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Makings of Icons: Alan Newsome, the Red Kangaroo and the Dingo

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The red kangaroo (*Macropus rufus*) and the dingo (*Canis dingo*) are two of Australia's iconic mammals. Both are ingrained in the national psyche and well known internationally. For the red kangaroo, recognition has come despite the fact that the highest densities of the species occur well away from most of the human population. The dingo has achieved its status despite being present on the continent for perhaps as little as 3,000 years. This article considers the question of how, and why, these two animals became so elevated in the popular imagination and the scientific literature. It is a story of both the integers and consequences of scientific research, a story best told with a particular focus on the contribution made by one individual. Alan Newsome changed our understanding of the interactions between agriculture, introduced species and native wildlife, and was one of the first to understand the possibilities of enriching western science with Indigenous knowledge. He was a pioneer in explaining—particularly by reference to the red kangaroo in central Australia—the remarkable story of how Australian wildlife has adapted to survive some of the harshest conditions on the planet. His work across the landscape of the arid zone has had profound implications for management and conservation in Australia. This, then, is the story of three icons: the red kangaroo, the dingo and Alan Newsome.

The Early Years of Kangaroo Research

Newsome's studies on the red kangaroo in central Australia between 1959 and 1962, while working for the Northern Territory Animal Industry Branch, coincided with the first field studies on macropods generally (Fig. 1). Research funding was made possible because pastoralists were concerned that kangaroos were competing with stock for resources.[1] Francis Ratcliffe, the founding chief of the CSIRO Division of Wildlife Research, laid the groundwork for a kangaroo program that was centred in the north of Western Australia.[2] It commenced in 1955 under the leadership of Harry Frith (who shortly thereafter became Chief of the Division), with John Calaby and George Dunnet as his first lieutenants.

As Brad Collis has recorded, Tim Ealey joined the kangaroo project in 1957, studying the euro (*Macropus robustus*) in the Pilbara region.[3] In 1959 Frith extended the focus to New South Wales and Queensland in studies later written up with Geoff Sharman.[4] Adding to this flurry of activity, Graeme Caughley studied the red kangaroo at the CSIRO sheep station, 'Gilruth Plains' in south-west Queensland as part of his Masters thesis at the University of Sydney.[5] Sharman joined the Division in 1962 to replace Frith in leading the research, although he departed in 1964 after butting heads with Frith.[6] Newsome himself joined the Division in 1966 after completing his Masters and PhD through the University of Adelaide.

Figure 1. Alan Newsome with red kangaroo in central Australia.

In addition to the CSIRO kangaroo project and Newsome's work in central Australia, the other early research into macropods were John Shield's studies on the quokka (*Setonix brachyurus*) on Rottnest Island and state parks on the mainland ~50 km south-east of Perth, through the University of Western Australia;[7] Richard Sadlier's studies on male fertility in the euro and red kangaroo between 1959 and 1961 on two pastoral leases in the Pilbara[8], also through the University of Western Australia;[9] and Tom Kirkpatrick's studies of eastern grey kangaroos (*Macropus giganteus*) in southern Queensland through the Queensland Department of Primary Industries.[10] Many other researchers soon conducted complementary studies. In particular, John Calaby, William Poole and Hugh Tyndale-Biscoe built on many of the early discoveries associated with reproduction in kangaroos.

The Key Questions

It is difficult to understate the amount of ecological understanding of kangaroos that existed at the time of these early studies. While the CSIRO's chief concern was the perceived over-abundance of kangaroos in pastoral areas and their deleterious effect on agriculture, a raft of basic ecological questions required attention before any meaningful assessment could be made of the actual interplay between kangaroos and agricultural endeavours.

For example, despite extensive mammal surveys by Hedley Finlayson over the previous 30 years, there was still at this time a basic question of identification and distribution: which species occurred, exactly and where? When Newsome arrived in 1958, red kangaroos were visibly abundant. Mobs of between 50 and 100 kangaroos were commonly reported on the open plains. Newsome himself recorded seeing one mob, just south of Alice Springs, numbering at least 1,500 strong.[11] However, there were popular reports of red kangaroos 'in millions' throughout the Northern Territory, even in the Top End (northern third of the Northern Territory), and that the eastern grey kangaroo was also abundant in these areas.

Early collecting trips solved the question of identification and distribution. The kangaroo sighted in the Top End proved not to be the red kangaroo, but rather the antilopine kangaroo (*Macropus antilopinus*). The grey-coloured kangaroos reported in the red centre were found to be female red kangaroos, whilst the grey-coloured kangaroos reported in the Top End were identified as the hill kangaroo or euro. While these answers proved relatively straightforward, the fact that such basic knowledge was only fully established in the 1950s is a valuable yard-stick against which to measure the extent of the ecological advances that came from the work of Newsome and others over the next twenty years. It was a remarkably productive and fascinating era for arid zone research.

Discovering the Reproductive Quirk

Newsome's studies of the red kangaroo coincided with one of the longest and driest droughts on record. That was the context in which Newsome worked out the answer to the first question baffling ecologists about the red kangaroo, that of their reproductive cycle and whether it was different between drought and more productive times.[12]

Previous studies in the 1920s had recorded somewhat incongruous and inconsistent observations. For example, Frederic Wood Jones, a British scientist and naturalist who spent considerable time in Australia, recorded some female red kangaroos with pregnancies lasting 30 to 40 days, but some females observed mating were found later with young so large as to indicate a considerably shorter gestation period. Further, one female gave birth after eleven months of separation from a male. To reconcile these results, Jones supposed that the female red kangaroo stores sperm in its genital tract, like bats. It is now well known how far off the mark that supposition was, but it took another 40 years before the reproductive cycle of the red kangaroo was described in full.[13]

The first major advances came from studies of captive animals led by Geoff Sharman, who found that mature females can breed continuously, producing three young approximately every two years.[14] As soon as a joey leaves the pouch permanently, at ~235 days, it is replaced in a day or so by a second joey. The rapidity was explained by Sharman's discovery of 'embryonic diapause' or 'delayed implantation': the second joey results from the implantation of a previously dormant blastocyst, a viable embryo that has been carried in the uterus for many months but the development of which has been arrested at the stage of the blastocyst.[15] The result is that two joeys, one in the pouch, and one running independently (a young-at-foot), can potentially be nurtured simultaneously until the young-at-foot is fully weaned (Fig. 2).

The field studies of Caughley[16] and of Frith and Sharman[17] in western New South Wales advanced the matter, finding that the death-rates of pouch young and young-at-foot were high during drought. Newsome's concurrent studies in central Australia similarly found high death-rates among the young during drought.[18] But Newsome's additional insight was his finding of a marked drop in birth rate during drought.[19]

Figure 2. Inspecting the pouch young of a red kangaroo in central Australia (circa 1958).

To explore this, Newsome conducted field studies in two areas in central Australia. The first was located on 'Yamba Station' in the Burt Plain ~50 km north of Alice Springs (Fig. 3). The second lay ~30 km to the north-west of Alice Springs, primarily on 'Hamilton Downs'. About every six weeks kangaroos were shot at night along transects ~45 and 65 km long. By the end of the study a total of 2,070 animals had been sampled, including 1,610 females and 460 males.[20] The age of each animal was estimated from their molar teeth, using a system developed by Sharman, Frith and Calaby.[21] The body of each animal was also weighed and sexed and the reproductive organs from sexually mature animals were removed and preserved for later examination under a microscope.

From the start of the sampling it was evident to Newsome that red kangaroos did not breed continuously in central Australia. He found that reproduction in red kangaroos was heavily dependent on weather. During drought, some adult females were found without young and with no sign of reproductive activity. Apparently,

Figure 3. Drought conditions on the Burt Plain, central Australia, in 1959.

pouch-young were dying during the drought and, after several attempts to rear young, reproduction ceased so that the female became sexually inactive or 'anoestrous'.

To understand the adaptive significance of the extraordinary finding that female red kangaroos can become anoestrous, it first requires an appreciation of mortality rates of young and the rate at which females become anoestrous during drought. For example, drought adversely affects the breeding condition of adult females as well as the survival of joeys. However, Newsome found that it takes about twice as long for the breeding conditions of females to deteriorate in comparison to the survival rates of joeys.[22] Thus, females can be expected to lose their pouch-young before they lose breeding condition. By doing so, breeding could continue well into drought allowing females to take immediate advantage of any improvement in conditions—a remarkable adaptation of a mammal to a drought-prone environment. Even more remarkable, if the female kangaroos entered 'anoestrous' due to prolonged drought, as soon as the drought-breaking rains fell and green herbage flourished once more, these 'anoestrous' females became sexually active and bred once again (they were now in 'oestrous' as if nothing had changed).

As was so often the case with Newsome's method of enquiry in arid Australia, one discovery about the ecology of his subject species revealed simultaneously another curiosity; another puzzle for science to resolve. In this instance, Newsome also noticed that few females became pregnant immediately after the drought-breaking rains, despite coming into 'oestrous'. Indeed, most pregnancies came about five weeks later. To Newsome, the delay in female pregnancy after drought seemed to be a major anomaly in his findings. As a matter of logic it seemed a wasteful process given that it resulted in loss of optimal breeding time.

The answer to the immediate question of why pregnancies were delayed proved to lie with the males, namely a defect in their sperm production. Newsome attributed this finding to heat exposure,[23] concluding that the hot summer of central Australia sterilised an increasing number of males as drought progressed, despite males attempting to keep their scrotums cool by licking them. This was the first report of heat sterilisation of a marsupial and, in combination with a lowered sexual drive in males, explained the high number of unmated females immediately after drought. But again, the explanation to one question only raised a further question: was reproductive failure an established characteristic of the red kangaroo that revealed itself as a matter of course when the desert climate was at its most harsh, or was there some other factor of more recent origin contributing to the heat sterilisation of male red kangaroos?

Linking Reproductive Failure to Habitat Alterations

A definitive answer to this last question came from Newsome's studies on the distribution and habitat preferences of red kangaroos.[24] To complete the first study, Newsome divided a 10,000 km^2 area in the plains country north of the MacDonnell Ranges into blocks corresponding to predominant landforms. Aerial surveys to estimate the numbers of kangaroos were completed between 1961 and 1962, and were timed so as to occur after six months of drought, and again six months later after good rains had fallen.[25] The surveys found that, during drought, when herbage was scarce in the broader mulga (*Acacia aneura*) woodlands, red kangaroos were mainly found in the fringing mulga trees close to the open plains and flood-out creeks where herbage was available. After the rains fell, the red kangaroos concentrated in the broader mulga woodlands where food was now available in addition to shelter. Thus, the red kangaroos were selecting habitats providing both food and shelter when they were available (Fig. 4). A repeat of the surveys four years later confirmed the results.[26]

What explained the reproductive anomaly in males was the selection of areas close to the open plains during drought. The availability of the selection in the first place, however, was attributable to the impact of pastoral endeavours on the landscape. Under a natural scenario, grasses in the open plains would sprout, mature and seed then completely dry off. But where cattle grazed the tall dry grass down, Newsome observed that it forced perennial grasses to tiller, creating a 'marsupial lawn' that attracted the kangaroos who favour green feed.[27] While this new 'marsupial lawn' and supplemental food source during drought enabled red kangaroos to extend their range greatly and increase recruitment into

Figure 4. Three red kangaroos taking refuge in the shade in central Australia (circa 1960).

the population, it also resulted in the impaired spermatogensis in males: as red kangaroos ventured into the open plains away from shelter in order to forage, they were fully exposed to the unrelenting heat accompanying this previously unavailable food source.

Raising the Profile of the Red Kangaroo

This work of Newsome and others on the red kangaroo brought national and international attention to the species. These were ground-breaking ecological discoveries that raised the profile of the red kangaroo. Attention was drawn first because of the novelty of the findings from an ecological perspective; second, because of the implications of the research for the interests of the pastoral industry in central Australia; and third, because of the potential application of the research to other macropods, particularly in different landscapes.

Newsome's own application to the euro of the insights gleaned from the red kangaroo is an apt example of the third matter. In the Pilbara Region in Western Australia the euro had been implicated in the demise of the sheep industry. There, sheep grazing and the availability of artificial watering points greatly enhanced the landscape to favour the euro. The increased availability of water meant that euros were no longer restricted to sheltered habitats in the hills. Euros could now survive out in the unsheltered open. But, as Newsome explained, as euro numbers increased, the combined effect of grazing by both the introduced flocks of sheep and the artificially increased number of euros led to overgrazing of the nutritious grasses. As the less nutritious spinifex (*Triodia pungens*) took over, particularly on scythed land, the euro could easily outcompete sheep because they could manage to survive better on this hard spinifex diet.[28]

While this outcome confirmed the suspicion of pastoralists implicating the euro in the demise of the sheep industry, it was a more nuanced explanation than what had originally been suspected. The increase in euro numbers in the Pilbara was directly attributable to habitat alterations by humans. The finding was not only significant in itself, but also an important chapter in the story of the red kangaroo. It demonstrated the facilitative effect that research on the red kangaroo had on explaining interactions between species in other landscapes.

What Made these Early Insights Possible?

Whilst 1955 marked a turning point in the quantity and financing of field studies and research directed specifically to macropods in Australia, an important body of other material was integral to the success of this new period of wildlife research. Newsome was particularly well suited to a cross-disciplinary approach. In a job that would be the envy of any early-career ecologist today, he at one point had a brief to travel around the Northern Territory with George Chippendale and Des Nelson (both botanists) exploring fauna and flora.

One sees reflected in Newsome's published work the realisation that the tale of the ecology of a species can only properly be told in conjunction with that of the history of the landscape. Unsurprisingly, Newsome's work drew heavily upon the work of Chippendale, who had found that green herbage was the dominant food of red kangaroos.[29] He also derived assistance from the works of the early explorers. The opening of a paper published in the *Quarterly Review of Biology* in 1975 is a particularly poetic example:

> Our concept of the primeval state of Australia's inland plains depends on the journals of European explorers of the early and mid-19th Century and other similar documents. The true deserts were condemned as unrelentingly harsh, but the explorers and scientists used such terms as 'well grassed' or 'splendidly grassed' to describe Australia's inland plains. Small wallabies (probably *Lagorchestes*), which are now rare, leapt out from beneath their horses' hooves; and the scientists found the fauna diverse and most species readily obtainable. A virginal state of nature prevailed.
>
> The release of ruminant stock onto these pastures came soon after the exploration by Europeans. Sheep and cattle were grazed first about the permanent rivers and waterholes, expanding away from them as artificial waters were created. At first, livestock can have made little impression on the rangelands, for there were too few of them and the land too vast. The first obvious changes, trampling and denudation, would have been around natural water-holes, some of which eventually silted up, although they had lasted till then under the utilization of Aboriginal man and the native fauna …
>
> It would be surprising if the endemic fauna of inland Australia had not been affected also. Indeed, such appears to have been the case. On the one hand, the ranges of some small to medium-sized marsupials have dwindled since European invasion, and some species are perhaps extinct. On the other hand, the large marsupial herbivores, just those species which it might have been thought would meet with severe competition from the alien ruminants, appear to have prospered under the new order.[30]

To this more traditional mix of sources, Newsome added an appreciation of the value of Indigenous knowledge to western ecological enquiry. Two of his most enduring contributions were made possible only because of the links he developed with the Indigenous occupants of the land (Fig. 5).

The first of these, made in combination with Geoff Sharman, occurred early in Newsome's career. During a trip in 1958 the duo saw a sand dune in the middle of the Tanami Desert. As they had not known there to be sand dunes out there, its appearance piqued their curiosity. Even more so when, approaching the dune, they were confronted with a scene that Newsome later described in an interview with Ken Johnson in 1996 as being 'just like Martin Place with tracks of small wallabies the whole length of the blessed thing'.

Newsome and Sharman did not recognise the tracks. Nor were they expecting a wallaby to be so common in the area. As Newsome explained to Johnson, at that time 'nobody was talking about small wallabies' in central Australia. Newsome and Sharman spent the night out on the dune, hoping that having dug a few big holes, that they would catch one. To this they added spotlighting every couple of hours until ~3 a.m., though they had no success. Yet when they awoke at sunrise, 'there were tracks all around us, round our swags, there were tracks all round our holes—none of them had fallen in—none of them had been so stupid'. The pair drove ~100 km to Old Mt Doreen Station to obtain the assistance of an Aboriginal tracker Newsome knew out there. On inspecting the tracks he—a man named Murray—took no time at all to identify the animal. He simply said: 'that's mala, that one'.

That was an astonishing answer. In the scientific community at that time, the mala (or rufous hare wallaby (*Lagorchestes hirsutus*))

Figure 5. The Indigenous connection: Alan Newsome and 'Long Jack' with emu (left panel) and community members from Haasts Bluff, central Australia (right panel) (circa 1958).

was thought to be very uncommon and possibly extinct. What happened next left no room for doubt: tracking one for ∼100 m, Murray suddenly gave out a cry and a mala leapt out from under his feet and tore off down the scrub. Indeed, it was not just the mala that Murray showed Newsome and Sharman. When Newsome later started to ask questions about other animals, Murray showed him the tracks of a spectacled-hare wallaby (*Lagorchestes conspicillatus*), a bilby (*Macrotis lagotis*) as well as a golden bandicoot (*Isoodon auratus*). As with the mala, the scientific community at that time had believed the golden bandicoot was also very uncommon, with a desperate status. There was also mention of a third wallaby, but the species was never confirmed.

These are the kinds of encounters that define a career. It cemented Newsome's career-long interest in, and respect for, the knowledge of Indigenous people to his own scientific enquiries and conservation efforts. Indeed, the early discoveries were instrumental in establishment of the Tanami Wildlife Sanctuary (∼37,530 km^2), which Newsome had campaigned for.

Exploring the Deeper Connections between Legend and Science

Perhaps the most celebrated example of Newsome's ability to blend Indigenous learning with Western science was a paper that, ironically, was one of his hardest to have published. The 1980 paper, 'The eco-mythology of the red kangaroo in central Australia'[31] recorded the congruence of Aranda (or Arerrnte) mythology with the ecological 'reality' of red kangaroos.

The paper was years in the making. To unravel the story of the red kangaroo, Newsome first studied the extensive works of Ted Strehlow. Strehlow had documented the sacred songs and creation legends of tribes in central Australia. Newsome's interest was in what these songs had to say about animals and plants. Combining published maps with the contents of the songs published by Strehlow, Newsome searched for the red kangaroo totemic sites. In 1969 he met with Strehlow in Adelaide.[32] Strehlow, however, was circumspect and did not reveal much on the location of *Krantji*, the most sacred of all the totemic red kangaroo sites. Newsome later recorded his own suspicion that Strehlow was 'cautious, probably because he thought I had worked out too much'.[33] In the 1970s Newsome managed to find *Krantji* himself, along with many other totemic sites associated with the red kangaroo dreaming. Patterns and ideas started to emerge, but it took Newsome another seven years and the linguistic capabilities of Ken Hale, an American professor then living in Alice Springs, to fully realize the possibility of a link between the mythological and ecological perceptions.

In Aranda mythology, the 'ara' or 'arara' (the Aranda peoples' colloquial name for the red kangaroo) had both an overland and supernatural journey. The totemic sites were part of the overland journey; a journey that crossed what Newsome identified as the very best of the ara's habitat and largely reflected the reality of the distribution of red kangaroos. Of the 14 totemic sites Newsome identified, 10 overlapped with the locations his earlier studies had recognised as the prime refuges for red kangaroos. On the other hand, as to the supernatural journey, this mostly

Figure 6. Aboriginal men with red kangaroo in central Australia (circa 1960).

corresponded with what Newsome identified as the very worst kind of habitat for red kangaroos: vast, unrelenting, desert so inhospitable that in reality it precluded the red kangaroo's passage. Hence the congruence of the ara's song with ecological reality: 'whether the totemic ancestors travelled overland or supernaturally (underground, or on big winds) is related to the favourability or otherwise of habitats between totemic sites'. To Newsome, this congruence between reality and myth was evidence that the Aboriginal people who created these legends were well acquainted with the ecology of the red kangaroo.[34] The traditional prohibition on hunting near totemic sites was also identified as being of ecological significance. The prohibition had the effect of protecting the red kangaroo in and around its best habitat. From an ecological perspective that custom gave the species the very best chance of survival during drought, a type of conservation reserve around prime habitat.[35] Thus, while the red kangaroo had always been iconic in Indigenous culture, Newsome's work brought the power and importance of Indigenous myth and associated land management techniques into the mainstream understanding of the species.

Newsome's conclusion 'that myth may have an underlying ecological rationale' was controversial at the time, though it stood the test of time. It was the first time the congruence between ecological principles and Indigenous myth had been documented. The paper became another cause for the elevation of the red kangaroo in the popular and scientific consciousness, this time because the eco-mythology of the red kangaroo represented the possibility of enriching western science with Indigenous knowledge, and conversely, attributing ecological insight to Indigenous myth (Fig. 6).

Bigger Conflict; Greater Attention

At the time of Newsome's work on the red kangaroo, central Australia was a landscape in rapid and obvious transition due to the introduction of the pastoral industry to that area only some 30 to 40 years before. Newsome's findings on the impacts of pastoralism on the availability and dispersion of resources for red kangaroos, and consequently on the abundance and distribution of the species, were early examples of his interest in interactions at a landscape scale. The direction of Newsome's research over the next few decades, and indeed the work that contributed

Figure 7. A dingo in central Australia (circa 1960).

to the rising profile of the dingo, was symptomatic of that thirst for what might be termed the 'landscape's logic'.

A focus on the broader impacts of pastoralism on the ecology of central Australia quickly brought the eye of Newsome and his colleagues at CSIRO Wildlife Research to the role of predators. The hypothesis was that the serial changes to the grasslands that Newsome had witnessed (and which were operating to the benefit of the red kangaroo), were destroying the habitat of many other smaller marsupials. The suspicion was also that these effects were compounded by competition with the introduced wild rabbit (*Oryctolagus cuniculus*) and predation by the European red fox (*Vulpes vulpes*) and feral cat (*Felis catus*). However, the dingo was the real quandary in this ecosystem mix: as a predator, it could have played a role in small mammal declines, but its existence on the mainland before European settlement pointed to a more complex interplay of interactions (Fig. 7).

As with the red kangaroo, while the ecological role of the dingo was sufficiently intriguing by itself to warrant study, the commercial incentive for this next phase of scientific research depended on the concerns of industry. Dingoes were considered a pest by the pastoral industry and, as such, were subject to widespread control. For example, a Dingo Destruction Ordinance had been in force in the Northern Territory since 1924. Professional doggers were employed to destroy dingoes on pastoral lands. A bounty system also encouraged landholders to conduct their own control.[36] The concerns of pastoralists led to the Australian Meat Research Committee providing the monetary backing for what would become a 10-year long dingo project with a primary focus on central Australia. Newsome spearheaded the project with Laurie Corbett, Peter Catling, Brian Green, Lindsay Best and Andy Shipway. Many field assistants and collaborators also contributed greatly to the work.

The Control of Dingoes in Central Australia

At the commencement of the dingo project in the mid 1960s, an obvious starting point was to assess the effectiveness of existing management regimes. Although aerial baiting was at that time advocated as the best method to control dingoes based on experiences in New South Wales and Queensland, there was no evidence to suggest that they were effective in reducing dingo numbers in central Australia.[37] For example, had the Northern Territory been baited in 1960, great success could have been claimed because scalp returns over the next eight years dropped from 8486 to 4024. However, this coincided with the worst drought on record, so dingo numbers would have declined irrespective of the control effort.[38]

To address the question of whether or not aerial baiting reduced dingo numbers in central Australia, Newsome led a study in 1968 on 43,156 km^2 of central Australia, covering 17 different cattle stations.[39] The abundance of dingoes on properties where aerial baiting took place was compared with that on unbaited properties. Population size was quantified based on the number of tracks found around waterholes. The data were based on three surveys of each area: one undertaken immediately before the aerial baiting campaign, and two undertaken afterwards.

The results from the study suggested a 3-fold increase in dingo numbers on properties where aerial baiting took place, whereas dingo numbers remained relatively constant on properties that were not baited. Thus, the aerial baiting campaign against dingoes appeared to be a failure. The cause of that failure, however, was open to some conjecture and the study demonstrated that many factors could potentially influence the efficacy of aerial baiting campaigns. The abundance of prey available to dingoes in good seasons could have affected the results. Some poison baits did not weather well and may have been unpalatable to dingoes. Local environmental conditions, such as water availability, may also have contributed to variable results between properties.

However, after the publication of this analysis in 1974, and despite its clear import that aerial baiting may not yield the desired results, there did not appear to be any changes in attitudes towards the use of aerial baiting campaigns against dingoes. By 1979, 80% of all Northern Territory pastoral properties had been involved with aerial baiting programs.[40] The disjunct between the lessons of ecological study and agricultural practice is a stark example of the depth of the pastoral industry's misgivings about the dingo at this time. Further, the extent of the baiting is indicative of the prominence the pastoral industry gave to the dingo above all other species of Australian fauna. While the dingo's elevation in the popular psyche was integrally connected with its perceived status as a threat to pastoral endeavours, its elevation in the scientific world was ironically the opposite: these early studies flagged a complex interplay of interactions that were richly worthy of further study. The first such question was: what exactly is a dingo?

The Dingo Identity Crisis

Interest in the seemingly banal question of 'what is a dingo?' was not unique to the scientists of the 1960s and 1970s. Even before 1900 there had been interest in the origin and identity of the dingo, albeit primarily inspired by man's close association with, and study of, domestic dogs. In the Proceedings of the Royal Irish Academy (1836–69) there is mention of a comparative study of the muscular anatomy of an Irish terrier and a greyhound, as compared with an Australian dingo (that was a resident in the Zoological Gardens of Dublin at the time). Based on the analysis the dingo was thought to be closely related to the Irish terrier, but different from the greyhound. (The conclusions have long since lost any further relevance, but the recording of the study's outcome remains instructive. The subject dingo died during the study, apparently by what was perceived to be his own misconduct. Having devoured his four pups for breakfast, he was promptly throttled by the mother, 'as if she herself would have been killed if she did not anticipate him'.[41])

The dingo origin and identity question remained of interest to science over the next few decades. A piece published in *The American Naturalist* in 1906 linked the arrival of the dingo on mainland Australia with the extinction of the Tasmanian tiger (*Thylacinus cynocephalus*) and devil (*Sarcophilus harrisii*).[42] Another piece, this time in 1923 in the *Journal of Mammalogy*, featured the dingo as part of a dataset on coat colour variations in wild animals.[43] A short note in *Nature* in 1932 also makes it apparent that dingoes were known to interbreed with other canids by at least the time of that publication. The note describes pairing between a male European wolf (*Canis lupus*) and a female Australian dingo in the Adelaide Zoological Garden that resulted in a litter of six hybrid pups.[44] A piece in *Science*

Figure 8. Peter Hanisch boiling dingo skulls collected from 'Brunette Downs' station in preparation for skull morphology analysis (circa 1970).

in 1942 also described dingoes and dingo-dog hybrids acting as scavengers around Aboriginal camps.[45]

A review of these early references to the dingo in the scientific literature indicates that before the mid-twentieth century, the dingo had not yet generated the kind of scientific interest that nowadays attaches to its name. A substantial shift in that state of affairs was caused by the long series of studies undertaken by Neil Macintosh at the University of Sydney on the origin and identity of the dingo, commencing in 1949.[46]

Macintosh estimated that dingoes had been present on the mainland of Australia for at least 3,000 years, but perhaps as long as 8,000.[47] He also developed a method to differentiate between dingoes and domestic dogs via comparisons of skull morphology using a large array (120) of measurements.[48] The fact that dingoes were known to successfully interbreed with domestic dogs caused much uncertainty about their identity. By 1975 the dingo had acquired various taxonomic names, including *Canis antarcticus, C. familiaris* and *C. f. dingo*.[49]

Newsome and his colleagues sought to resolve the problem of dingo identity through a series of studies.[50] The first study aimed to separate dingoes and domestic dogs using a new set of skull measurements. To undertake the study, 50 adult dingoes were caught in remote parts of central Australia (remote areas were targeted in an attempt to sample pure populations; i.e. away from humans who keep domestic dogs) (Fig. 8). Forty-three similar sized dogs were also collected from the Canberra pound to provide a representative sample of domestic dogs. Skull morphology from both populations were then compared and contrasted.

Harry Wakefield was acknowledged in the subsequent publication for undertaking the 'most tedious task' of measuring the great majority of skull variables.[51] One can only imagine the patience he must have possessed. In the end, a new set of 15 skull characteristics was chosen to best discriminate dingoes and domestic dogs. The basic differences were that dingoes had longer muzzles, larger bullae and main teeth, longer and more slender canine teeth, and flatter crania with larger nuchal crests. All these characters had functions related to predation efficiency.[52]

Overall, the differences between the skulls of dingoes and domestic dogs were clear-cut, even when comparisons were made with just 15 measurements. This supported the taxonomic classification of the dingo as separate from domestic dogs. It is somewhat ironic then that, at the very point when science confirmed the separateness of the dingo from the domestic dog, it was coming under increasing threat of losing that identity because of hybridisation.

The second study on 'dingo identity' was therefore directed at exploring the nature and extent of hybridisation. In the late 1960s and early 1970s, it was known that domestic dogs were free-roaming in south-eastern Australia and that they were potentially breeding with dingoes, although the possibility of hybridisation in the wild had been variously asserted and denied. The dingo project undertook a captive breeding program in Alice Springs over six years (1969–75) to establish whether hybridisation was in fact possible, and, if so, to quantify its prevalence (Fig. 9).

From a historical perspective, the methodology accompanying the breeding program is of interest. The original breeding stock comprised five pups caught in central Australia and two pups caught in remote South Australia. Upon reaching adulthood, the breeding stock was bred first for purity of line, and then the offspring were crossed with domestic dogs. Measurements were taken from the hybrid skulls and compared with a sample of 50 skulls from south-eastern Australia (where hybrids possibly existed) and 50 skulls from central Australia (where mostly pure dingoes were thought to exist).[53] In a concurrent study, a further 1,184 skulls were collected from seven regions of the Northern Territory between 1966 and 1976. Those skulls were then compared to 407 skulls collected from regions in south-eastern Australia. The coat colours of animals determined to be hybrids on the basis of skull morphology, were then compared and contrasted with those determined to be dingo.[54]

The key results from the studies were that (i) dingoes can and do breed with domestic dogs and could produce hybrids in the wild; (ii) hybrids are also fertile and can produce offspring, and (iii) that the hybrid-bred animals closely resembled the samples collected from south-eastern Australia. This confirmed the presence of free-roaming hybrids in the south-east, and also established that no reason of genetics would preclude breeding between the dingo and domestic dog in the wild. Based on the broader morphological study, 97.5% of skulls collected from remote inland Australia were dingoes, whereas only 55.3% of skulls collected from south-eastern Australia were classed as dingo. This further suggested that most hybrids were located close to human settlements, whereas dingoes dominated remote inland Australia. Moreover, the great majority of dingoes in central Australia were ginger in colour, whereas in south-eastern Australia only about half were ginger. There were also other 'non-standard' colour forms such as black, brown and bluish found in south-eastern Australia, but not in the populations sampled in central Australia.

The research concerning 'what is a dingo?' certainly contributed to the increasing prominence of the dingo in the scientific literature. It is a matter of speculation whether it also contributed to the elevation of the dingo in the popular imagination, though arguably it did through the knowledge that 'pure' dingoes still existed in remote inland Australia. That the work was published around the same time as the infamous death of Azaria Chamberlain on the night of 17th August 1980 no doubt also contributed to interest in the results. It was never determined if it was a dingo, domestic dog or dingo/dog hybrid that took the baby, but the dingo took the blame.

Predator–Prey Interactions

The focus of the morphological and breeding studies explained above went to the identity question of 'what is a dingo'. The obvious corollary in the context of research directed to making evidence-based management recommendations is a question of function: 'what does the dingo do?' The CSIRO dingo project considered the functional question by assessing interactions between dingoes and prey in a series of studies conducted in south-eastern and central Australia. These studies ultimately impacted on how dingoes came to be perceived among both the scientific and the pastoral community.

The first detailed insights came from a long-term study that tracked dietary preferences of dingoes to changes in prey availability. The study was undertaken between 1971 and 1980 in south-eastern Australia at Nadgee Nature Reserve and

Figure 9. Harry Wakefield feeding the captive dingo population in Alice Springs in 1968.

Kosciuszko National Park.[55] The study sought to address three questions: (i) what is the nature of the relationship between the incidence of prey in dingo diet and its abundance in the wild, (ii) how does the relationship change with fluctuations in prey abundance and (iii) do the numbers of dingoes respond to changes in prey availability?

The key results from the study were that native mammals form the majority of dingo diet, but in selecting animals to consume, the dingo is opportunistic and hunts prey that is available. For example, as water-birds became abundant in the study area, dingoes started to eat them. An increase in dingo numbers also coincided with water-birds becoming super-abundant. This suggested that dingoes can respond, both through dietary selection and in numbers, to changes in availability of different types of prey.

In a seven-year study at Erldunda Station in central Australia between 1968 and 1974, the dataset again suggested that dingoes shift their diet depending on prey availability.[56] The study commenced after great rains broke a long drought, causing eruptions of rodents and then rabbits. The dingoes shifted their diet when rodents and rabbits became available. As drought began to set in again and the availability of smaller prey declined, dingoes switched to eating larger prey with an initial emphasis on red kangaroos and then cattle (mostly carcasses).

One further contribution made by these studies to the scientific and popular perception of the dingo is particularly noteworthy. While the dataset suggested that dingoes switch their prey depending on availability, the major outlier concerned rabbits. For example, at Erldunda, dingoes appeared always to target rabbits, irrespective of rabbit abundance. Although this apparent preference for rabbits was in stark contrast to many other dingo diet studies at the time,[57] if correct, this result suggested that dingoes potentially could inhibit rabbit population growth, primarily by eating the young as soon as they emerged from the burrow.[58] Further, the finding that, during drought, dingoes exhibit a preference for red kangaroos, was evidence that dingoes also have a role in controlling red kangaroo abundance, and in particular, contributing to the scarcity of red kangaroos during drought. It was from these studies that the hypothesis was born that dingoes can suppress rabbit populations after drought, and red kangaroo populations during drought.

In the early 1980s, an opportunity arose to test the hypothesis that predators could suppress prey populations after they collapsed during drought. The site for the study was Yathong Nature Reserve in central New South Wales, a place where rabbit numbers had exploded before drought.[59] Before the drought, rabbit counts were as high as 5,580 along an 18 km transect.[60] As the ensuing dry conditions set in, rabbit numbers collapsed in the space of four months by $>99\%$.[61] These were ripe conditions in which to test whether predators (in this instance the red fox and feral cat) could delay rabbit population recovery after its collapse from drought.

To complete the experiment, red foxes and feral cats were persistently shot over an area of 70 km^2. Rabbit numbers at that site were then compared to two other areas (respectively, 180 and 50 km^2 in size) where no control took place. Fourteen months after the first rains, rabbit counts were more than four times higher on the treated site than on the untreated sites. On the treated site, rabbit numbers were on their way to an eruption in the absence of predators. On the untreated sites, rabbit numbers remained low for the duration of the period between droughts (a period of 2.5 years). These results supported the hypothesis that predators could regulate prey by suppressing recovery in prey abundance after drought. It was described as 'environmentally modulated predation' given that predation could only limit population recovery after its initial collapse during drought.[62] In other words, for rabbits, it appeared that a drastic reduction in their numbers brought on by drought was necessary before regulation by predators ensued.

From a pastoral perspective, the important contribution made by the Erldunda and Yathong studies was the controversial possibility that dingoes could be an ally to the pastoral community who were suffering from excessive rabbit and red kangaroo numbers. As Newsome later noted during *The Symposium on the Dingo*, held in 1999, the predator–prey work at Erldunda was the first set of data to indicate that predator–prey relationships actually matter.[63] Once the importance of such relationships was recognised, albeit with their full complexity yet to be appreciated, it made it all but inevitable that the status of the dingo as Australia's largest mammalian predator would be elevated in the popular and scientific imagination.

It is now known that the ecological role of the dingo is a dynamic one. These early studies by the CSIRO Division of Wildlife Research laid the groundwork for decades of further research that sought to identify further the other elements of that role. One particularly significant study was conducted in the 1970s and 1980s and was later published in 2001 by Newsome and co-authors Peter Catling, Brian Cooke and Robert Smyth under the provocative title: 'Two ecological universes separated by the dingo barrier fence in semi-arid Australia: interactions between landscapes, herbivory and carnivory, with and without dingoes'.[64] The study had several aims, but of particular relevance to understanding the ecological role of the dingo were the patterns and distribution of fauna on either side of the dingo barrier fence (Fig. 10).

The study took advantage of the artificial divisions created by the fence in respect of dingo distribution. To complete the study, aerial and ground surveys of selected fauna were undertaken either side of the dingo fence in the western division of New South Wales and eastern South Australia. This provided the experimental basis to compare the distribution of fauna in areas with and without dingoes. The key results were that kangaroos, feral goats (*Capra hircus*) and pigs (*Sus scrofa*) were found in New South Wales, but they were virtually absent in South Australia where dingoes were common. Emus (*Dromaius novaehollandiae*) and red foxes were also more abundant in New South Wales where dingoes were uncommon. Thus, as suggested in the title of the paper, a series of ecological interactions existed with different functioning on either side of the dingo fence (Fig. 11).[65]

The broader implications of the study were that dingoes could not only regulate numbers of rabbits and red kangaroos, but possibly other vertebrate pests such as goats, foxes and pigs. Unsurprisingly, Newsome used the results from the dingo fence study to support his argument that the dingo had an important ecological role to play by suppressing numbers of various prey species. Indeed, Brad Collis noted that Newsome 'spent years talking to pastoralists, persuading them that the dingo was in fact their ally against foxes, cats, rabbits and excessive kangaroo numbers' and that 'over time, most Northern cattlemen came to accept his arguments'. On the other side of the dingo fence in New South Wales, where sheep are predominantly run it was a different story, with most scientists acknowledging

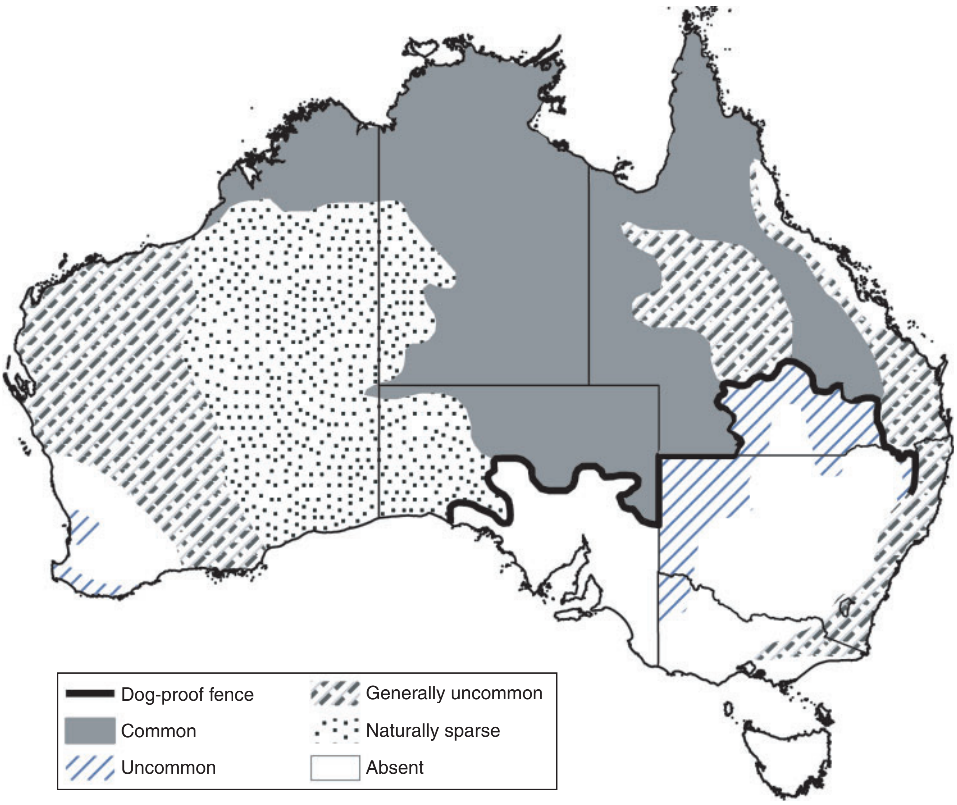

Figure 10. The distribution of dingoes in Australia in relation to the dingo (dog-proof) fence. The fence was erected in the late 1890s and early 1900s and was later "dingo proofed" in an attempt to protect sheep against attacks by dingoes. It is now approximately 5,500 km long. Sheep are predominantly run on the 'inside' of the fence (New South Wales side) whereas cattle are predominantly run on the 'outside' (northern Queensland and northern South Australian side).

that dingoes and sheep do not mix. Nonetheless, it was a remarkable turn-around in perceptions in central Australia given that, when Newsome commenced his work, dingoes were a widely controlled species and considered vermin. The body of scientific research accumulated and disseminated by Newsome and his colleagues in just a few decades had had the effect that, at least in central Australia, the dingo was seen as having a place in the modern human world.

Enduring Icons

The red kangaroo is Australia's largest marsupial. The dingo is its largest mammalian predator. The profile of both, however, derives not merely from their size, but from the complexity of their ecological role in both the Aboriginal and the settler managed landscape. The red kangaroo and dingo are two species that first captured the sustained attention of scientists because of perceived conflicts with humans, and it was in each case the concerns (and funding) of industry that enabled ecologists to uncover the remarkable story of their ecological roles. Over the course of twentieth-century research, both the red kangaroo and dingo proved to be controversial among scientists, conservationists and pastoralists alike. In that process they found a national profile that endures well beyond the legacy of any one researcher. Indeed, since the publication of the early work on red kangaroos and the dingo by CSIRO Wildlife Research, the literature on both species and their scope has exploded.

The red kangaroo has continued to capture the imagination of scientists through its remarkable

Figure 11. The dingo fence at 'Camerons Corner' where the boundary of Queensland, South Australia and New South Wales meet (circa 1977).

Figure 12. Alan Newsome (2001).

adaptations for survival in variable environmental conditions. The dingo continues to be at the centre of public and scientific debate on a range of issues associated with its ecological role. However, the contribution made by Alan Newsome is integral to the story of these icons. His contribution to the popular and scientific imagination about these animals was immense. He was a visionary, able to see the vastness and complexity of the landscape. Sadly too, he saw the impossibility of fully reconciling the conflicts between human demands and their environment. Newsome wrestled with the seemingly impossible task of saving many of Australia's unique animals from extinction as the impacts of introduced foxes, cats, rabbits, sheep and cattle took their toll on the landscape. Thus he left us, as contemporary custodians of the environment, with the challenge of finding a balance between conservation and eradication (Fig. 12).[66]

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References

1. C. Hugh Tyndale-Biscoe, *Life of Marsupials*, (Collingwood, 2005), p. 315.
2. Brad Collis, *Fields of Discovery: Australia's CSIRO* (Sydney, 2000), p. 89.
3. Brad Collis, op. cit. (n. 2), p. 89; Tim Ealey, 'The biology of the euro', Ph.D. Thesis, University of Western Australia (1962).
4. Harry Frith, 'Mobility of the red kangaroo, *Megaleia rufa*', *CSIRO Wildlife Research*, 9(1) (1964), 1–19; Harry Frith and Geoff Sharman, 'Breeding in wild populations of the red kangaroo, *Megaleia rufa*', *CSIRO Wildlife Research*, 9(1) (1964), 86–114.
5. C. Hugh Tyndale-Biscoe, 'Graeme James Caughley 1937–1994, '*Historical Records of Australian Science*, 12(3) (1999), 363–381, p. 366; Graeme Caughley, 'The comparative ecology of the red and grey kangaroo', MSc Thesis, Zoology Department, University of Sydney (1962); Graeme Caughley, 'Social organization and daily activity of the red kangaroo and the grey kangaroo', *Journal of Mammalogy*, 45(3) (1964), 429–436; Graeme Caughley, 'Density and dispersion of two species of kangaroo in relation to habitat', *Australian Journal of Zoology*, 12(2) (1964), 238–249; Graeme Caughley and R. I. Kean, 'Sex ratios in marsupial pouch young', *Nature*, 204 (1964), 491.
6. Brad Collis, op. cit. (n. 2), p. 89.
7. John Shield, 'Aspects of the field ecology of the quokka (*Setonix brachyurus* Quoy and Gaimard)', Ph.D. Thesis, University of Western Australia (1958).
8. Richard Sadlier, 'Fertility studies of Macropods', Ph.D. Thesis, University of Western Australia (1961).
9. Richard Sadlier, 'Reproduction in two species of kangaroo (*Macropus robustus* and *Megaleia rufa*) in the arid Pilbara region of Western Australia', *Proceedings of the Zoological Society of London* 145(2) (1965), 239–261.
10. Tom Kirkpatrick, 'Studies of Macropodidae in Queensland. 1. Food preferences of the grey kangaroo (*Macropus major* Shaw)', *Queensland Journal of Agricultural and Animal Science*, 22 (1965), 89–93; Tom Kirkpatrick, 'Studies on Macropodidae in Queensland. 2. Age estimation in the grey kangaroo, the red kangaroo, the eastern wallaroo and the red-necked wallaby, with notes on dental abnormalities', *Queensland Journal of Agriculture and Animal Science*, 22 (1965), 301–317; Tom Kirkpatrick, 'Studies of Macopodidae in Queensland. 3. Reproduction in the grey kangaroo (*Macropus major*) in southern Queensland', *Queensland Journal of Agricultural and Animal Sciences*, 22 (1965), 319–328.
11. Alan Newsome, unpublished manuscript (1974), forthcoming 2015 (CSIRO Publishing).
12. Alan Newsome, 'Anoestrus in the red kangaroo *Megaleia rufa* (Desmarest)', *Australian Journal of Zoology*, 12(1) (1964), 9–17; Alan Newsome, 'Oestrus in the lactating red kangaroo', *Australian Journal of Zoology*, 12(3) (1964), 315–321.
13. Alan Newsome, op. cit. (n. 11).
14. Geoff Sharman, 'The female reproductive system in the red kangaroo, *Megaleia rufa*', *CSIRO Wildlife Research*, 9 (1964), 50–57; Geoff Sharman and Phyllis Pilton, 'The life history and reproduction of the red kangaroo (*Megaleia rufa*)', *Proceedings of the Zoological Society of London*, 142(1) (1964), 29–48; Geoff Sharman and John Calaby, 'Reproductive behaviour in the red kangaroo, *Megaleia rufa*, in captivity', *Wildlife Research*, 9 (1964), 58–85.
15. Alan Newsome, 'Reproduction in natural populations of the red kangaroo, *Megaleia rufa* (Desmarest), in Central Australia', *Australian Journal of Zoology*, 13(5) (1965), 735–759, p. 736.
16. Graeme Caughley, 'The comparative ecology of the red and grey kangaroo', MSc Thesis, Zoology Department, University of Sydney (1962); Graeme Caughley, 'Density and dispersion of two species of kangaroo in relation to habitat', *Australian Journal of Zoology*, 12(2) (1964), 238–249.
17. Harry Frith and Geoff Sharman, 'Breeding in wild populations of the red kangaroo, *Megaleia rufa*', *CSIRO Wildlife Research*, 9(1) (1964), 86–114.
18. Alan Newsome, op. cit. (n. 12).
19. Alan Newsome, op. cit. (n. 15), p. 736.
20. Alan Newsome, op. cit. (n. 15), p. 739.
21. Geoff Sharman, Harry Frith and John Calaby, 'Growth of the pouch young, tooth eruption, and

age determination in the red kangaroo, *Megaleia rufa*', *CSIRO Wildlife Research*, 9 (1964), 20–49.
22. Alan Newsome, op. cit. (n. 15), p. 756.
23. Alan Newsome 'Cellular degeneration in the testis of red kangaroos during hot weather and drought in Central Australia', *Journal of Reproduction and Fertility', Supplement* 19 (1973), 191–201.
24. Alan Newsome, 'The abundance of red kangaroos, *Megaleia Rufia* (Desmarest), in Central Australia', *Australian Journal of Zoology* 13(2) (1965), 269–287; Alan Newsome, 'The distribution of red kangaroos, *Megaleia rufa* (Desmarest), about sources of persistent food and water in central Australia', *Australian Journal of Zoology*, 13(2) (1965), 289–300; Alan Newsome, D. R. Stephens, and A. K Shipway, 'Effect of a long drought on the abundance of red kangaroos in Central Australia', *CSIRO Wildlife Research*, 12(1) (1967), 1–8.
25. Alan Newsome, 'The abundance of red kangaroos, *Megaleia rufa* (Desmarest), in Central Australia', *Australian Journal of Zoology* 13(2) (1965), 269–287, p. 269; Alan Newsome, 'The distribution of red kangaroos, *Megaleia rufa* (Desmarest), about sources of persistent food and water in central Australia', *Australian Journal of Zoology*, 13(2) (1965), 289–300, p. 289.
26. Alan Newsome, D. R. Stephens, and A. K Shipway, 'Effect of a long drought on the abundance of red kangaroos in Central Australia', *CSIRO Wildlife Research*, 12(1) (1967), 1–8.
27. Alan Newsome, 'Competition between wildlife and domestic livestock', *Australian Veterinary Journal*, 47(12) (1971), 577–586, p. 580.
28. Alan Newsome, op. cit. (n. 27).
29. George Chippendale, 'Botanical examinations of kangaroo stomach contents and cattle rumen contents', *Australian Journal of Science*, 25 (1962), 21–22; George Chippendale, 'The plants grazed by red kangaroos, *Megaleia rufa* (Desmarest), in central Australia', *Proceedings of the Linnean Society of New South Wales*, 93 (1968), 98–110.
30. Alan Newsome, 'An ecological comparison of the two arid-zone kangaroos of Australia, and their anomalous prosperity since the introduction of ruminant stock to their environment', *The Quarterly Review of Biology*, 50 (1975), 389–424, pp. 389–390.
31. Alan Newsome, 'The eco-mythology of the red kangaroo in Central Australia', *Mankind*, 12(4) (1980), 327–333.
32. Alan Newsome, op. cit. (n. 11).
33. Alan Newsome, op. cit. (n. 11).
34. Alan Newsome, op. cit. (n. 31).
35. C. Hugh Tyndale-Biscoe, op. cit. (n. 1), p. 314.
36. Steve Eldridge, B. J. Shakeshaft and T. J. Nano, *The impact of wild dog control on cattle, native and introduced herbivores and introduced predators in central Australia*, (unpublished report to the Bureau of Rural Sciences, Canberra, 2002), pp. 1–2.
37. Alan Newsome, L. K. Corbett, and D. R. Stephens, 'Assessment of an aerial baiting campaign against dingoes in central Australia', (Commonwealth Scientific and Industrial Research Organization, Division of Wildlife Research Technical Paper, No. 24, 1972), pp. 3–4.
38. Alan Newsome, op. cit. (n. 37), pp. 3–4.
39. Alan Newsome, op. cit. (n. 37). pp. 1, 6.
40. Steve Eldridge, op. cit. (n. 36). pp. 1–2.
41. Samuel Haughton, 'Notes on Animal Mechanics: No. 12. On the muscular anatomy of the Irish terrier, as compared with that of the Australian dingo', *Proceedings of the Royal Irish Academy (1836–1869)*, 9 (1864–1866), 504–507, p. 504.
42. Henry Osborn, 'The causes of extinctions of Mammalia (concluded)', *The American Naturalist*, 40(480) (1906), 829–859, p. 842.
43. Sarah Jones, 'Color variations in wild animals', *Journal of Mammalogy*, 4(3) (1923), 172–177, p. 174, 175, 176.
44. Unknown, 'Hybrid between wolf and dingo', *Nature*, 130 (1932), 280.
45. M. F. Ashley Montague, 'On the origin of the domestication of the dog', *Science*, 96(2483) (1942), 111–112, p. 112.
46. Neil Macintosh, 'The origin of the dingo: an enigma' In 'The Wild Canids - Their Systematic Behavioural Ecology and Evolution' M. W. Fox ed. (1975) pp. 87–106, van Nostrand, New York.
47. Neil Macintosh, op. cit. (n. 46), p. 92.
48. Neil Macintosh, op. cit. (n. 46), p. 103.
49. Alan Newsome, L. K. Corbett, and S. M. Carpenter, 'The Identity of the Dingo I. Morphological discriminants of dingo and dog skulls', *Australian Journal of Zoology*, 28(4) (1980), 615–625, p. 615.
50. Alan Newsome, op. cit. (n. 49); Alan Newsome, and L. K. Corbett, 'The identity of the dingo II. Hybridization with domestic dogs in captivity and in the wild', *Australian Journal of Zoology*, 30 (1982), 365–374; Alan Newsome, and L. K. Corbett, 'The identity of the dingo III. The incidence of dingoes, dogs and hybrids and their coat colours in remote and settled regions of Australia', *Australian Journal of Zoology*, 33 (1982), 363–375.
51. Alan Newsome, op. cit. (n. 49), p. 622.
52. Alan Newsome, op. cit. (n. 49), p. 615.
53. Alan Newsome, and L. K. Corbett, 'The identity of the dingo II. Hybridization with domestic dogs in captivity and in the wild', *Australian Journal of Zoology*, 30 (1982), 365–374, p. 366.
54. Alan Newsome, and L. K. Corbett, 'The identity of the dingo III. The incidence of dingoes, dogs and hybrids and their coat colours in remote and

settled regions of Australia', *Australian Journal of Zoology*, 33 (1982), 363–375, p. 365.
55. Alan Newsome, P. C. Catling, and L. K. Corbett, 'The feeding ecology of the dingo II. Dietary and numerical relationships with fluctuating prey populations in south-eastern Australia', *Australian Journal of Ecology*, 8 (1983), 345–366, p. 346.
56. Laurie Corbett, and A. E. Newsome, 'The feeding ecology of the dingo III. Dietary relationships with widely fluctuating prey populations in arid Australia: an hypothesis of alternation of predation', *Oecologia*, 74 (1987), 215–227, p. 217.
57. See references in Laurie Corbett, op. cit. (n. 56), p. 222.
58. Laurie Corbett, op. cit. (n. 56), p. 222.
59. Alan Newsome, I. Parer, and P. C. Catling, 'Prolonged prey suppression by carnivores—predator-removal experiments', *Oecologia*, 78 (1989), 458–467, p. 459.
60. Alan Newsome, 'The control of vertebrate pests by vertebrate predators', *Trends in Ecology and Evolution*, 5 (1990) 187–191, p. 190.
61. Alan Newsome, op. cit. (n. 59), p. 459.
62. Alan Newsome, op. cit. (n. 59), p. 465.
63. Alan Newsome, *The biology and ecology of the dingo*, In 'A Symposium on the Dingo' C. R. Dickman, and D. Lunney ed. (2001) pp. 20–33, Royal Zoological Society of New South Wales, Sydney, Australia.
64. Alan Newsome, P. C. Catling, B. D. Cooke, and R. Smyth, 'Two ecological universes separated by the dingo barrier fence in semi-arid Australia: interactions between landscapes, herbivory and carnivory, with and without dingoes', *The Rangeland Journal*, 23 (2001), 71–98.
65. Alan Newsome, op. cit. (n. 64), pp. 94–95.
66. Alan Newsome, op. cit. (n. 63), p. 20.