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R. A. Stirton: pioneer of Australian mammalian palaeontology

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ABSTRACT
Beginning in 1953, under the inspired leadership of R.A. Stirton, in just over one decade, a systematic program to discover new fossil sites and specimens of Australian terrestrial mammals, dramatically increased the knowledge of their Neogene history on this continent. At the beginning of this program, only a single incomplete skeleton and a handful of isolated teeth of terrestrial mammals were known from three sites. When Stirton died in 1966, nine additional Neogene terrestrial mammal sites had been found and dozens of new species of mammals had been recognized, and in many cases published on – all the result of Stirton's foresight and determination.

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Background

At last I had gotten to Australia in my quest for the ancestry of the monotremes and the marsupials. Thus wrote Ruben Arthur Stirton or "Stirt" as he preferred to be called, in his field notes for 14 February 1953. He had just arrived in Sydney on his first visit to the continent. What had brought him to Australia was an abiding interest in the distribution of land mammals in time and space (Figures 1 and 2).

At that time, there was a significant record of the Pleistocene terrestrial mammals from Australia. But the first 99% of the history of that group was represented by only a single partial skeleton, that of *Wynyardia bassiana* Spencer, 1901, and less than half a dozen isolated teeth. In contrast, except for Antarctica, at least the broad outlines of the history of land mammals during the Cainozoic Era or "The Age of Mammals" was known on all the other continents.

The first Australian Pleistocene terrestrial mammal was found in the Wellington Caves of New South Wales when Major Mitchell collected a jaw fragment of what became the holotype of *Diprotodon optatum* Owen (1838) the largest marsupial that ever lived. This was the basis for the first of Sir Richard Owen's many publications on the extinct, Pleistocene mammals of Australia. Owen (1859) also wrote briefly on the topic of mammalian palaeobiogeography, citing specific instances where it could be

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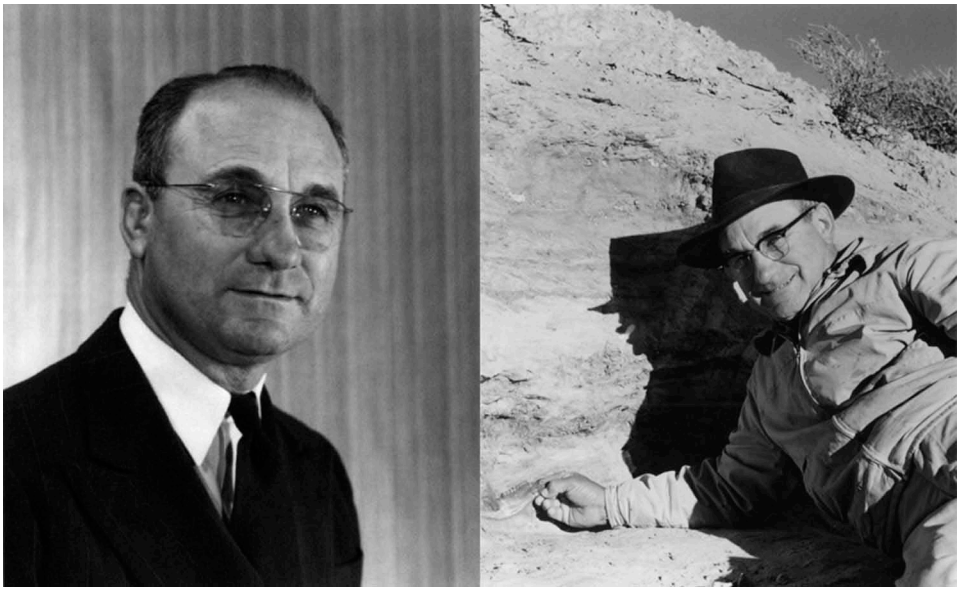


Figure 1. Ruben Arthur Stirton or "Stirt" as he was affectionally known to his friends and colleagues. Director of the Museum of Paleontology and Professor of Mammalian Paeontology at the University of California, Berkeley. Born 20 August 1901. Died 14 June 1966 (Kleinpell, 1968). Image on the right shows him with his right hand near the holotype of the extinct kangaroo *Troposodon kenti* at Stirton Quarry, Lake Kanunka, South Australia in 1958. Source: R.H. Tedford.

Figure 2. Richard H. Tedford, born 25 April 1929, died 15 July 2011 (left). Paul F. Lawson, born 9 August 1918 (right). These two men were most closely involved with Stirton's Australian vertebrate palaeontological research programme. Both participated in the majority of field trips that Stirton undertook. Richard H. Tedford published both jointly authored research with Stirton along with his own work. Paul Lawson, based at the South Australian Museum, was Stirton's main contact regarding the organization of the vital logistics related to the field work as well as participating in many of those trips. Sources: P.F. Lawson.

demonstrated by the fossil and recent records that terrestrial mammalian groups had migrated from one continent to another. Throughout the remainder of his career, he described and named a number of the larger Australian Pleistocene mammals.

In the decades that followed Owen's initial work, particularly in the 19th century, Australian palaeontologists including Gerard Krefft, H.H. Scott, Edward Charles Stirling, A.H.C. Zietz, Charles W. de Vis also described Australian Pleistocene terrestrial mammals.

As early as 1948 Stirton had begun thinking about carrying out exploration for fossil mammals in Australia. That year, he wrote a letter of enquiry to Sir Douglas Mawson, the famed Antarctic explorer, who was then head of the Geology Department at the University of Adelaide. The letter pointed out that Tertiary terrestrial mammals were all but unknown in Australia, briefly summarized the relevant geology of the continent that he was able to glean from the published literature, and sought advice about how to proceed. In a friendly response more than one year later, Mawson began his letter by apologizing for the tardiness of his response citing being overwhelmed by administrative duties. He encouraged Stirton in his quest and would continue to do so during their subsequent association, suggesting areas Stirton might investigate.

The term Tertiary, although now considered obsolete, is used in this paper for historical reasons. It is equivalent to the Paleogene and Neogene combined in modern usage.

What led this native Kansan, born in the Brush Creek District southwest of the rural community of Horton, to desire to do this was in large part owing to his all-too-brief contact with William Diller Matthew. The reasons why this association was so critical in shaping Stirton's future can realistically be traced back as far as two centuries.

In the 18th century, European knowledge of the biota of the world had reached a point where it was possible to characterize the mammalian communities on the various continents. Comte de Buffon in the middle of that century recognized how different they were from one another and saw the parallels between the assemblages in North America on the one hand and Europe, Asia and Africa on the other. The extinct mammoths in the Americas and Siberia led to the realization that animals clearly similar to living elephants had once existed in areas where they no longer did and that animals had gone extinct at least locally.

Early in the 19th century, Georges Cuvier, the Father of Vertebrate Palaeontology, speculated on the movement of terrestrial mammals from one continent to another, the beginnings of mammalian palaeobiogeography.

In his 1876 two volume work *The Geographic Distribution of Animals*, Alfred Russel Wallace (1876) was able to summarize the then known information on the distribution of mammals through time and space. He concluded that terrestrial mammals had originated in the Northern Hemisphere and subsequently dispersed to the Southern. This view was maintained by later workers and persists in large part to the present day; e.g. Matthew (1915), Mayr (1944), Simpson (1961), and Luo, Cifelli, and Kielan-Jaworowska (2001).

In his *The Age of Mammals*, Osborn (1910) was able to outline in considerable detail the chronological and geographical distribution of terrestrial mammals in Europe, Asia and North America during the Cenozoic. His colleague and life-long friend William Berryman Scott published Scott (1913), which did much the same for both North and South America. As the first half of the 20th century proceeded, despite horrendous wars, at least the broad outlines of the evolution of land mammals during the Cainozoic Era also became known in Africa.

Up to the middle of the 20th century almost all that was known about the evolution of mammals during the Mesozoic Era, the first two-third of their history, was contained in two monographs by Simpson (1928, 1929). The first Australian Mesozoic mammal, however, was not found until 1984.

William Diller Matthew began working for Henry Fairfield Osborn at the American Museum of Natural History in 1891 (Colbert, 1992). Matthew's initial task given to him by Osborn was to go to Philadelphia and pack up and catalogue the fossil collection of Edward Drinker Cope. That collection had been amassed in the American West during the preceding 25 years. In doing so, Matthew made his first acquaintance with the fossil mammals of the Cenozoic of western North America. Gaining a PhD from Columbia University under Osborn, Matthew continued to work at the American Museum until 1927. During that time, he undertook numerous field trips to the American West. He analysed those fossils as well as specimens collected in Asia and Europe by Barnum Brown and Walter Granger, also based at the American Museum of Natural History, as well as those housed in collections on those continents. The broad knowledge of mammals and their distribution in time and space gained during his tenure at the American Museum of Natural History led, among other things, to his renowned classic *Climate and Evolution* (Matthew, 1915).

Taking up a professorship of palaeontology at the University of California, Berkeley in 1927, in the brief time he had there, Matthew had a profound effect on the Department of Paleontology. He fundamentally changed the direction of research there to emphasize the areas of his special interests in the temporal and spatial distribution of mammals.

Stirton began his studies as a graduate student at the University of California, Berkley in 1926. While at Berkeley, he received training in the systematics of recent vertebrates and ecology from Joseph Grinnell and vertebrate palaeontology from Charles Camp and Matthew, after the latter arrived there in 1927 to take up the position as the second Director of the Museum of Paleontology. Stirton became Matthew's assistant and also took an advanced course in mammalian palaeontology from him, evidently the only formal training Stirton ever received on the topic. Although studying modern mammals and birds as an undergraduate at the University of Kansas, while associated with the Dyche Museum there, it is not clear from a transcript of his academic record there that he had any exposure to vertebrate palaeontology during that time. Informal training seems likely, because there were significant collections of mammalian fossils both from western North America and Argentina in that museum that had been made early in the 20th century. Besides teaching a course in ornithology in his final undergraduate year, he also took part in a trip to collect the full gamut of modern terrestrial vertebrates in El Salvador in 1925.

In 1929, Stirton published his first two mammalian palaeontological papers. The following year saw him publish three more papers in that field, two of them being co-authored papers with Matthew, who died of kidney failure that year. In 1930, he was appointed Curator of Fossil Mammals at the University of California Museum of Paleontology, Berkeley, and he began a highly productive decade focusing primarily on the late Cainozoic mammals of western North America. He completed an MA thesis on the Tertiary beavers of North America in 1931. Five years later, he was appointed Acting Director of the Museum of Paleontology, a position that did not become permanent until 1949.

His first publication focusing on the comparison between mammalian fossil assemblages was a 1937 abstract "Significance of Tertiary mammalian fauna in Holarctic correlation."

Although he subsequently published little explicitly dealing with the broader aspects of mammalian palaeobiogeography, as two of his former students wrote, he "…initiated a series of study guides and lectures outlining the history of mammalian faunas of the world," (Savage & Russell, 1983). In his lectures on mammalian palaeontology, he referred more than once to Matthew as a source of both authority and inspiration to him.

Stirton's first foray outside of the USA in search of terrestrial mammalian fossil assemblages was in 1941–1942 in discovery of a Pleistocene mammalian assemblage in El Salvador and resulted in the publication of a brief abstract in 1943.

Four successive expeditions followed (1944–1951) where he discovered the Miocene LaVenta mammalian faunal assemblage, the first such assemblage of pre-Pleistocene terrestrial mammals known from northern South America. This was in spite of his seeing on his initial visit, the ship transporting him to Columbia burn and sink before his very eyes.

Stirton's final trip before embarking on the Australian phase of his research searching was to Mexico in 1952.

South Australia 1953

Twenty-seven well-wishers were at the San Francisco airport to see Stirton, his wife Lillian, and Richard Tedford (then Stirton's graduate student) off when he left for Australia on his first visit there on 12 February 1953. Stirton listed all the well-wishers in his remarkably detailed field notes for this trip that would eventually amount to more than 500 pages.

The day after reaching Australia, Stirton and his party flew to Adelaide where he was expected at the South Australian Museum. Why the South Australian Museum was to be his base of operations while in Australia was a consequence of the correspondence he had begun with Sir Douglas Mawson in 1948. Through that correspondence, Mawson had made C. Warren Bonython, later a member of the Board of Directors of the South Australian Museum, aware of Stirton's interest in searching for fossils of Australian marsupials and monotremes.

In 1893, the South Australian Museum had a nearly year-long expedition to Lake Callabonna in the northeastern part of the State. The outcome of this was a collection of large, Late Pleistocene marsupials and ground birds described soon after in a series of monographs by Edward Charles Stirling and A. H. C. Zietz. The area where the fossils had been collected was declared a fossil reserve by the Parliament of South Australia. After the passage of more than half a century, however, it was unknown exactly where the site was located.

Tedford (1985) wrote:

> *The South Australian Museum was most anxious that we find the Lake Callabonna locality, since the area had been set aside as a Fossil Reserve under state administration. No one at that time knew exactly where within the Fossil Reserve the site was located, and it was not known whether it was actually within the Reserve! Old hands from the north claimed that it had been buried and could no longer be found.*

Visiting San Francisco and knowing of Stirton's interests in Australia, Bonython made it a point to meet Stirton and discuss with him Lake Callabonna. What was offered to Stirton, if he would seek out the original site and collect fossils from there, was the use of a large

truck hired from the Electricity Trust of South Australia or ETSA subsequently dubbed appropriately enough *Diprotodon*. Also the services of one staff member of the South Australian Museum would be provided. That person was eventually to be Paul Lawson.

Before first going into the field, a month was spent in Adelaide. While there Stirton discussed with knowledgeable geologists other places he might go to find the desired fossils. Sir Douglas Mawson suggested the country around Lake Eyre while the Queensland geologist Frederick William Whitehouse suggested possibilities in that State. By chance a copy of J.W. Gregory's 1906 book *The Dead Heart of Australia* was found on a bookshelf in the house at 59 Brigalow Ave, (Figure 3) where Stirton was staying while in Adelaide. This account of an expedition in the summer of 1901–1902 around Lake Eyre by Gregory and students from the University of Melbourne was to prove to be a valuable guide.

During that month Stirton devoted much time to examining the collections of both recent and fossil mammals in the South Australian Museum, filling his notebooks with extensive detailed descriptions focusing particularly on the dentitions with lesser attention paid to the features of the skulls and jaws. This practice continued all through this trip at every museum he stopped at, both in Australia and in countries visited on the return trip to the USA via Asia and Europe.

At the South Australian Museum, Stirton examined fossils of both marsupials and humans from Lake Menindee collected by Norman Tindale in 1939. The first field trip was to Lake Menindee, with Tindale participating in the first part of that visit. Amongst

Figure 3. 59 Brigalow Ave., Kensington, South Australia (above) today where a copy of J.W. Gregory's 1906 book *the dead heart of Australia* (below) was found by chance on a bookshelf in this house where Stirton, his wife Lillian, and Tedford stayed during their first visit to Australia in 1953. Source: P. Vickers-Rich.

other things, Tindale wanted to learn how to use plaster of Paris and hessian/burlap to jacket fossils in order to collect them. A number of brief trips were made there in subsequent years, and Tedford's Ph.D. dissertation on the macropods and geology of Lake Menindee was a direct outcome (Tedford, 1967).

After just over a fortnight at Lake Menindee, Stirton returned to Adelaide. Plans were then laid for both an exploration of potential fossiliferous outcrops around Lake Eyre and along Cooper Creek and to relocate the site at Lake Callabonna.

In a discussion with Paul Lawson and the director of the South Australian Museum, Herbert Hale, Stirton suggested that all human remains and artefacts remain at the South Australian Museum where active research was underway. All type specimens of mammalian fossil remains would go to the University of California Museum of Paleontology along with a split of referred material between that institution and the South Australian Museum. This division was suggested because there was no one active in mammalian palaeontology at the South Australian Museum.

In later years, Stirton was a strong advocate that all holotypes should be returned to Australia. He expressed his view on this matter at length in a letter of 14 March 1957 to Hale,

> "I am glad you brought up the matter of type specimens. My attitude has not changed, but you will know we scientists have an obligation towards the advancement of learning in our respective fields. It has always been my wish to have someone in South Australia take up the study of fossil mammals and continue with the work we have tried so hard to initiate. Otherwise the types we leave with you will be so far removed from the centres of study where they could do the most good. This, we must avoid. Nevertheless, I shall return all of the holotypes collected in South Australian {*sic*} to the South Australian Museum, even the ones we got when we were out on our own funds, for I feel confident that your Board because of the interest they have shown, will make a determined effort to carry on this important work, where it belongs, in South Australia."

After three weeks in Adelaide, Stirton headed north initially to the Lake Eyre region accompanied by Tedford, Lawson and Geoff Woodard of the University of Adelaide. Lawson drove the promised large truck, a World War II surplus Ford vehicle manufactured in Canada, obtained from the Electricity Trust of South Australia. The truck nicknamed *Diprotodon* was an ideal vehicle for their purposes, but it had been left out in the sun for years and consequently proved to be quite unreliable (Figure 4). Fortunately, Paul Lawson was quite familiar with this model as he had experience with them when serving in the Australian Army in World War II.

Following the narrow gauge railway line north of Marree, only Cretaceous marine invertebrates were found. The decision was then made to go to Lake Callabonna. At this point, the radiator of *Diprotodon* failed. Ten days were required to obtain and install a replacement, but the time was not wasted. Recent mammals, birds, lizards and insects were collected for both the South Australian Museum and the University of California Museum of Paleontology. Collecting representatives of the living fauna were an ongoing project during all of Stirton's Australian expeditions. (Figures 5 and 6).

The field party finally departed for Lake Callabonna on 25 May 1953, reaching it on 27 May. The first order of business was finding a way across the lake to its eastern side where, it was thought that the 1893 site was located. After four days of searching, Stirton found a Jeraboam whiskey jug, unfortunately as he ruefully remarked in his notes, empty (Figure 7). But that and other debris soon established the location of the 1893 camp, and

Figure 4. *Diprotodon*, workhorse of the 1953 field trip to Lake Callabonna, in a bit of trouble! Source: P.F. Lawson.

Figure 5. Camp at Margaret River near Coward Springs. 1953. Source: P. F. Lawson.

Figure 6. Looking at a map of South Australia, Stirton had concluded that there were several towns along the narrow gauge railway between Marree and Oodnadatta where supplies could be obtained. The Coward Springs Hotel was the only such "town". Source: P.F. Lawson.

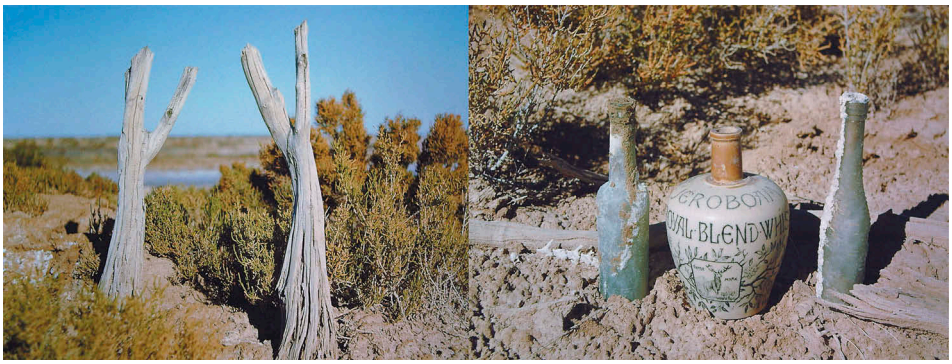


Figure 7. The clues to the location of the 1893 South Australian Museum camp at Lake Callabonna. Left: Y-shaped posts that once supported pots over a fire. Right: Jeroboam Whiskey jug (alas empty) together with glass bottles. Sources: P.F. Lawson.

from there, the nearby sites where fossils had been collected were soon identified. Stirton and the others were astounded at the number of *Diprotodon* skeletons to be seen (Figure 8).

Under trying conditions, including high, cold winds and unctuous mud, the next three weeks were spent collecting one nearly complete skeleton of *Diprotodon*, two skulls of it, as well as isolated elements. At one point, Stirton built a fire behind

Figure 8. R.A. Stirton probing for *Diprotodon* bones at Lake Callabonna, 1953. Source: P.F. Lawson.

a hessian shelter he constructed in the pit he was excavating in order to keep warm while eating lunch (Figure 9).

The trip back to Adelaide, with all the specimens loaded into *Diprotodon* and the Land Rover and its trailer, was a saga that would take four days owing to continual breakdowns of *Diprotodon*, the truck. Paul Lawson working in the open in miserable conditions of cold, windy, rainy weather somehow managed to get it started repeatedly. Stirton commenting on Lawson's tenacity was to write in his field notes *Paul was invaluable – he never gives up*.

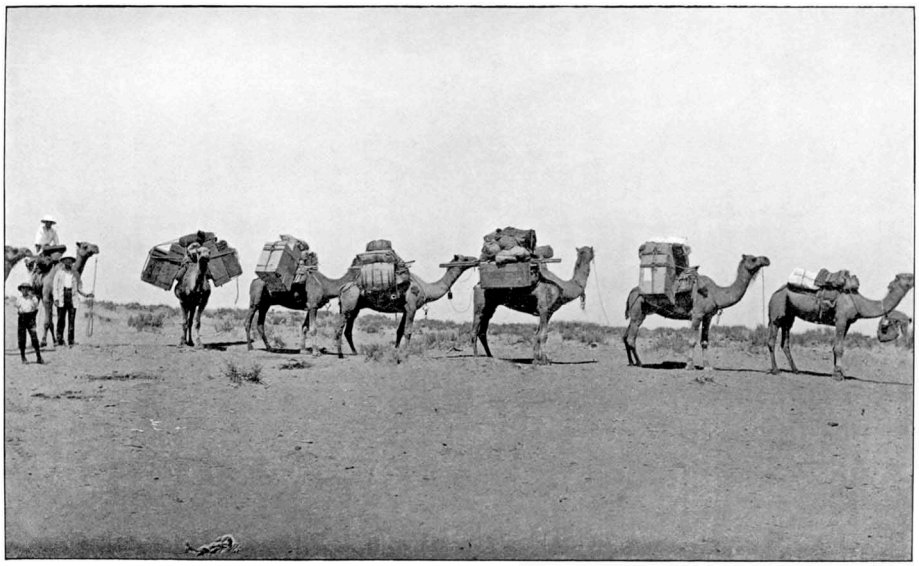
Nearly, a fortnight was then spent in Adelaide preparing for a trip to the east side of Lake Eyre, particularly to follow in the steps of J. W. Gregory, exploring along Cooper Creek. Stirton noted that Gregory mentioned discovery of a half fossilized jaw of dingo at Lake Palankarinna. One entire week of Stirton's notes is devoted to a brief comment that he was entirely taken up with dealing with the media concerning the re-discovery of the 1893 fossil site at Lake Callabonna.

During this time in Adelaide, Sir Douglas Mawson encouraged Stirton to return to Australia to continue his programme. But Stirton was not sure that he could get away from his duties at the University of California.

On the 12th of July, Stirton together with Tedford and Woodard drove north with a single Land Rover and trailer, but Lawson and *Diprotodon* were left behind.

Exploring along Cooper Creek, Stirton and his crew found frequent fragmentary fossil remains of *Diprotodon* along with other large mammals and flightless birds, just as Gregory and his party had done half a century earlier (Figure 10). After frequently

Figure 9. Excavating *Diprotodon* at Lake Callabonna, 1953. Source: P.F. Lawson.



Our Baggage Camels.

Figure 10. Gregory's field party on their expedition around Lake Eyre in the summer of 1901–1902. After his experience in the same area, Stirton remarked that perhaps Gregory had a better mode of transport than Land Rovers. Photo from *The dead heart of Australia* by J.W.G regory (1906).

being bogged in sand, Stirton was of the opinion that perhaps Gregory had a better mode of transport than a Land Rover, namely camels. Although fossils were being found, the results were not encouraging (Figure 11). All that were to change on 27 July 1953 at Lake Palankarinna.

Tedford (1985) wrote:

> *On 27 July 1953 at Lake Palankarinna in South Australia, R.A. Stirton ('Stirt') and I of the University of California had completed our search for fossils in the northwestern-most outcrops of Tertiary rocks and drove down the lake edge to pick up G.D. Woodard of the University of Adelaide.*

My field notes record the following:

We were rather disappointed that these deposits had not yielded mammal remains and were ready to give the show away. Pulled up across a green clay bench where Woodard was prospecting to be greeted by a "top of the morning" doff of hat, big smile and outstretched hand bearing fragments of kangaroo bones and teeth (Figure 12). *Geoff had done it and we had rolled over his hunting ground, a bench strewn with mammal bones, turtle shell and crocodile teeth. This was it, the first Tertiary mammals from Australia!*

Actually, these bones were the first diverse array of Tertiary mammals, because such fossils as Wynyardia, *a primitive marsupial from Tasmanian marine rocks of Miocene age, were already known. This youthful elation was tinged with relief, for our nine-month stay as Fulbright scholars in Australia in search of Tertiary mammals had come within 10 days of being a complete failure. In fact, we were saved from failure three days before by a chance happening known as 'bone diggers luck'. Lake Palankarinna is one of many saltpans isolated in the sea of sand ridges east of Lake Eyre and hidden from all except from aerial view. We had seen it only by chance from a towering dune crest where we had gone to eat our lunch in the wind to escape the bush flies!*

Woodard's locality, later the Woodard Quarry, proved to be just barely of Tertiary age, representing the Pliocene or last epoch (2 to 5 million years ago) of the Tertiary Period, which began 67 million years ago. This together with the Quaternary Period (about the last 2 million years) constitutes the Age of Mammals or the Cainozoic Era. The quarry yielded the remains of a rabbit bandicoot, a wallaby and a small diprotodontid, all new genera, plus crocodile teeth, turtle shell fragments, fish bones and the remains of yabbies. The day of discovery was climaxed by finding a tiny koala maxillary at another site (the 'Tedford Locality') in older deposits, lower in the rock sequence at Lake Palankarinna (Figure 13).

1953 was the beginning of a concerted search for Tertiary mammals in Australia, and the initial discovery at Lake Palankarinna in the eastern Lake Eyre Basin had justified the opinions of Sir Douglas Mawson, F.W. Whitehouse and C.W. Bonython, who suggested to us that the region was promising. We had also chanced upon, Gregory (1906), *which described a journey with a similar purpose to our own. Gregory, following up on discoveries made by the pioneer South Australian geologist H.Y.L. Brown, had made a large collection of fossil vertebrate remains from the lower reaches of the Cooper and Warburton rivers near Lake Eyre at the turn of the century. These proved to be Quaternary remains, but they focused attention on the fossil potential of this area, and we retraced some of Gregory's steps that year before the chance sighting of Lake Palankarinna. Then thought to be Tertiary, Jack Woods had begun a review of the large and important collections from the Darling Downs that Charles* de *Vis had brought*

Figure 11. The western extremity of Cooper Creek where it enters Lake Eyre. Source: P.F. Lawson.

Figure 12. Geoff Woodard left and Richard Tedford right engaged in an activity that was very familiar to them during their exploration of the country west of Lake Eyre – digging out! Source: P.F. Lawson.

Figure 13. Richard H. Tedford excavating at Woodard Quarry, Lake Palankarinna, 1953. Source: P.F. Lawson.

together at the Queensland Museum. Woods later proved that the materials de *Vis had obtained from the western Downs near Chinchilla represented an older fauna and one probably of Pliocene age. Edmund Gill at the National Museum, Victoria, using the fluorine content of fossil bones, was able to show that the famous skeleton of* Wynyardia *from Tasmania and certain fragmentary fossil marsupials from Victoria were really contemporary with the marine deposits in which they had been found. He thus established a Tertiary (Oligocene-Miocene) age for fossils that had lain in collections unrecognized, most since the last century, as the remains of truly ancient marsupials. Stirton and Gill collaborated in 1953 to study the remains that Gill's investigations had indicated were of Tertiary age. This was a most important project, despite the fragmentary nature of the material, because it provided an independent estimation of the geological age of the fossil marsupials by reference to a marine geochronology that could be correlated with the international geological time scale.*

Thus, the doubts that Stirton had expressed to Sir Douglas Mawson about returning to Australia immediately prior to departing for the east side of Lake Eyre, gave way to confidence that his Australian programme would continue.

South Australia and Queensland 1954

Tedford (1985) wrote:

> *In 1954 "Stirt" expected to spend most of a field season excavating the Woodard Quarry and carrying out other work at Lake Palankarinna. A large party including Paul Lawson and William Riedel of the South Australian Museum; William Cassidy, a Fulbright scholar; Woodard; and Leslie Marcus from the University of California was established at the site*

(Figure 14). *When Stirton arrived 11 days later, they were able to tell him that the Woodard Quarry had been worked out and no extension could be found* (Figure 15). *It had been a deep pocket in a Pliocene stream channel, preserved from erosion before deposition of the overlying red sands and clays.*

The party had had little luck at the Tedford Locality, so after exploratory work on the lower Warburton and the Diamantina River where some Pleistocene mammals were found, they split-up; Stirton, Woodard and Marcus went on into Queensland and eventually to the Darling Downs for a first-hand examination of that classic ground (Figure 16).

*Paul Lawson had a hunch that the party had overlooked something at Lake Palankarinna and he spent a few days there before returning to Adelaide. A lucky blow from his geology hammer rolled out a tiny koala jaw from a site south of the Tedford Locality, but at the same geological level. This became the type specimen of the oldest known koala (*Perikoala palankarinnica Stirton, 1957, *mid-Miocene in age).*

The breadth of Stirton's, "…quest for the ancestry of the monotremes and the marsupials…," is shown by his 1954 work in Queensland. As he, Woodard and Marcus drove eastward, they visited prospective fossil vertebrate sites that had been gleaned from the scientific literature and suggestions by Whitehouse. Northeast of Roma Queensland, the Eurumba Creek locality of the still only known partial skeleton of an Australian Jurassic dinosaur, *Rhoetosaurus brownei*, occurred, was investigated in the hope of finding Mesozoic mammals. Although Stirton never excavated or described a Mesozoic mammal in

Figure 14. The full field party. Front row left to right: Jim Connell, William Riedel, Les Marcus. Middle: William Cassidy. Rear row left to right: R.A. Stirton, Geoff Woodard, Paul F. Lawson. Source: P. F. Lawson.

Figure 15. R.A. Stirton graphically expressing his disappointment when it had become clear that Woodard Quarry was exhausted. Source: P. F. Lawson.

his life, clearly his thinking while in Australia was to elucidate the history of land mammals on the continent at any age where such fossils could be found.

Interlude

Stirton had arranged with the Australian Museum for Leslie Marcus to remain in Australia for several months after the field trip was over to make a collection of the Pleistocene mammals known from Bingara, N.S.W., which became the subject matter of his Ph.D. dissertation (Marcus, 1976).

Stirton's invitation to Paul Lawson allowed him to spend the academic year 1955–1956 at the University of California Museum of Paleontology where, amongst other things, he assisted with the preparation of fossils. While there, he lived at Stirton's home in Lafayette, California.

1957

Tedford (1985) wrote:

> The failure in 1954 to find other Tertiary sites teased Stirton. When I returned to graduate studies in 1956, he was easily persuaded to send me back for another look. Plans were made for a joint venture with the South Australian Museum that would combine fossil hunting and a biological reconnaissance of the northeastern part of the state. Both the 1953

Figure 16. "A sad moment", Paul Lawson. Stirton on left near Birdsville, Queensland, preparing to travel across southern Queensland with Les Marcus, Geoff Woodard (person in centre?) and Jim Connell (right) while Lawson prepares to return to South Australia, 1954. Source: P.F. Lawson.

and 1954 parties had collected small vertebrate fossils from Lake Palankarinna, and we thought we might try the technique of soaking the fossil-bearing matrix in water and washing the fine sediments through screens so that the fossils were retained on the mesh. We had the koala locality particularly in mind. We had also stumbled on the report of a scholarly well-digger, G.L. Debney, who in 1881 reported to the Royal Society of South Australia on his geological observations while drilling water bores north of Cooper Creek from Killalpaninna westward nearly to Lake Eyre. He found fossil bones and wood at a saltpan in the middle of the sand-ridge desert 40 km northwest of Killalpaninna. This seemed a lot like the situation at Lake Palankarinna. Brian Daily had joined the staff of the South Australian Museum as Curator of Fossils and Minerals, and he was able to confirm that such saltpans did exist (Figure 17). Brian persuaded the RAAF to let him examine the only comprehensive airphoto coverage then available for that remote area. He carefully examined the photos for the tell-tale serrated pattern of rock outcrops along the edge of the numerous saltpans buried in the sand ridge country east of Lake Eyre. These outcrops were plotted on a tracing of the air photo mosaic and the map he produced served as our guide to potential discoveries for many years.

Brian Daily, Paul Lawson and Harry Bowshall of the South Australian Museum and I had a very full schedule for 1957, one that would determine whether more detailed work at Lake Palankarinna would yield useful results, and whether there were other localities in the eastern Lake Eyre Basin that contained Tertiary fossils. In several ways the 1957 trip was one of the

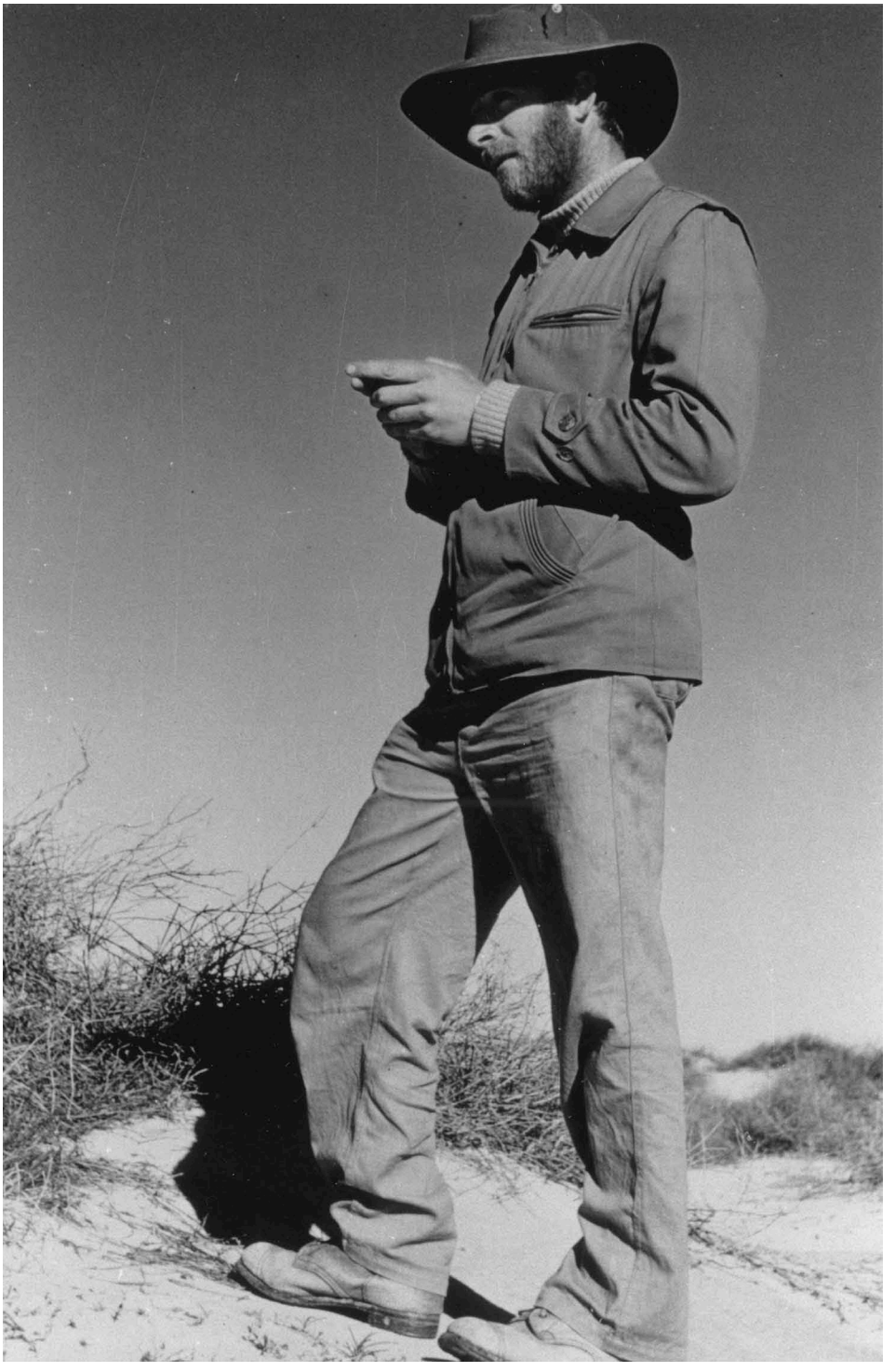


Figure 17. Brian Daily. Source: R.H. Tedford.

most significant undertaken east of Lake Eyre, not in the quantity of fossils obtained, but in the discoveries made that set the stage for all future work there. We found that we could collect fossils from the Lake Palankarinna deposits by the washing technique, but no significant fossils were obtained because we had neither the time nor the equipment to process the tons of matrix required for success. Field parties in the 1970s came equipped and had success with the method. Work of this kind continues there.

We found another locality not far from the Woodard Quarry and at the same geological level that yielded abundant marsupial bones of the same types found at the previous site. We actually had two sites, the Daily and Lawson quarries which subsequent work proved to be parts of one Pliocene stream channel. We did find rich fossil deposits approximately where Debney had indicated and Daily's map showed outcrops. Two small saltpans, later called Lakes Kanunka and Pitikanta, bordered by high dunes yielded two fossil faunas, one above the other, and thus in direct geological superposition. The older, from green and dolomitic clays, contained strange little diprotodont marsupials of a previously unknown and primitive type. A younger stream channel cut through the red clays and into the green contained a variety of animals more modern in appearance than those from the Woodard Quarry, yet more archaic than the widely known Late Pleistocene forms.

Brian Daily's careful geological work, carried on while the bone diggers were exalting over each new fossil, began to make sense out of the geological history of the region. From our camp at Kalamurina I wrote to Stirton to tell him of our success and to outline the stratigraphic evidence that placed four distinct fossil assemblages in relative geological time. When we published our results in 1961, we drew on the experience of an additional field season, but the outline was unchanged from the 1957 discoveries. In keeping with codified practice in geology, the major rock units were named after geographic locales: Woodard had already used the term Etadunna Formation for the green and dolomitic clays; the name coming from a nearby station on the Birdsville Track. This station was long our base of operations thanks to the kindness and hospitality of the Oldfield family. The channel sands containing the Woodard, Daily and Lawson quarries were called the Mampuwordu Sand from a site nearby at Lake Palankarinna. The unfossiliferous red clays and sands were named the Tirari Formation after the Aboriginal tribe that inhabited the area east of Lake Eyre where these deposits crop out widely. Finally, the overlying fossil-rich channels were named the Katipiri Sands for an outcrop at a waterhole of that name in the lower reaches of Cooper Creek (Figure 18).

Geologic Age	Formation	Local Fauna or Fauna
Pleistocene	Katipiri Sands	Malkuni
Pliocene	Tirari	Kanunka
Pliocene	Mampuwordu Sands	Palankarinna
Early Miocene	Wipijari	Kutjamarpu
Late Oligocene	Etadunna	Ngapakaldi

Figure 18. Rock units and local fauna or faunal names utilized here. Age assignments taken from Woodhead et al. (2014).

Paul Lawson, to the contrary, did find a fossil skeleton of a large kangaroo in the Tirari Formation.

Tedford (1985) wrote,

> Thus, we had four fossil-bearing rock layers stacked one on top of the other, but we did not know their ages in terms of the geological time scale. At first we had only the probable Late Pleistocene age of the Diprotodon-bearing youngest assemblage based on correlation with radiocarbon dated faunas of similar type from elsewhere in Australia. The silicified sandstones were thought to be Cretaceous, and our other faunas were scattered between these rather wide limits. Remember that all the species, and in some cases the genera, we had found were new to science, and that none had been found with other fossil animals that could be referred to the standard geological column. At first we resorted to an educated guess which followed the assumption that the rates of evolution of these now extinct herbivorous marsupials might approximate those established for comparable placental mammals elsewhere in the world. Thus, we suggested a Late Oligocene or Early Miocene age for the fauna of the Etadunna Formation, a Pliocene age for the Woodard Quarry and a Pleistocene age for the two faunas from the Katipiri Sands. In this scheme the geological succession that yielded mammals east of Lake Eyre covered only a small part of the last 25 million years.

Much to his regret, Stirton was not able to participate in the 1957 field trip. He felt that he had an obligation to complete a general textbook on palaeontology, *Time, Life and Man*. Because of Stirton's decision to remain behind, Paul Lawson in correspondence with him referred to it as, "the damn book". With his many responsibilities, all through his career at the University of California, Berkeley, Stirton had to constantly prioritize his commitments. So it was typical of him to put professional obligations before personal desires.

The 1957 field trip led by Brian Daily at the insistence of the director of the South Australian Museum was plagued by rain (Figure 19). Because of the generally wet conditions, the trailer containing much of their supplies was left behind at Etadunna HS when the crew left Lake Palankarinna and crossed Cooper Creek to investigate the potential fossil sites at playas to the north. Without the trailer only five days of rations for four people plus equipment to collect fossils were in the two Land Rovers the party had with them. Rich fossil mammal sites found at the two small playas were subsequently named Lakes Pitikanta and Kanunka. A third playa to the north of Lakes Pitikanta and Kanunka that was named Gnappakaldi on the map in Gregory's 1906 book and currently known as Lake Ngapakaldi. After attempting to reach it, with only three days of food left, it was considered prudent to turn back when the route proved too boggy and if further rain occurred the route back to the trailer might well have become impassable as well.

After all the difficulties owing to heavy rain that had been the case up to this point, a few days later after reluctantly leaving this promising area north of Cooper Creek, a quite different situation was encountered just 70 km north. When starting to search for fossil sites along the Warburton River, the party was now in country that had received only 1.0–1.2 cm of rain during the previous 2 years (Figure 20).

South Australia 1958

Tedford (1985) wrote:

> Such was the status of our work when in 1958 'Stirt', Paul and I returned to capitalize on the discoveries of 1957. We explored Lake Ngapakaldi a few miles north of Pitikanta and

Figure 19. Tedford surveying the flooded Birdsville Track in 1957. Source: P.F. Lawson.

Figure 20. Innamincka ruins in drought stricken area investigated in 1957. Source: P.F. Lawson.

> found that concentrations of marsupials in the Etadunna Formation there gave us our first real look at our oldest fauna accordingly named the Ngapakaldi Fauna. [Figure 21] We worked the Daily and Lawson quarries and connected them, finding more complete material than in the Woodard Quarry, but no greater diversity of mammals. We called this the Palankarinna Fauna. I did a lot of detailed geological work everywhere we went, drawing section after section of rocks in the hope of testing and extending the ideas Brian Daily had proposed. We discovered a Diprotodon-bearing channel cut deeply into the Tirari Formation at Lake Palankarinna, and like its equivalent at Lake Kanunka it bore a gypsum cap. At the latter site we opened an excavation, eventually called the Stirton Quarry, and obtained a diverse suite of marsupials we named the Kanunka Fauna [Figures 22 and 23].

Our explorations carried us again down into the lower reaches of Cooper Creek, where J.W. Gregory had collected, and we recognized there, as we had on the lower Warburton, that the typical Katipiri Sands were deposited in an ancient riverine tract cut deeply into the Tirari Formation and covered by the sand ridges of the modern desert. Like Gregory and H.Y.L. Brown, we made our best collections from Malkuni and Katipiri waterholes, where the river in flood had winnowed the fossils from outcrops of the Katipiri Sands along the river banks into gravel bars at the ends of these permanent waterholes. We called this Diprotodon-*rich assemblage the Malkuni Fauna* [Figure 24].

South Australia 1961

Tedford (1985) wrote

> These conclusions were summarized in the first comprehensive review of the evidence published by Stirton, Alden Miller and myself in 1961. Since the beginning of our

Figure 21. Lawson left and Stirton right examining aerial photographs north of Cooper Creek, 1958. Source: R.H. Tedford.

Figure 22. Stirton excavating overburden at Stirton Quarry, Lake Kanunka. It was this image that eventually led to an Adelaide benefactor, Vin P. Keane, to donate a backhoe that was used to great effect on Stirton's final field trip to Australia in 1962. Source: P.F. Lawson.

collecting in this region, we had been impressed with the very abundant representation of fossil birds in all these vertebrate faunas, usually more abundant than mammals, in contrast to the reverse situation in most fossil deposits around the world. Accordingly, Alden Miller, a University of California ornithologist with a family tradition in the study of fossil birds, was a welcome addition to our field party.

In 1961 'Stirt', Alden, Virginia Miller and I, with Paul Lawson and Harry Bowshall returned to the Lake Eyre Basin. Our work alternated between exploration for new sites and exploitation of those previously discovered. We explored outcrops indicated by Daily's map on the eastern limb of Kallakoopah Creek and nearby saltpans. The results were of more geological than palaeontological interest. We returned to prospect the Warburton River near Kalamurina, so that I could show Stirton the evidence behind our 1957 conclusions and we could improve our sample of the Malkuni-like fauna obtained there. Most of our work was divided between the little lakes and nearby Ngapakaldi. We used a winch-powered, man-hauled, 1 m scoop to take a part of the overburden off the Stirton Quarry at Lake Kanunka [Figure 25]. *A plough was used to crack the gypsum cap rock off the top of the Tirari Formation at the Daily-Lawson Quarry, so that the scoop could be brought into action to cut this unit down to the fossiliferous level in the Mampuwordu Sand. The Ngapakaldi Quarry was opened up at that lake, and the whole party got a chance to collect the skeletons of the strange little diprotodontoid, later called* Ngapakaldia, *from the green clays that entrapped them 15 million years ago. The intense physical labour was always rewarded by the excitement of collecting remains of very ancient animals whose bones and teeth had been previously unknown to science. It is a unique*

Figure 23. R.A. Stirton working deposit at Lake Palankarinna revealed by fossils seen on a dingo burrow by Paul Lawson, 1958. These yellow sands yielded *Diprotodon* and thus was younger than any previously found fossiliferous unit at Lake Palankarinna. Source: P.F. Lawson.

> *experience today, given the extent of palaeontological exploration in other lands, to be collecting fossils in which every day's work brings to light totally new kinds of animals!* [Figure 26].

South Australia 1962

Tedford (1985) wrote:

> *These were the thoughts that urged us back into the field the following year. By that time, I had joined the staff of the Department of Geology at the Riverside campus of the University of California, and our party was augmented by Michael Woodburne from the Berkeley campus, in addition to 'Stirt' and Paul. By the time we reached Adelaide to outfit our trip, Brian Daily had received a small collection of fossil marsupials from Alcoota Station in the Northern Territory. This collection was made by Keith Rochow, of the Alice Springs office of the Bureau of Mineral Resources, and Alan Newsome then of the Northern Territory Wildlife Management. One look convinced us that the collection of small diprotodontid teeth was of Tertiary age and we resolved to visit that site rather than do further work at Lake Callabonna as planned for that year.*

Waiting in Marree in 1962 was a tractor with backhoe, presented by an interested Adelaide contractor, Vincent P. Keane and a large four-wheeled trailer built by Paul

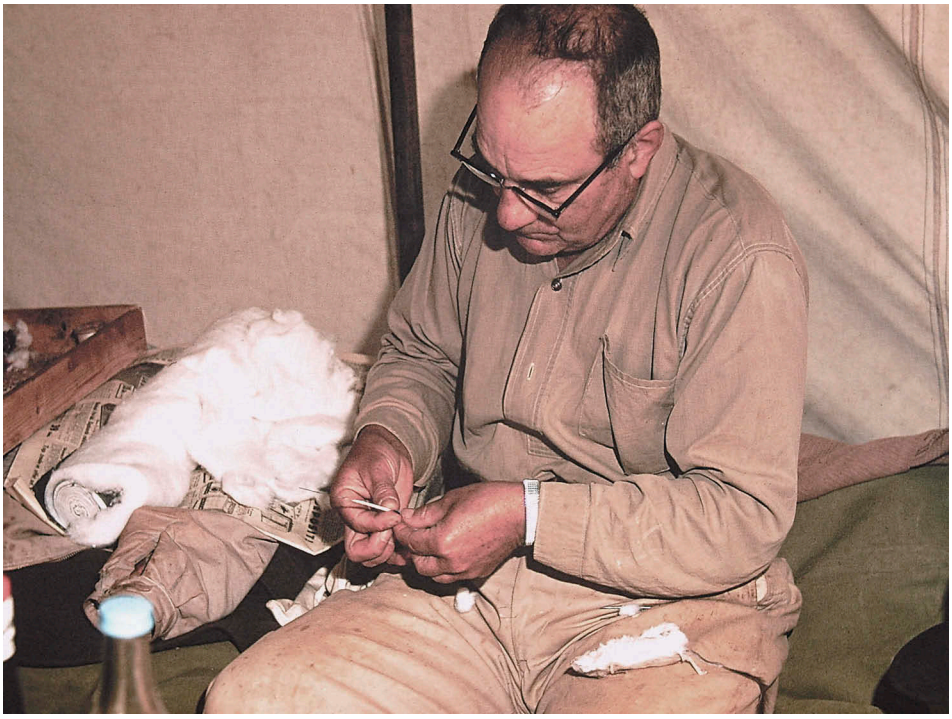


Figure 24. Stirton preparing a bird skin. On all of Stirton's field trips in South Australia, the collection of Recent birds, mammals, and insects was an integral part of the programme. Typically, Lawson shot the specimens and others processed them, principally Stirton. Source: P.F. Lawson.

Lawson for £600 that was *drawn by the tractor* [Figure 27]. *This equipment saved us hundreds of man-hours of backbreaking labour in cleaning the overburden from the Lawson and Ngapakaldi quarries. We also dug trenches to reveal the geology beneath sand-covered slopes. In this way we discovered another bone-bearing Mampuwordu channel at Lake Palankarinna between the Woodard and Daily quarries. This was appropriately named Keane Quarry and proved to contain remains of a large diprotodontid*, Zygomaturus, *that was poorly represented at the other sites*. [Figure 27].

While we were working the Ngapakaldi Quarry, Paul continued exploration along the eastern shore of the saltpan and found a site north of the quarry where several fossil turtle shells and pebbles of silicified sandstone were exposed. He took the backhoe to the site and dug a trench well inland of the shells, exposing the edge of the filled ancient stream channel that contained the turtles. A few days later under Paul's urging, the whole party began to follow the outline of this channel and soon encountered a jaw of a tiny fossil possum. When we reluctantly left that site in 1962 we had collected a variety of marsupials, birds, turtles, fish and impressions of fossil leaves from various units in the channel fill. The fauna was a completely new one, unlike any from the underlying Etadunna Formation and included the first teeth of the weird possum Ektopodon *that we originally thought was a monotreme because the construction of its teeth seemed not to follow the pattern of more advanced mammals. The rest of the mammal fauna included a small diprotodontid, small kangaroos, a koala, a wombat and small possums, all of a more modern stamp than comparable forms from the Ngapakaldi Fauna in the Etadunna Formation. The leaf*

Figure 25. Removing overburden at Stirton Quarry, Lake Kanunka in 1961. Alden Miller on the left helped Stirton on the right collect fossils and Stirton helped Alden collect birds. The plan was for Miller to describe all the fossil birds Stirton collected. He published a few but this was cut short by his premature death in 1965. Stirton then asked Patricia Vickers if she wished to write up the avian component of his Australian fossil collection which she did. Source: R.H. Tedford.

impressions included forms closely resembling Eucalyptus *species; we called this the Leaf Locality* [Figures 28 and 29].

The backhoe was invaluable in working out the geological relationship of the Leaf Locality channel. The channel was cut into the Etadunna Formation and its basal gravel included large fragments derived from that older formation as well as debris (silicified sandstone) from the distant edges of the Lake Eyre Basin. Clearly the channel was part of a well integrated drainage system of a type unknown in the older rocks. We eventually called the channel fill the Wipajiri Formation, its fauna the Kutjamarpu. Thus the backhoe had helped us find a fifth fossil vertebrate fauna, interposed between the Ngapakaldi and Palankarinna faunas, presumably therefore of Late Miocene age. The Wipajiri Fauna was an assemblage of more modern type that included forms similar to those which now occur in Australia's eucalypt forests.

Northern Territory 1962

Tedford (1985) continues

> More surprises awaited us at Alcoota, situated about 120 km northeast of Alice Springs in the upper part of the Sandover River drainage that eventually joins the Georgina and loops around the eastern end of the MacDonnell Ranges in its long course toward Lake Eyre.

Figure 26. Morning tea at Lake Ngapakaldi, South Australia, 1961. Left to right, R.A. Stirton, H.J. Bowshall, Alden and Virginia Miller. Source: R.H. Tedford.

> Keith Rochow and Alan Newsome showed 'Stirt', Mike Woodburne and me the fossil site. Bones were exposed in a gilgai where Keith had found them. The Aboriginals had long known of the locality and had told Alan about it. The best preserved material was revealed by the rabbits, whose warren at the spot was littered with bone and tooth fragments brought up from below. Carefully following the rabbit burrows we encountered a stratum packed with bones about two feet from the surface. We had only time enough to excavate a test pit of about two cubic metres, but what riches there were! I took out one block that contained five jaws stacked on top of one another! The bones, jaws, teeth and skull fragments were so numerous that in some cases they rested on one another without intervening sediment. It took great patience to collect this material doing the least damage to the tightly interleaved bones. The leg bones of giant mihirung birds formed the framework of the bone heap that contained the limbs, jaws and skull parts of three diprotodontids of medium size, two kangaroos, a marsupial lion and crocodiles. This assemblage is now known as the Alcoota Fauna. We had barely scratched the surface of this unique locality, whose fauna seemed more closely allied to the Palankarinna than the Kutjamarpu.

South Australia 1962

Prior to arriving in Australia to begin the 1962 field trip, Stirton wrote in a letter to Norman Tindale, Acting Director of the South Australian Museum, that this was to be his last field

Figure 27. Tractor with backhoe towing large trailer in a bit of strife in the bed of Cooper Creek. Without this equipment donated by Adelaide benefactor Vin P. Keane, much less overburden could have been removed at the Leaf Locality and Lawson-Daily Quarry in the 1962 field season. Source: P.F. Lawson.

trip. After the brief visit to Alcoota, he had a discussion with Norman Fisher, Chief Geologist of the Australian Bureau of Mineral Resources. He had first written to Fisher about his desire to carry out a search for Australian Tertiary mammals in 1949. Fisher was anxious to promote vertebrate palaeontological research in Australia, and Stirton was very much of the same mind, as he had done everything he could to do just that\from the beginning of his programme 9 years before. As a consequence, they agreed to try to persuade their respective organizations to fund field projects in 1963. Woodburne was to be supported to carry out a systematic excavation of the Alcoota locality that would be the subject of his Ph.D. dissertation (Woodburne , 1967). Tedford was to carry out a vertebrate palaeontological reconnaissance of the northern part of the Northern Territory and north-western Queensland. Both of these came to pass in 1963.

New Guinea 1962

Tedford (1985) wrote,

> Woodburne and I had to return to the university, but Stirton went on to the Wau and Bulolo goldfield district in Papua, where placer gold mining early in the century had turned up fossil marsupial bones. Some of these had been described in 1937 by C. W. Anderson of the Australian Museum. Geoff Woodard had been sent by the University of California in 1955 to survey the situation and his report, together with

Figure 28. R.A. Stirton, left, and R.H. Tedford, right, excavating fossils at the Leaf Locality, Lake Ngapakaldi 1962. Source: P.F. Lawson.

> a small collection, had prompted another look. He had been investigating the geological occurrence of these fossils and had located some of the old placer claims where material could still be obtained. The abundance of new fossils and the geological importance of the finds made a review of these faunas desirable. Mike Plane of the Bureau of Mineral Resources office at Wau was to be Stirton's host.

Mike Plane takes up the account here. Alden Miller and Bill Liddicker, an ornithologist and mammalogist, from the Museum of Vertebrate Zoology at the University of California, Berkeley accompanied Stirton to New Guinea in 1962. This trio and Plane continued field work at the Sunshine localities where Woodard had made collections some of which disappeared en route between the port of Lae and San Francisco and were never recovered. The UC party and Plane established a base camp at Bulolo and prospected in the Watut valley. On the UC party's departure, Stirton asked Plane if he could continue prospecting for fossils and work on the stratigraphy of the Otibanda Formation. Plane's efforts led to the discovery of a further 21 fossil localities, and spectacular fossils were excavated from a locality which was subsequently designated the type locality for the Awe fauna. The fossils

Figure 29. Michael O. Woodburne sorting concentrate obtained by underwater sieving of sediments from the Leaf Locality, Lake Ngapakaldi 1962. Source: R.H. Tedford.

were sent to the Museum of Paleontology at UC Berkeley together with further material of living specimens collected from the Wau, Bololo and Watut areas. On receiving this material at Berkeley, Stirton asked Plane if he would come to the USA to continue working on the stratigraphy and fauna of the collection (Figure 30).

Which he did.

Tedford (1985) wrote:

> *Plane brought his collection to Berkeley, where he eventually obtained his masters degree using the fossils as the subject for his thesis* (Plane, 1967). *The Awe Fauna, as the fossil assemblage was called, shows that New Guinea was biologically a part of Australia in the Pliocene with diprotodontids and kangaroos similar to those from Alcoota. Volcanic ash interbedded with the fossil-bearing sediments was eventually dated by isotopic means as being between 3 and 5 million years old.*

Plate 5/2. Awe fauna type locality on top of cliff near umbrella. Looking south, Ekuti Range in background beneath clouds.

Figure 30. From Plane, M.D., 1967. The stratigraphy and vertebrate fauna of the Otibanda Formation, New Guinea. *Bulletin of the Australian Bureau of Mineral Resources, 86*, 1–64.

Australia 1965

1962 was Stirton's last field season in Australia. His final visit to Australia took place in 1965, accompanied by his wife Lillian and graduate student Michael Plane. He attended a meeting of the Australian Mammal Society in Hobart Tasmania and took advantage of that visit to once again examine the holotype of *Wynyardia bassiana* (Figure 31). He also visited Adelaide where he gave a lecture at the University of Adelaide attended by amongst others, Neville Pledge and Roderick Wells, who would in future years carry out mammalian palaeontological investigations of their own. Departing from Adelaide, he bid his final farewell to Paul Lawson.

The legacy

Tedford (1985) wrote:

> *"Stirt's" death in 1966 ended what might be called the "Stirton years", the decade of intensive field search for a record of Tertiary mammals in Australia that centred on the Lake Eyre Basin, carried out by himself, his graduate students, and colleagues from the South Australian Museum* (Figure 32).

Figure 31. Stirton and Michael Plane comparing the skull of the holotype of *Wynyardia bassiana* to that of a brush tailed possum, *Trichosurus*, in the Queen Victoria Museum and Art Gallery, Launceston, Tasmania in 1965. Source: Launceston newspaper.

At the end of his work in Australia, Stirton was well aware that his, "*…quest for the ancestry of the monotremes and the marsupials…*," had only begun. In the *Summary and Conclusions* of a posthumous paper concerning the deposits containing the Tertiary mammals of Australia (Stirton, Tedford, & Woodburne, 1968) appear the following sentences. *These assemblages of mammals support a long held hypothesis that the initial differentiation of the Marsupialia in Australia was an early Tertiary or even late Cretaceous event. Summarizing the evidence on the broader aspects of the evolution of the Australian marsupials, it is apparent even at this state of our knowledge that all the families with living representatives have histories extending back into Miocene times. Most of the adaptive radiation that yielded the late Cenozoic families of Australian marsupials apparently took place before the Oligocene – in Paleocene and Eocene, or possibly late Cretaceous, time. We can only guess at the ramifications of this radiation* [of Australian terrestrial mammals], *for the known fossil record shows only some of the more successful lines that survived into the late Cenozoic. The late Cenozoic history of the Australian marsupials roughly parallels that of the placentals of the northern hemisphere and especially that of the isolated placental and marsupial fauna of Tertiary South America. Thus, there is every reason to suppose that the early phases of the adaptive radiation in Australia also gave rise to a host of groups that failed to persist into the late Cenozoic.*" "*Great strides have been made in the past thirteen to fourteen years in documenting the history of the Australian mammals, but still only a small part of this complex subject has been revealed. One of the principal challenges for the future is the*

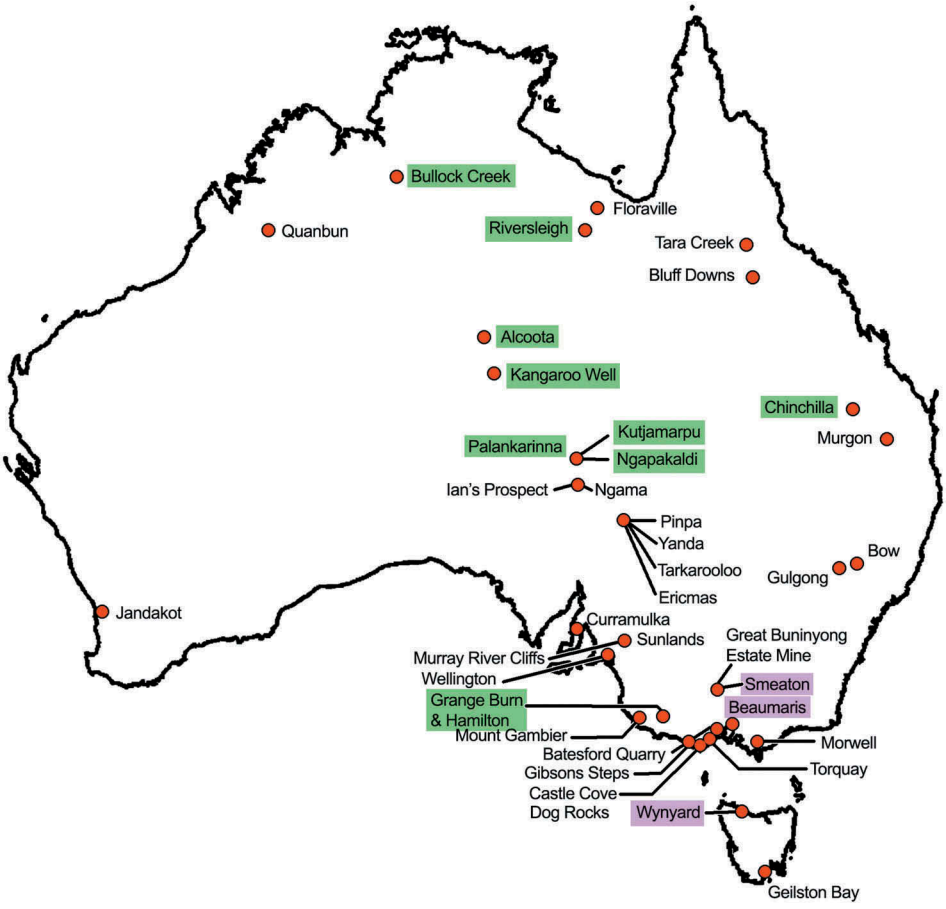


Figure 32. Australian Tertiary mammal localities known to Stirton prior to 27 July 1953 ▬. Australian Tertiary mammal localities mentioned in Stirton, Tedford & Woodburne (1968) ▬▬.

discovery of early Cenozoic mammals in Australia. Only then will the origin and primary differentiation of its marsupial fauna be revealed. Kleinpell (1968) is an obituary for Stirton.

Stirton began his quest with the specific intention of finding Tertiary terrestrial mammals when he first arrived in Australia. He was fully aware that the pre-Pleistocene record of terrestrial mammals on the continent was all but non-existent. However, had Jurassic mammals turned up when he searched Eurumba Creek in 1954, undoubtedly the entire direction of his subsequent research programme would have been entirely different. Addressing specifically this possibility in a letter written at the end of 1953 summarizing the results of his first trip to Australia, Stirton stated, "We have made no effort in our work in Australia to specialize in any particular epoch."

Even after rich sites had been found, he continued to seek additional ones to broaden the knowledge of the history of Australian terrestrial mammals both spatially and temporarily. Although his publications on Australian fossil mammals concern primarily those of Neogene age (Appendix 1), in 1963 he published a review of the genus *Protemnodon*, the record of

which known to him was primarily Pleistocene. So although he is best remembered by Australian vertebrate palaeontologists for his ground-breaking results regarding the Neogene terrestrial mammals of the continent, in his own mind he was not restricted to that time interval (Figures 33–36).

Quite logically, Stirton began his course at the University of California, Berkeley with a focus on the Mesozoic record of the group. In doing so, he expressed admiration for the efforts being made in the Bristol region of the UK to recover the record there of Triassic mammals. This was done by searching for fissure fillings in Carboniferous limestones underlying Triassic terrestrial deposits. In these fissures, Triassic fossils had accumulated in what were when the animals lived, steep sided, narrow caverns. Had Stirton continued to extend the record of Australian terrestrial mammals further back in time than he had been able to do, he might well have carried out a program to systematically ascertain the geological context of every limestone quarry on the continent. He would have been looking for situations where the limestone deposits were overlain as they are in the Bristol region, by younger terrestrial sediments of Paleogene or Mesozoic age.

Other things he might have done in searching for older deposits were to focus on the Cenozoic basalts of various ages widespread in the Dividing Ranges. He would have been aware of the Pliocene mammals then being found by William Turnbull and Ernest Lundelius near Hamilton, Victoria. There the productive sediments are preserved immediately under a basalt flow which had sealed them off from erosion. With a determined effort to explore the rock units immediately beneath the basalt flows in the Dividing Ranges, similar sites of geological ages of interest could possibly have been found.

Figure 33. *"Platyhippus"*, a Christmas present crafted and given to Stirton much to his amusement by his student Patricia Vickers. Being a hybrid between a platypus and a horse, it reflects his interests in both the history of the mammalian fauna of Australia and the Equidae. Source: P. Vickers-Rich.

Figure 34. Some of Stirton's intellectual descendants had a disagreement about the spelling of a geographic feature at Lake Palankarinna. It was eventually resolved by referring to Stirt's field notes. Left to right: Mike Archer, Neville Pledge (being choked), Patricia Vickers-Rich (rear view), Tom Rich and Mike Plane. Artist Rhyllus Plant.

Figure 35. *Dromornis stirtoni* Rich (1979). Restoration by Peter Trusler © Peter Trusler. This bird was the centerpiece of P. Vickers-Rich's (Rich, 1979) research from the Alcoota fauna of the Northern Territory.

Figure 36. The end of a productive day. Source: P.F. Lawson.

Had the occurrence of Early Miocene terrestrial mammals in the Haughton crater or astrobleme on Devon Island been known to him, Stirton might well have carried out a search for similar occurrences in Australia. There fossils are preserved in the lacustrine deposits laid down in a lake that formed in the floor of the crater. With more than 30 astroblems known in Australia, most in the western half of the continent, aware of this occurrence in the High Arctic of Canada, surely Stirton's appetite for extending the record of Australian terrestrial mammals would have led him to seriously consider systematically investigating the circumstances of deposition of any sediments in those craters as possible.

Finally, the widespread occurrence of Cretaceous deposits, both marine and terrestrial ranging in age from late Early to early Late Cretaceous in western Queensland would have drawn his attention.

Sources

This work was based on a combination of sources. In the first place, all the authors knew R.A. Stirton personally and each other as well. Second, Stirton kept voluminous field notes during his visits to Australia in 1953, 1954, 1958, 1961 and 1962. Copies of these are housed at the University of California Museum of Paleontology (UCMP), Berkeley and a photocopy of them is housed at Museums Victoria, Melbourne. Abstracts were written of these field notes. Also, at UCMP, 13 folders in the Stirton archives are devoted to his activities in Australia. Abstracts were written about 371 documents in these archives. Correspondence was carried out with Stirt's son Jack and Stirton family member Judith Wilson, together with a number of former graduate students at the UCMP who knew Stirt, whom contributed useful information. Copies of Stirton's academic transcripts were provided by the Universities of Kansas and California, Berkeley. Published accounts consulted included Stirton (1954) and Tedford (1985, 1991) together with the numerous technical publications by Stirton and his colleagues.

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