acacia aneura</i>	25	40	50	30	40	50	40	50	50	60	50	30	30
<i>A. pruinocarpa</i>	5	20	30	10			10						
<i>A. tetragonophylla</i>	20	20	10	10			10	30	40	50	60	40	20
<i>A. victoriae</i>	10	80	70	40			40	10		10	10	10	40
<i>Cassia desolata</i>	20	30								50	50	60	30
<i>C. sturtii</i>	15	10		10			10			30	50	60	20
<i>Eremophila fraseri</i>	20	100	50	50	70	60	40	30	50	90	80	100	70
<i>Hakea suberea</i>	5					20	10	10	40	40	30	20	10
<i>Santalum spicatum</i>	5					30	40	20		40			10
<i>Scaevola spinescens</i>	5		30	50	50	50	30	80	100	30	10	10	10

Many of the more conspicuous, and therefore possibly the dominant, organisms in the mulga lands of Western Australia, are *resident* (or perennial) and maintain regular breeding seasons. It is easiest to demonstrate this in shrub species, and Table 1 summarises the flowering and fruiting period of ten common arid zone shrubs. The results of observations on *Acacia aneura* provide a particularly good example of the way observations can make it appear that an organism can breed at any time of the year. Table 1 shows this shrub will flower at any time of the year but Davies (1968) has shown that fruit is only set after rain in summer and only matures if good winter rain falls. Data for some animals are summarised by Davies (1970). The strategy of these organisms appears to be that resources occur with sufficient annual regularity in the Murchison district for natural selection to have evolved regular breeding seasons as the mechanism leading to the production of most offspring that will live to reproduce themselves.

PRODUCTIVITY OF CREEK SYSTEMS IN MULGA LANDS

Studies of native organisms in the mulga lands of Western Australia by the CSIRO Division of Wildlife Research have shown that their abundance and distribution is closely related to the environmental characteristics of the creek systems. The study area, at Mileura Station, Cue, has been described in detail by Mabbutt

et al. (1963). It occupies about 900 square miles and covers the head waters of a major southern tributary of the Murchison River. Figure 1 is a diagrammatic section and plan of successive creek and wash systems starting in the highlands of the Sherwood or Koonmarra land systems, passing through the Ero system to the Berrigarra system of the main creek. The Belele land system forms a matrix dissected by the creeks and their associated land systems. Such a diagram is useful in a description of the habitat because the same format can be used for topography, precipitation, temperature, vegetation and animals.

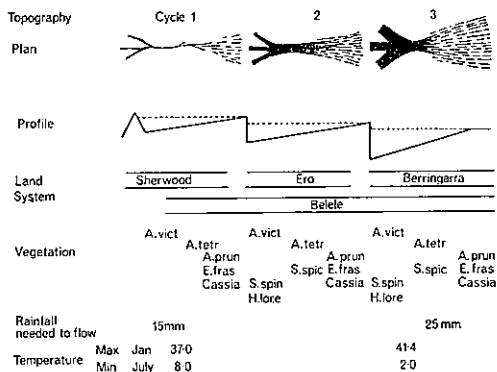


FIGURE 1

The environmental factors related to the ecology of native animals in the mulga lands of Western Australia. Abbreviations: A—*Acacia*; Cassia—*C. desolata* and *C. sturtii*; E. fras—*Eremophila fraseri*; H. lore—*Hakea suberea*; prun—*pruinocarpa*; Sant.—*Santalum spicatum*; S. spin—*Scaevola spinescens*; tetr—*tetragonophylla*; vict—*victoriae*.

For the purposes of this example it is useful to emphasise the way the structure of the creek systems is recurrent. In cycle* 1 the creeks flow away from their headwaters as narrow, well defined channels which soon branch, forming small flood plains between the branches. Later the channels become indistinct and the typical 'wash' habitat is formed, with few channels and a wide flood plain until this watercourse complex eventually runs into a larger channel of a cycle 2 creek. Figure 1 shows three successive cycles of this structure. At a sample site on Mileura cycle 1 occupies 5 km, cycle 2, 10 km and cycle 3, 34 km.

Slatyer's (1961) work in mulga lands near Alice Springs suggested that run-off began after 15 mm of rain. Mott's observations (1973) at Mileura indicate that significant run-off does not start on the Belele land system until 20 mm have fallen, although the creeks of cycle 1 certainly run after less rain than that. On the other hand the creeks in cycle 3 do not run until 25 mm have fallen. The capacity of the creek systems for storing rainfall is considerable and may be illustrated from the output of a water depth gauge placed in a creek of cycle 3. The bottom of the recording well was 750 mm below the sand surface. The main fall of rain (42 mm) fell on May 31 and the water level in the creek rose 540 mm. Another 5 mm fell on June 4, and the level rose 26 mm; from May 31 to June 6 the water depth fell rapidly to 160 mm above the level on May 30 as the superficial water ran down the channel and thereafter fell steadily until August 6 when the record ceased. By that time there were still 22 mm more water in the creek sand as free water than when the rain first fell, and this water was lying less than 750 mm below the surface, so that it would be available to most perennials

* 'cycle' is used here in a broad sense; it emphasises the repetition of similar habitats along a creek system.

and many annuals. In fact the creeks concentrate and store a significant quantity of the rainfall so that plants growing in or near them have much more available water than the 190 mm annual average would suggest.

There is an interesting temperature differential between the different areas. Thermograph records from sites near cycle 1 and cycle 3 creeks showed that the hills represented by cycle 1, always have lower maxima and higher minima than the main creek, represented by cycle 3. The hills are therefore less extreme habitats, less hot in summer and less cold in winter than the main creek. This difference appears to influence the productivity of animals and plants directly, as well as having an indirect effect on animals through its effect on vegetation productivity.

Not only the physical structure of the creeks but also the distribution of the vegetation exhibit a recurrent pattern, as illustrated by the nine shrub species noted on Figure 1. In each case the individual species are more abundant in successive cycles as one travels down the creek systems towards the river, but always occur in greatest abundance within each cycle at particular stages of it. In addition *Acacia aneura* (mulga) grows widely over the Belele land system matrix of the study area, and also occurs in the creeks and watercourses, although not dominant there in the way that it is on the plains.

Regular measurements of the productivity of some native shrubs have been made at Mileura over the past ten years. In general cycle 3 creeks are more productive than cycle 1 creeks, both relatively—because they receive and store much more run-off from rainfall—and absolutely—because the shrubs are more abundant there. But temperature can have limiting effects and in cold winters the young fruits of frost-sensitive shrubs, such as *Cassia sturtii* are killed in the cycle 3 creeks and this species then fruits most abundantly in the warmer cycle 1 areas. Productivity was usually directly proportional to rainfall but in certain years of exceptionally good rainfall the productivity of some shrubs, e.g. *Acacia tetragonophylla*; *Eremophila fraseri* was much lower than in less wet years because the heavy rainfall allowed a large hatch and survival of caterpillars which stripped the first generation of shoots from the plants. The inverted U-shaped nature of productivity-environmental variable relationships is often overlooked in arid areas.

The distribution of animals, which are mobile, does not follow the creek systems as closely as that of the plants. The productivity of animals, however, depends ultimately on the productivity of the vegetation and is usually greater in wet years than in dry ones, but flooding and lower temperatures in winter can negate the beneficial effects of heavy rain. Cycle 1 areas can then become better breeding grounds than cycle 3 areas, even though the latter will ultimately produce more food and be better maintenance habitats in the hot weather. Different parts of the creek systems may thus provide the best habitat for any given animal species at different times of the year and in different years. The importance of the creek systems as a whole is clear, and the abundance of mulga land organisms depends upon the condition of these relatively small areas of water concentration and storage.

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