Late Pleistocene faunal remains from Seton rock shelter, Kangaroo Island, South Australia

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ABSTRACT. Seton rock shelter (35° 59' S, 137° 03' E) is located in the southwest of Kangaroo Island, South Australia. Excavation of the late Pleistocene deposit in the rock shelter has provided a rich assemblage of mammal, bird and reptile remains dating from more than 16 000 BP to about 10 000 BP. Analysis of these remains shows that the late Pleistocene fauna of Kangaroo Island was more extensive than the depauperate island fauna of today. The disappearance of many species reflects a reduction in open vegetation probably due to a combination of climatic change, the separation of the island postglacially by rising sea level, and the disappearance of a human population within the last 5000 years. The deposit also provides evidence for the contemporaneity of man and one of the extinct Pleistocene kangaroos, Sthenurus cf. gilli, at 16 000 BP.

Introduction

Kangaroo Island lies 14.5 km from the coast of mainland South Australia. Although it was uninhabited at the time of its discovery by Europeans, a stone industry of large core tools, named Kartan by Tindale (1937, 1957), shows that the island had once been occupied by an earlier human population. There has been much speculation about the antiquity of the Kartan industry on Kangaroo Island, and the fate of the occupants of the island (Cooper, 1960; Bauer, 1970).

In 1972, R.J. Lampert reconnoitred all the known limestone caves on Kangaroo Island, looking specifically for stratified deposits containing evidence for human occupation. Excavations were carried out at Seton rock shelter, beside a freshwater lagoon some 6 km inland from the south coast. From a late Pleistocene deposit, an industry of small stone tools was recovered, which was clearly not Kartan. Lampert (in press) has made some preliminary comments on the stone assemblage and its significance for the prehistory of Kangaroo Island.

The deposit contained a rich collection of mammal, bird and reptile bones, egg shell, marine and freshwater molluscs and plant remains, including species not now living on Kangaroo Island. Because of the archaeological and palaeoenvironmental implications of the deposit, the faunal remains have been analysed in detail prior to further excavation. In this report, the rodents have been identified by J.H. Hope, marsupials by E. Edmondson, reptiles by M.J. Smith and birds by G.F. van Tets. The faunal material from Seton will be registered in the collections of the South Australian Museum, Adelaide.

Kangaroo Island

Kangaroo Island is about 145 km long from east to west and averages 60 km in width,
FIG. 1. Kangaroo Island and the adjacent mainland of South Australia.
Faunal remains from Seton rock shelter

with a land area of 4400 km². It is separated from Fleurieu Peninsula by Backstairs Passage (14.5 km wide), and from Yorke Peninsula by the wider expanse of the Investigator Strait (50 km) (Fig. 1). The main body of the island consists of a flat plateau reaching 300 m at its highest point, bounded on the north by steep coastal cliffs, and dissected by north-flowing streams. To the south of the plateau at about 30–50 m altitude lies a discontinuous corridor of impeded drainage behind coastal calcarenites and sand dunes. The dunes, built up during progressive halts in the last major sea level retreat, act as barriers to south-flowing streams, creating many small basins of internal drainage, and often supporting lagoons, as well as preventing the drainage of several more lagoons which may date to former high sea level periods.

The climate is Mediterranean, with rainfall concentrated in winter (July–October). Annual rainfall varies from 425 mm on the eastern end, to 550 mm along the southern coastal plain, and rises on the plateau slopes to a maximum of 813 mm in the northwest. Higher rainfall areas being associated with orographic uplift of moisture-bearing south-westerly air (Bauer, 1959; Specht, 1972). Temperatures are not as extreme as those of nearby regions on the mainland. The mean annual temperature for the island is 15°C, compared with 17°C for Adelaide. Winter temperatures are similar to those on the mainland, but summers are much milder. However, the three temperature recording stations are all coastal, and higher summer temperatures are probably reached in the interior of the island. Maximum summer temperatures in South Australia are associated with northerly winds from Central Australia, however, and these are ameliorated by the gulfs and straits to the north of the island.

The most important vegetation formation is mallee scrub (Wood, 1930; Bauer, 1959). This is dominated by several small species of Eucalyptus, which typically have many stems rising from a large lignotuber, to form an almost continuous canopy at 5–10 m. Structurally the mallee scrub communities are intermediate between low forest and tall closed shrubland. Bauer defines several mallee scrub associations, which tend to be adapted either to the dry eastern part of the island or to the very poor soils of the southern sandplain or dunefields. They all have a prominent shrub understorey, unlike some of the analogous mallee associations on the mainland.

Much of the eastern part of the island supports Eucalyptus cneorifolia–E. rugosa mallee scrub, which has a rather open shrub layer. This community yielded most readily to burning and clearing and was largely converted to pasture during the first stage of European settlement after 1840. The western mallee scrub associations, E. remotia, E. diversifolia–E. rugosa, and that around the Seton site, E. baxteri–E. diversifolia–E. Cosmophylla, usually have dense shrub layers which regenerate readily after burning or cutting, and these occur on soils not naturally suited to the growth of pasture grasses. The western end of the island has been less affected by clearing, which was not begun extensively until the 1950's.

Small areas of dry sclerophyll forest and open woodlands are developed mainly on the wetter plateau and its northern slopes. Around lagoons and along river courses, Eucalyptus cosmophylla forms a woodland with a tall shrub layer. The only non-shrubby communities recorded by Bauer are saline marsh and freshwater swamp sedgelands, and some low coastal heaths.

The whole island has suffered occasional to frequent burning since settlement, but the western mallee scrubs and coastal shrublands have remained dominated by shrubs. The forest and woodland associations may have been more open in the absence of fire. Although open areas may have been present prior to settlement, early reports suggest that the dense mallee scrub was much more extensive on the island than on neighbouring Fleurieu and Yorke Peninsulas.

During the late Pleistocene, Kangaroo Island was connected to the South Australian mainland. Sea level during the last glaciation had fallen to about 100 m below present levels by about 19 000 BP. It then began to rise and eventually isolated Kangaroo Island from the mainland. The glacioeustatic curve derived from southern Australian data by Thom & Chappell (1975) allows approximate cutoff times to be estimated for Kangaroo Island, using depths given on the relevant Admiralty Charts. Thus, there was probably
little areal change until about 12,000 to 13,500 BP. The link between eastern Kangaroo Island and the Fleurieu Peninsula across Backstairs Passage, which is 35 m deep, may have been cut between 9,300 and 10,500 BP; and the wider but shallower (25 m) Investigator Strait, between the north coast of the island and the Yorke Peninsula would have formed soon after, between 8,800 and 9,900 BP.

**Seton rock shelter: general description**

Seton rock shelter (35° 59' S, 137° 03' E) is situated on Mr D. Seton’s property in Section 15 of the Hundred of Newland, on the southern foothills of the western plateau. Consisting of an overhang about 4 m high and 3 m deep, it is the most vertically-expanded section of a long, low, horizontal opening in the northern face of a limestone ridge. The ridge stands at 65 m a.s.l., about 15 m higher than the surrounding sand plain. It is on the western shore of a circular freshwater lagoon about 250 m in diameter, fed from a local catchment by an intermittent stream on the northeast, and drained by an outlet channel running southwest, which is active only during high water levels. Usually the lagoon is less than 1 m deep and is often dry.

The limestone ridge and lagoon lie in undulating country with unconsolidated siliceous dunes and other lagoons of wind-deflated origin. These dunes support *Eucalyptus*...
Faunal remains from Seton rock shelter

diversifolia—E. rugosa mallee scrub, which is dense along drainage lines but stunted and more open on dune crests. Inland from the site the plateau slopes are occupied by E. baxteri—E. diversifolia—E. cosmophylla low sclerophyll forest, and the site itself appears to support an intermediate community between mallee scrub and forest. The dominant tree species is E. fasciculosa, about 5 m in height. There is a dense shrub layer 1–2 m in height consisting of dwarf Casuarina sp., Banksia spp., Isopogon sp., Acacia myrtifolia, Correa rubra, Melaleuca lanceolata and Spyridium spp., interspersed by smaller shrubs such as Astroloma spp. and Adenanths spp. There are few grasses, but the sedge Hypo-

laena fastigiata is common. The vegetation around the lagoon also supports shrubs but is dominated by the large eucalypt, E. cosmophylla, the bog gum, forming a riparian wood-

An initial test pit, 1 m x 1.5 m, was dug inside the dripline of the rock shelter in 1971. Part of this pit, a one-metre square (designated K7), was later excavated to bedrock in 1973. A second one-metre square, K6, was dug adja-

cent to the first and towards the back of the rock shelter. The excavation was carried out stratigraphically, in spits that varied from 5 cm to 10 cm in depth, depending on the strata. The spits in the first square (K7) were necessarily more arbitrary than in K6. In the 1971 test pit, the material excavated was sieved through 2 mm mesh and only the bone and tools so recovered were kept. In 1973, however, the largest rocks and boulders were removed, and the remainder of the material sun-dried and bagged unsifted.

In the laboratory, the bulk material from each level was first sorted by hand to remove most of the bone and artefacts. The matrix was then washed, a little at a time, in a bucket of water. Light material, mainly plant remains and small molluses, was skimmed off the surface and dried. The remainder of the washed material was also dried and again sorted by hand.

The stratigraphy of the deposit is shown in Fig. 2. After examination of the vertical sections, the spits were grouped into stratigraphic units (designated alphabetically a–o from top to bottom), which were later grouped into major units that appeared to have had particular significance in the site’s occupational history. These are:

Unit I
0–0.90 m An upper cultural horizon containing a large hearth, stone tools and much bone. This comprises subunits a–f. One radiocarbon date is available (Lampert, 1972). ANU-925
10 940 ± 160 Charcoal from ash lens in subunit e, square 6.

Unit II
0.90–1.40 m An upper non-cultural pre-
dator horizon, subunits g–k.

Unit III
1.40–1.44 m A lower cultural horizon, marked by charcoal and four stone flakes. Subunit 1.

ANU-1221
16 110 ± 100 Charcoal.

Unit IV
Below 1.44 m A lower non-cultural hori-
zon; subunits m–o.

The matrix throughout is dry sand and limestone gravel. No sediment analysis has yet been attempted. Bone is abundant throughout the deposit, with a marked concentration in subunits e to f. The bone in all levels is highly fragmented and much of that in Unit I is burnt. The results of a size analysis of all unidentifiable bone fragments (the great majority) from square K6 shows a clear distinction between Unit I, the upper cultural horizon, and the three lower units (Fig. 3). For units II–IV, over 80% of bone fragments, by weight, are less than 20 mm in length. In Unit I the percentage of fragments less than
### FIG. 3. Analysis of bone fragmentation, square K6, Seton rock shelter.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Subunit</th>
<th>A (Weight of all unidentified bone fragments)</th>
<th>B (Percentage of fragments less than 20 mm in length)</th>
<th>C (Number of fragments more than 20 mm in length)</th>
<th>D (Mean and standard deviation of length of bone fragments more than 20 mm in length)</th>
<th>E (Percentage of burnt bone, by weight)</th>
<th>F (Weight of flaked stone)</th>
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<tbody>
<tr>
<td>I</td>
<td>a</td>
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20 mm is less than 80% for all subunits; only the very burnt bone from the hearth in subunit e approaches this degree of fragmentation.

All bone fragments longer than 20 mm were sorted in 10-mm size classes, and the mean and standard deviation calculated for each subunit. In all subunits of Unit I the mean fragment length is more than 27 mm, while for subunits h—o in the lower units, the mean length is very constant, lying between 25 and 27 mm. Subunit g is intermediate between the upper and lower groups in this and in other analyses and probably represents a transitional zone. The graph of burnt bone as a percentage of total bone (by weight) distinguishes clearly between Units I and II (Fig. 3). Most of the bone in Unit I, and especially in the hearth in subunit e, has been severely burnt. Much of it is a translucent ashy-white colour, light in weight, and brittle. The graph also separates the lower cultural horizon, Unit III, from the two predator horizons. The burnt bone here is black in colour, and is concentrated immediately below Unit III, rather than in it. While this latter may be an artefact of the excavation procedure, it is likely that fires lit in the cave during the early occupation phase affected bone fragments already present on the cave floor. Apart from this, the graph of burnt bone percentages matches closely an independent measure of degree of occupation, the weight of flaked stone in each subunit.

The composition of the fauna, in both qualitative and quantitative terms, also differs from unit to unit. Most of the bone in Unit I can be attributed to one species, the western grey kangaroo (*Macropus fuliginosus*) and the minimum numbers for this species based on maxillae, mandibles and isolated teeth are certainly an underestimate. Unfortunately the bone is too highly fragmented and burnt to make comparative counts of different skeletal elements. One mammal species, the brushtail possum (*Trichosurus vulpecula*), occurs only in Unit I, as do most of the marine molluscs. (The presence of one specimen of the mollusc *Donacilla* sp. in subunit o may be due to mislabelling during analysis.) Emu eggshell fragments are also concentrated in Unit I (Fig 4). Probably all the eggshell and molluscs, and most of the bone in Unit I results from human activities, although some of the fragments of small mammals, birds and reptiles, which tend to be less burnt, may be derived from the underlying non-cultural levels.

The lower three units contain a very wide range of species. Whereas the fragmentation of the bone in Unit I seems to be due mainly to burning, possibly accompanied by treadage in the small cave, the kind of fragmentation in the lower three units is very similar to that attributed to the Tasmanian devil (*Sarcophilus*...
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**FIG. 4.** Molluscs and egg shell in Seton rock shelter. A, Number of freshwater and terrestrial molluscs; B, Weight of emu egg shell.

harrisii) (Lundelius, 1966; Douglas, Kendrick & Merrilees, 1966). This species is present in Seton, and some bone fragments bear tooth marks. Since the bone from all three lower units is indistinguishable in terms of fragment size, it seems likely that *Sarcophilus* (and possibly also the *Dasyurus* species) is responsible for all the fragmentation. *Sarcophilus* is a scavenger, which might account for the wide species diversity in these levels.

At other cave deposits where some bone fragmentation has been attributed to *Sarcophilus*, owls have contributed as well, for example at Cloggs Cave, Buchan, Victoria (Flood, 1974; Hope, 1973a). However, it seems likely that the bone remains left by owls and marsupial carnivores differ in the size range of species taken. Wakefield (1960a, b) attributed different deposits (at Buchan, Victoria) to owls or dasyurids on the basis of species composition. Medium-sized mammals, particularly possums, predominated in deposits interpreted as dasyurid dens while smaller mammals, especially rats, predominated in the owl deposits. By comparison with the bone deposits at Buchan and elsewhere in eastern Australia, the bone in Units II–IV at Seton can best be attributed to *Sarcophilus* in terms of both fragmentation and species composition.

The lower cultural horizon, III, does not differ from the non-cultural horizons above and below it in fragmentation size of bone. However, it is distinct in two respects. First, there is a peak in abundance of tiny freshwater and terrestrial molluscs (Fig. 4). This is all the more significant, given that Unit III is by volume one of the smallest in the excavation. Although most of these molluscs could have been blown into the site, the larger numbers in Unit III may have been accidentally carried in on plant material by man. This is reminiscent of the accumulation of freshwater molluscs, thought to be carried in on reeds, in the Grotte du Lazaret in Southern France (de Lumley, 1969).

Secondly, within Units II–IV, the identifiable teeth of the largest marsupials, the extinct kangaroo (*Sthenurus* cf. *gilli*) and the kangaroo (*cf. Megaleia rufa*) cluster around Unit III. Although their fragmentation is similar to that of the rest of the bone in these units, there is the possibility that these large animals were carried into the shelter by man, and their bones subsequently chewed up by *Sarcophilus*. There has been much controversy over the question of the relationship of man and the extinct Pleistocene fauna of Australia (e.g. Jones, 1968; Merrilees, 1968). It has been suggested that some of the very few apparent associations of the remains of extinct animals and archaeological material are due to the reworking of older fossil deposits into younger, archaeological ones, as in Madura Cave on the Nullarbor Plain, Western Australia (Milham & Thompson, 1976). At Seton, however, we feel that the small size of the deposit, its location in a rock shelter, rather than in a cave, and the integrity of the stratigraphy (Hughes & Lampert, 1977), makes it unlikely that reworking has occurred. As well, comparable dates have been recorded for species of *Sthenurus* in southeastern Australia (Flood, 1974; Goede & Murray, 1977), and elsewhere on Kangaroo Island. Therefore, it seems that the extinct genus *Sthenurus* must, at least, have been a contemporary of man on Kangaroo Island, and was possibly exploited by him.

**Faunal remains**

**Mammals**

Marsupial and rodents species from Seton are listed in Table 1. Estimates of minimum num-

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<td><strong>Table 1. Minimum numbers of mammal species in Seton rock shelter</strong></td>
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<tr>
<td><strong>Sminthopsis spp.</strong> narrow-footed marsupial mice</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>6</td>
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<tr>
<td><strong>Antechinus cf. flavipes</strong> yellow-footed marsupial mouse</td>
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<tr>
<td><strong>Dasyurus cf. geoffroii/vermiculus native cat</strong></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>4</td>
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<tr>
<td><strong>Dasyurus maculatus tiger cat</strong></td>
<td>1</td>
<td>1</td>
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</tr>
<tr>
<td><strong>Sarcophilus harrisii Tasmanian devil</strong></td>
<td>1</td>
<td>2</td>
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<tr>
<td><strong>Pteramiscus bouchainvillei barred bandicoot</strong></td>
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<tr>
<td><strong>Dasyurus abrotricans</strong> yellow-footed marsupial mouse</td>
<td>1</td>
<td>6</td>
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<tr>
<td><strong>Dasyurus maculatus native cat</strong></td>
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<td><strong>Sarcophilus harrisii Tasmanian devil</strong></td>
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<tr>
<td><strong>Cercartetus lepidus little pigmy possum</strong></td>
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<tr>
<td><strong>Trichosurus vulpecula brush-tailed possum</strong></td>
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<td><strong>Potorous platypus broad-faced potoroo</strong></td>
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<tr>
<td><strong>B. cf. leauer/pennicillata rat-kangaroo</strong></td>
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<tr>
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<td>1</td>
<td>9</td>
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<tr>
<td><strong>Macropus greyi toolache</strong></td>
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<td><strong>Macropus rufogriseus eastern brush wallaby</strong></td>
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<tr>
<td><strong>M. cf. grey/rufogriseus wallaby</strong></td>
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<td><strong>Cl. Megaleia rufa red kangaroo</strong></td>
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<td><strong>Sthenurus cf. gilli</strong></td>
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<tr>
<td><strong>Rattus fuscipes grey southern bush-rat</strong></td>
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<tr>
<td><strong>Rattus lutreolus eastern swamp-rat</strong></td>
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<tr>
<td><strong>Mastacomys fuscus broad-toothed rat</strong></td>
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<tr>
<td><strong>Hydromys chrysogaster water rat</strong></td>
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</table>
bers are based on maxillae and mandibles. In this and later tables, raw numbers have been given, with no correction factors applied to allow for different volumes of the various subunits, because of the small numbers involved and the differences in preservation of identifiable fragments between burnt and unburnt levels. For an approximate correction, particularly in Units II–IV, numbers in subunit g should be divided by four, and those in subunit k by five. Identifications of the smaller marsupials are based on criteria established by Smith (1971, 1972). Because of the fragmentary nature of the bone, specific identification is in some cases tentative or impossible. The classification used follows Ride (1970): habitat considerations are also taken from Ride (1970), except where otherwise stated.

Only seven of these species still occur on Kangaroo Island. Of these, the western grey kangaroo (Macropus fuliginosus), the brush-tailed possum (Trichosurus vulpecula), the bandicoot (Isoodon obesulus), and the bush rat (Rattus fuscipes) are common; the common marsupial mouse (Sminthopsis murina), the little pigmy possum (Cercartetus lepidus), and the swamp rat (R. lutreolus), are uncommon or rare. Two further species, the tiger cat (Dasyurus maculatus), and the eastern native-cat (D. viverrinus), may have occurred on the island within historic times, but have apparently died out (Waite & Jones, 1927; Marshall & Hope, 1973).

Three modern species, the echidna (Tachyglossus aculeatus), the tammar wallaby (Macropus eugenii), and the pigmy possum (Cercartetus concinnus) have not been found in the Seton deposit. The tammar wallaby is one of the most abundant marsupials now on the island (the commonest being the brush-tailed possum, Trichosurus vulpecula). There is also an historic record of the brush-tailed phascogale (Phascologale tapoatafa) on the island (P. Aitken, pers. comm.); it is apparently now extinct. The platypus (Ornithorhynchus anatinus), the ringtail possum (Pseudocheirus peregrinus), and the koala (Phascolarctos cinereus), have been successfully introduced to the island, but attempts to introduce the wombat (Lasiorhinus latifrons), and the rat-kangaroo (Bettongia lesueur) failed (Waite & Jones, 1927). The dingo (Canis familiaris) has never been recorded from Kangaroo Island.

Most of the remaining species at Seton occurred historically on the nearby South Australian mainland, and some have been recorded as fossils on Kangaroo Island. Several are now rare or extinct and their former distributions and ecological requirements poorly known.

Sminthopsis spp. encompasses at least two and possibly three species of marsupial mice, namely S. crassicaudata, which is widespread in woodland heaths and grassland through much of southern central Australia, and S. leucopus or S. murina or both. The latter occurs uncommonly on Kangaroo Island today (Aitken, 1972), and both species are common in sclerophyll forest in southeastern Australia. The yellow-footed marsupial mouse, Antechinus flavipes, is difficult to distinguish from A. stuartii, both species occurring in a wide range of vegetation, from rainforest to woodland, in eastern Australia. Neither has previously been recorded from Kangaroo Island.

Either or both native cats, Dasyurus viverrinus and D. geoffroii, are present in the Seton deposit. Historically, these two species had complementary distributions across southern Australia, D. geoffroii occurring in the east, and D. viverrinus in the west, overlapping in South Australia. Today D. geoffroii survives only in Western Australia, and D. viverrinus is common only in Tasmania, where its distribution suggests a preference for dry sclerophyll and heathland areas. Dasyurus geoffroii has been recorded from forest, woodland and desert associations. The tiger cat (Dasyurus maculatus) has a similar distribution range to D. viverrinus, but it also is common now only in Tasmania, where it is more typical of wet sclerophyll and rainforest habitats (Green, 1974).

The Tasmanian devil (Sarcophilus harrisii), though restricted to Tasmania historically, is represented throughout Australia in late Pleistocene and recent fossil deposits. In Tasmania, the species occurs mainly in sclerophyll forest, but on the mainland it is associated in fossil sites with species of a wide range of habitats, from forest to desert. It has previously been recorded as a fossil on Kangaroo Island (Calaby & White, 1967).
The brown bandicoot (Isoodon obesulus), which is still widespread throughout southern Australia and Tasmania, occurs in sclerophyll forest, woodland and heaths, wherever there is good ground cover. The smaller barred bandicoot (Perameles bougainville) at the time of European settlement occurred in drier areas of southern Australia, from Western Australia to western New South Wales. Its historic distribution in eastern Australia is poorly known; it survives today only on Bernier and Dorre Islands in Shark Bay, Western Australia. Ride (1970) gives its habitat as heaths and dune vegetation.

However, the remains of this species, as well as several others in Seton, occur on the mainland in a series of archaeological and palaeontological sites. These range from the late Pleistocene fossil deposit in Victoria Cave, in the extreme southeast of South Australia (Smith, 1972), through Holocene archaeological sites, such as Fromms Landing rock shelter on the Murray River (Wakefield, 1964b), to late Pleistocene sites in western New South Wales, including Lake Victoria, on the Murray River (Marshall, 1973), Lake Menindee, on the Darling River (Tedford, 1967), and archaeological sites such as Lake Mungo, on the Willandra Lakes (Allen, 1972). The majority of the modern mammal species present in these more northerly sites are animals of arid and semi-arid habitats.

In spite of the small number of identifiable fragments of the two species of bandicoot at Seton, the figures suggest that Perameles bougainville was more abundant in the older levels of the deposit, while Isoodon obesulus was commoner in the younger levels. A similar relationship between the two species has been recorded in cave deposits in Western Australia, where the wider distribution of Perameles bougainville in the past has been attributed to more extensive open vegetation communities, possibly resulting from drier conditions (Merrilees, 1967; Baynes, Merrilees & Porter, 1975).

The hairy-nosed wombat (Lasiorhinus latifrons), though now rare, historically had a wide distribution from the Murray River in South Australia to the far southeast of Western Australia. Very closely-related species occurred in western New South Wales and Queensland. These plains wombats inhabited woodland savannah or grasslands. Remains of Lasiorhinus have been found in all the fossil sites in western New South Wales mentioned above.

The brush-tailed possum (Trichosurus vulpecula) is surprisingly rare in the deposit. Common today on the island, it is widespread throughout eastern and southern Australia. Although usually found in trees, it is not restricted to forest or woodland, occupying caves and holes in the ground in areas where trees are rare. The little pigmy possum (Cercartetus lepidus) was considered to be confined to Tasmania until its discovery on Kangaroo Island in 1964 (Aitken, 1967). In Tasmania, its preferred habitat is dry sclerophyll forest (Green, 1974). It has been found fossil on the mainland at Wombeyan Caves in eastern New South Wales and at Buchan Caves in eastern Victoria (Wakefield, 1972).

At the time of European settlement, the rat-kangaroos Bettongia lesueur and B. penicillata were widely distributed through southern Australia. B. penicillata occurred in southwestern Australia, southern South Australia, northwestern Victoria and western New South Wales; it is now restricted to a few areas in the extreme southwest of Western Australia. Bettongia lesueur similarly extended across southern Australia, but is now found only on Bernier, Dorre and Barrow Islands, in Western Australia. On the mainland it survived longest in parts of Central Australia.

Bettongia penicillata occurred mainly in sclerophyll woodland, while B. lesueur constructed burrows in steppe, heath and sclerophyll vegetation. Finlayson (1958) suggested that the relationship between these sympatric species was one of equilibrium in areas of assured rainfall, with B. penicillata often maintaining denser populations in higher rainfall areas, and B. lesueur supplanting it in areas of greater aridity.

The remains of Bettongia lesueur occur in recent cave deposits in southwestern Victoria (Wakefield, 1964a), and in the extreme southeast of South Australia (Tidemann, 1967), though it is absent from the late Pleistocene deposit in Victoria Cave (Smith, 1971). In contrast, B. penicillata has not been found in cave deposits in Victoria (Wakefield, 1964a), but does occur at Fromms Landing (Wakefield, 1964b), Mt Burr rock shelter (Finlay-
Faunal remains from Seton rock shelter  

son, 1966), and Victoria Cave (Smith, 1972) in South Australia. Both species are present in sites at the Willandra Lakes and at Lakes Menindee, Tandou (Merrilees, 1973) and Victoria along the Darling River.

The broad-faced rat kangaroo (Potorous platyops), which is now possibly extinct, was recorded in historic times only from the extreme southwest of Western Australia. Although subfossils found on Kangaroo Island were described by Finlayson (1938) as a new species, Potorous morgani, the fossil Kangaroo Island and modern Western Australian populations are now considered to be closely related, and not distinct species. The species has been recorded fossil near Dongara, about 430 km north of Perth, at Bremer Bay, and in the southern Nullarbor region (Butler & Merrilees, 1971). In South Australia, its remains have been found in archaeological sites at Fromms Landing and Devon Downs on the Murray River (Wakefield, 1964b; Finlayson, 1938, 1959), and at Victoria Cave (Smith, 1971). The habitat requirements of Potorous platyops are unknown.

The eastern hare-wallaby (Lagorchestes leporides), which is probably now extinct, was abundant in historic times in semi-arid areas of eastern and southern Australia. It has been found in fossil sites at Lake Menindee and Lake Victoria, in archaeological sites at the Willandra Lakes, and in some cave deposits in southwestern Victoria (Wakefield, 1964a) and southeastern South Australia (Tideman, 1967).

Lagorchestes leporides is similar in size to the tammar wallaby (Macropus eugenii) which, although not recorded from Seton, has been found in undated cave deposits on Kangaroo Island, and is now abundant on the island. Macropus eugenii occurred in historic times in southern South Australia and southwestern Western Australia. It was extremely numerous in scrub-covered districts of South Australia (Jones, 1924), but relict populations now survive only on Kangaroo Island, Flinders Island (South Australia), and on the Eyre Peninsula.

These two species are quite distinct in their habitat preferences. Macropus eugenii occurs in dense thickets in dry sclerophyll forest and in mallee and shrub woodland (Calaby, 1971), while Lagorchestes leporides lived as a solitary animal in grassy woodlands and plains (Ride, 1970). The two species have been found together as fossils in only one place, Fromms Landing rock shelter, an archaeological site on the Murray River (Wakefield, 1964b), suggesting that their habitat requirements may be quite strict, and that neither is found in ecotonal situations.

The toolache wallaby (Macropus greyi), and the red-necked wallaby (Macropus rufogriseus), were sympatric species in southeastern South Australia and western Victoria at the time of European settlement. Macropus greyi, which is restricted to this area, is now extinct, while M. rufogriseus is still common throughout its much wider range in eastern Australia and Tasmania. In South Australia, the two species occurred in open dry sclerophyll woodland. Macropus greyi, however, was a semi-gregarious animal, with a preference for grassland, while M. rufogriseus was a shyer animal which retreated to dry sclerophyll vegetation with dense undergrowth as settlement pressure increased (Finlayson, 1927).

The largest species of Macropodidae are very difficult to distinguish from isolated teeth such as occur in Seton. Most of the teeth material, however, is indistinguishable from that of the species still present on Kangaroo Island, the western grey kangaroo, Macropus fuliginosus. However, some upper molar fragments in the lower levels lack a forelink, the absence of which is characteristic of the red kangaroo (Megaleia rufa), and they are tentatively attributed to that species. The western grey kangaroo occurs throughout southwestern New South Wales, South Australia and Western Australia in forests and woodland. The red kangaroo is common in mid-latitudes in Australia, wherever there are open grassy plains.

The specific identity of the extinct kangaroo, Sthenurus, is similarly difficult to determine because of the fragmentary nature of the remains. In contrast to the abundance of Macropus fuliginosus remains, especially in Unit I, Sthenurus is represented by three molar fragments, one in each of subunits k, l and m. It is likely that some of the unidentifiable fragmentary bone belongs to this species as well. On the basis of morphology and size, the teeth are most similar to those of S. gilli. This species, one of the smallest members of
the extinct Pleistocene fauna, has been recorded from Strathdownie and McEacherns Cave, in western Victoria (Merrilees, 1965; Wakefield, 1967) and from Madura Cave, Western Australia (Milham & Thompson, 1976). On Kangaroo Island, Sthenurus sp. occurs in a swamp deposit at Rocky River, about 28 km west of Seton, in association with other extinct Pleistocene genera, including Diprotodon, Zygomaturus and Protemnodon (Tindale, Fenner & Hall, 1935). A recent small re-excavation at Rocky River suggests that the bones of the animals were deposited on the edge of the swamp (or pond) in marly peats which subsequently dried out and eroded. Preliminary radiocarbon dates of about 19,000 BP have been obtained from organic sediments in the deposit. Sthenurus sp. has been recorded from Kelly Hill Caves and Emu Caves, respectively 14 km west and 4 km east of Seton. In these undated deposits, it is associated with modern species, some of which, such as the koala (Phascolarctos cinereus), the Tasmanian devil (Sarcophilus harrisii), and an unidentified wombat, are no longer naturally present on the island (N. Pledge, pers. comm.).

The three species of native mice of the genus Pseudomys found at Seton are now rare, and relatively little is known of their habitat requirements. The smallest, P. occidentalis, has been collected alive only in restricted areas of southwestern Western Australia where it occurs in shrublands and tree heaths. It has been recorded as a fossil from several cave deposits in the southwest of Western Australia, including Devil’s Lair (Baynes et al., 1975), and from Murra-el-elevyn Cave on the Nullarbor Plain (Lundelius, 1964). This record of the species on Kangaroo Island extends its known range considerably eastward.

The two medium-sized species, Pseudomys australis and P. shortridgei, are difficult to distinguish on fragmentary material. Although they are grouped together in Table 1, both species do occur in each subunit. Pseudomys australis is now very rare over much of its historical range. Early distributional records, summarized by Wakefield (1972), suggest that it originally occurred in comparatively dry and open habitats in southern Queensland and inland New South Wales and South Australia. A surviving population, P. a. minnie, occurs in gibber country in much of the Lake Eyre basin, where it is seasonally abundant and at no time rare (P. Aitken, pers. comm.). P. shortridgei occurs in the southwest of Western Australia, and in the Grampians and Portland districts of Victoria. Rare in Western Australia, it was originally collected in swampy country surrounded by thick bush. It still survives in shrub and tree heaths of various densities in western Victoria. Remains of both species occur in caves in southwestern Victoria (Wakefield, 1964a).

The bush rat (Rattus fuscipes greyi) occurs on the mainland from Portland, western Victoria to Mt Drummond on the Eyre Peninsula, South Australia. It is still found on Kangaroo Island, and its insular distribution extends as far west as Goat Island, off Ceduna, South Australia. It is mainly coastal in distribution, though fossils have been found in the Grampians, and in cave deposits in southwestern Victoria (Wakefield, 1963, 1964a). R. f. greyi inhabits areas with a low canopy of dense vegetation or with shelter in the form of boulders and fallen logs. On Kangaroo Island, it is most abundant in stands of Melaleuca growing in seasonally-dry swamps (Taylor & Horner, 1973).

The swamp rat (Rattus lutreolus) also still occurs today on Kangaroo Island, the westernmost part of its range, which extends from Queensland through eastern Australia to Tasmania. On the mainland it is most commonly associated with swamp environments, where it tends to be restricted to the swamp itself, not invading adjacent forest or scrub. A second major habitat is along water courses. Taylor & Horner (1973) first recorded R. lutreolus on Kangaroo Island in thick grass along Rocky River. The adjacent Melaleuca swamp, which was dry at the time, was inhabited only by R. fuscipes greyi. It was presumed that R. lutreolus moves into the swamp in wet seasons.

The fossil record of Rattus lutreolus, however, suggests that it has been able to survive a wide range of environments, so long as riparian conditions are present. The species has been recorded from late Pleistocene fossil sites at Lake Menindee, Tandou and Victoria, and from archaeological sites at the Willandra Lakes. In all these cases, R. lutreolus...
Faunal remains from Seton rock shelter

was associated with a suite of semi-arid species, including several of those present in the Seton deposit.

Similarly, the water rat (Hydromys chrysogaster), whose modern distribution extends throughout freshwater rivers and creeks, and along the coasts of Australia, frequents waterways irrespective of the surrounding vegetation. It also has been recorded fossil at Lake Menindee and Lake Victoria in western New South Wales. The lack of a record of the species as part of the modern fauna of Kangaroo Island is surprising, and may be an oversight, as it occurs along the southeastern coast of South Australia, in the Mt Lofty Ranges and along the Murray River (Watts, 1972), and on the Bass Strait islands (Hope, 1973b).

The broad-toothed rat (Mastacomys fuscus) now occurs in Tasmania and in isolated, relict populations in southeastern Australia. In Tasmania, the species is found in the vicinity of drainage systems of wet sedgelands, which form forest openings (Green, 1968). Modern mainland specimens are all from high-rainfall areas, in alpine and forest vegetation. However, the species is represented in almost all late Pleistocene and Recent fossil deposits in southeastern Australia, many of which are in areas of lower rainfall. Wakefield (1972) summarized its habitats as very wet open areas with low dense vegetational cover, and in areas of wet terrain with grass/sedge coverage in other vegetational formations. Mastacomys has never been recorded living in South Australia, but specimens are known from caves at Mt Gambier, Naracoorte and Carrieton (Calaby & Wimbush, 1964; Tidemann, 1967), and from undated deposits in Mt Taylor Cave, Kangaroo Island. Kangaroo Island is the westernmost record of the species.

On the basis of these distributional and habitat records, the species recognized in the Seton fauna can be divided into three categories. The first of these comprises several species which are restricted to or show a marked preference for grassland or open vegetation: Lasiorhinus latifrons, Bettongia lesueur, Lagorchestes leporides, Macropus greyi, and Megaleia rufa. Perameles bougainville and Pseudomys australis might also be included here, on the basis of their modern distribution and fossil records. Most of these species have either become extinct, or are restricted to a fraction of their former range, since European settlement. None survive in the modern fauna of Kangaroo Island.

Most of the remaining species whose habitats are known either occur in dense vegetation, particularly in heathland or shrubland, or are basically woodland-forest animals with a wide tolerance of vegetation types. Many of these species persist in the modern fauna of Kangaroo Island.

Finally, three species of rodents, Rattus lutreolus, Mastacomys fuscus and Hydromys chrysogaster, are relatively independent of vegetation, being associated with riparian or swampy situations.

Although this categorization oversimplifies a complex situation, it does suggest that there was a greater variety of vegetation around the Seton rock shelter between 20 000 and 10 000 years ago than there is today. This may have consisted of areas of open grassland and woodland, as well as of closed scrub or shrubland. The latter, denser vegetation formations were probably associated with the Seton Lagoon.

Birds

Material from birds is slight in quantity when compared with that from mammals and reptiles. It consists of shell fragments of emu eggs, mainly in Unit 1 (Fig. 4), and of small bits of bone of about forty other species throughout Units II–IV (Table 2).

The classification of the birds follows Condon (1975) for non-passerines, and Schodde (1975) for passerines. Identification is based on comparisons with reference material in the collections of the National Museum of Victoria (Melbourne) and the CSIRO Division of Wildlife Research (Canberra). Many Australian species are not represented by skeletal material in these, nor in any other reference collections. Consequently it was not possible to determine the generic and specific identity of some very distinctive passerine long bones.

About thirty bones appear to be of five species of passerine birds, and forty bones may be attributed to at least two species of Meliphagidae. The latter bones are similar in
TABLE 2. Minimum numbers of bird species in Seton rock shelter. Figures in parentheses for Meliphagidae and Passerines are numbers of different species present.

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<td>1</td>
<td>1</td>
<td>1</td>
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<tr>
<td></td>
<td>very small</td>
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size and shape to those in the genus Meliphaga. Honeyeaters occur throughout Australia, including Kangaroo Island. Other bones were too fragmentary to make more than a tentative determination as to genus or species. Unless otherwise indicated, statements about the present range and status of the birds are based on Abbott (1974), and Condon (1968, 1975).

Of the birds that appear to be represented in the material from Seton, five species of waterbirds and eight species of land birds have not been recorded on the island in historical times. The water birds are Pachyptila cf. salvini, Puffinus sp., Threskiornis molucca, Anseranas semipalmata and Rallus philippensis. Several species of Pachyptila may be found washed up on South Australian beaches; none of them breeds there. The shearwater species may be either the flesh-footed shearwater (Puffinus carneipes), or the short-tailed shearwater (P. tenuirostris). Both species occur in the seas around Kangaroo Island, and the short-tailed shearwater breeds in large numbers on nearby islands.

The white ibis (Threskiornis molucca) is nomadic; the pied goose (Anseranas semipalmata) formerly bred in southeastern Australia, but is now a rare vagrant. The land rail (Rallus philippensis) is nomadic, and ranges throughout Australasia. It has not been recorded on Kangaroo Island, but does occur on nearby islands in Spencer Gulf.

The landbirds not occurring naturally on Kangaroo Island at present are Hieraaetus morphnoides, Ocyphaps lophotes, Grallina cyanoleuca, Gymnorhina tibicen, Strepera graculina, Lathamus discolor, Pezoporus wallicus and Gallinula (Tribonyx) mortierii. Of these, the little eagle (Hieraaetus morphnoides) occurs in woodland and is an occasional nomadic breeder on the mainland of South Australia. The crested pigeon (Ocyphaps lophotes), and the magpie lark (Grallina cyanoleuca) occur naturally in open country on the Fleurieu Peninsula, and together with the magpie (Gymnorhina tibicen), have recently colonized man-made clearings on Kangaroo Island, either having been introduced by man or as vagrants.

The swamp parrot (Pezoporus wallicus) is restricted to coastal heathlands of southern
Australia and Tasmania, and the swift parrot 
(*Lathamus discolor*), a woodland species, 
breeds in Tasmania and migrates in winter to 
southeast Australia, rarely reaching South 
Australia. The pied currawong (*Strepera 
graculina*) occurs in montane woodland, 
mainly in eastern Australia, but not in South 
Australia or on Kangaroo Island.

The flightless rail, the Tasmanian native 
hen (*Gallinula (Tribonyx) mortierii*) frequents 
open grassy areas near water. It is a secondary 
grazer, relying on swards created by bush-
fires and other grazing animals including mar-
supials (Ridpath, 1972). In historic times it 
has been restricted to Tasmania, though a 
fossil form, *G. (T.) m. reperta*, occurred in the 
late Pliocene and early Pleistocene in south-
eastern Queensland (Olson, 1975). The 
remains at Seton are too fragmentary to make 
a subspecific determination.

The assemblage of bird species at Seton 
supports the environmental picture suggested 
by the mammals, namely the presence of 
more open country than that noted for 
Kangaroo Island historically. The large num-
ber of waterbirds and those that require 
swampy conditions affirms the existence of 
the lagoon throughout the period of deposi-
tion of at least the lower half of the deposit. 
Further, several of the species found at Seton 
but no longer occurring on Kangaroo Island 
are now restricted to Tasmania or to south-
eastern Australia. Their past and present dis-
tributions parallel that of the broad-toothed 
rat *Mastacomys*.

**Reptiles**

Although the reptile fauna comprises fewer 
species than the mammalian or avian, the 
minimum number of specimens per reptile 
species was much higher at some levels (Table 
3). Identifications are based on a wide range 
of preserved bones. The two most abundant 
species are large skinks, the shingle-back 
(*Trachydosaurus rugosus*), and the blotched 
bluetongue (*Tiliqua nigrolutea*). Neither 
species has been recorded from Kangaroo 
Island previously. For *Trachydosaurus rugosus*, 
many bones show characteristics specific for 
the species, the quadrates and angulars in 
particular being quite distinctive. All remains 
of *Tiliqua* have been attributed to *T. nigro-
lutea* rather than *T. scincoides*, although the 
osteological differences between the two 
species are slight, and specific determination 
can be made only on complete bones. The 
number of complete bones from Seton is 
low, despite abundant material. Wherever 
diagnostic features are preserved, they are 
those of *T. nigrolutea*, but the possibility 
that *T. scincoides* is also represented in the 
collection cannot be excluded.

*Trachydosaurus rugosus* is widespread over 
the southern half of continental Australia, 
except for the coast and ranges of the east

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**TABLE 3. Minimum numbers of reptile species in Seton rock shelter. Second row of figures for Elapidae gives total number of vertebrae found in each level.**

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<th>II</th>
<th>III</th>
<th>IV</th>
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<tbody>
<tr>
<td></td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><em>Trachydosaurus rugosus</em> shingleback lizard</td>
<td>2</td>
<td>1</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td><em>Tiliqua nigrolutea</em> blotched bluetongue</td>
<td>5</td>
<td>7</td>
<td>34</td>
<td>17</td>
</tr>
<tr>
<td><em>Ct. Egernia whitei</em> White's skink</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td><em>Varanus sp</em> goanna</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Amphibolurus spp</em> dragons</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>Elapidae snakes</td>
<td>1</td>
<td>1</td>
<td>1</td>
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9 40 16 32 36 110 | 19 | 29 | 42 | 30
and southeast (Cogger, 1975). It is found on the western offshore islands of Western Australia (Bernier, Dorre, Dirk Hartog, Abrolhos and Rottnest Islands) (Douglas & Ride, 1962; Worrell, 1963), but not on the southern offshore islands of Western Australia, nor South Australia. An attempt to establish *T. rugosus* on Kangaroo Island (Waite, 1929) was apparently unsuccessful.

*Tiliqua nigrolutea* is a ‘cool temperate’ species found in Tasmania, the Bass Strait islands and southeastern Australia (Rawlinson, 1974). Its present range does not extend west of Mt Gambier, and its presence as a fossil on Kangaroo Island confirms Rawlinson’s suggestion that in the past its range may have been greater. The small skink tentatively recorded at Seton, *Egernia whitti*, is common on Kangaroo Island today. A goanna (*Varanus gouldii*) is now abundant on the island, in contrast to the sparse representation of varanid bones in the deposit.

Both a large and small species of agamid lizard occur in the site. Because size alone is not a reliable criterion for identifying reptile fragments, the agamid specimens have been lumped together in Table 3. The larger species conforms in size and shape with the bearded dragon (*Amphibolurus barbatus*), but cannot positively be identified. This species has not been recorded from Kangaroo Island and no other agamid living on the island at present grows to this size. The smaller species is consistent with *A. decresii*, which occurs on the island at present.

The elapid snakes are represented by vertebrae only, none of which are complete. At least two species are present, and one of them is consistent with a *Notechis* species. The black tiger snake (*Notechis ater*) and the copperhead *Austrelaps superbus* are found on Kangaroo Island today.

**Mollusca**

At least nine genera in four families of freshwater and terrestrial molluscs were recovered.
from the Seton deposit (Table 4). These have been identified by Dr Brian Smith, of the National Museum of Victoria, Melbourne. At the present state of knowledge of the taxonomy and habitats of Australian freshwater and terrestrial molluscs, only generalizations can be made as to the significance of the species present.

Molluscs of the family Endodontidae are terrestrial, with a wide temperature and water tolerance. They tolerate saline conditions. The family Hydrobiidae includes species characteristic of a wide range of environments, from hypersaline to freshwater. *Potamopyrgus* tolerates saline to freshwater conditions, as well as fluctuating salinity. *Pupipryx* is found in flowing water; *Coxiella* in saline conditions. Members of the family Planorbidae are found in freshwater, which is either slowly flowing or non-flowing; *Gryraulus* specifically likes non-flowing waters with plenty of weed. Species of the family Succineidae are terrestrial or marginally aquatic, tolerating freshwater or saline conditions.

The general conclusion that can be drawn from the genera present, and their fairly even distribution through subunits f–o, is that water, at times fresh, was present throughout the period of deposition of most of the deposit. The freshwater genera of the family Planorbidae tend to be concentrated in the lower levels, while the more tolerant genera are found throughout.

Fragments of seven species of marine molluscs were found, mostly concentrated in Unit I. These have been identified by Dr K. Conover, Department of Prehistory, Research School of Pacific Studies, Australian National University, Canberra. The most abundant of these are the dog cockle (*Tucetona flabellatus*), represented by seven valves, and the mussels *Brachiodontes rostratus* and *Mytilus planulatus*. The remaining species are each represented by one specimen. While the mussels occur on rocky substrates, and *T. flabellatus*, *Katelysia* sp. and *Donacilla* sp. are sandy beach dwellers, together they suggest a protected beach environment, such as found in protected lagoons and backwaters. The limpet, *Cellana* sp., occurs in contrast, on more exposed rock platforms. Today, such environments lie some 6 km from Seton, but in Unit I times they must have been at least 9 km away.

**Palaeoecological implications: discussions and conclusions**

Each of the major faunal groups represented at Seton (mammals, birds and reptiles) suggests the same environmental picture during the late Pleistocene. While areas of woodland, shrublands and heath persisted, there must also have been more extensive open vegetation, probably grasslands, than today occurs naturally on Kangaroo Island. The historical range of many of the mammal species and, among the reptiles, of *Trachydosaurus rugosus*, has been in semi-arid areas of southern Australia; most extended either historically or in the past into the southeast of South Australia. At the same time, a further element of the late Pleistocene fauna, consisting of some birds, of *Mastacomys fuscus*, and of *Tiliqua nigrolutea*, could be described as cool-temperate, and is now restricted to Tasmania and the more southeasterly areas of the mainland. Furthermore, the presence of many species of waterbirds, of some rodents and of freshwater molluscs, indicates the immediate presence of water, probably in the form of the Seton lagoon.

Three major changes have affected Kangaroo Island since the time of deposition of the Seton site: a change in the regional climate, a change in the position of the coast, and the disappearance of man and other predators.

Recent work by Dodson (1974, 1975) in the extreme southeast of South Australia has established a climatic sequence extending back 50,000 years, based on pollen analysis and sedimentology of cores from Wyrie Swamp and Lake Leake, shallow basins which lie respectively 50 km northwest of Mt Gambier, and 250 km southeast of Kangaroo Island. Together with similar dated records from lakes in western Victoria, and the Willandra system in western New South Wales, these have provided the data for a recent reconstruction of Late Quaternary climates in southeastern Australia (Bowler et al., 1976). This suggests that from 25,000 BP there was a widespread change towards dry conditions, with lakes drying and aeolian activity. The maximum phase of aridity occurred between 17,000 and 16,000 BP. The fall of lake levels at the beginning of this period (i.e. near the glacial maximum) is not yet explained; if
they fell while temperatures were still at or near their minimum values, a drastically lower rainfall is implied. The period between 15 000 and 10 000 BP was one of transition from intense aridity to a more humid environment; however, conditions were still relatively dry while the temperature was rising.

About 9500 years ago water levels in lakes along the southern coastal fringe of southeastern Australia began to rise, maintaining maximum Holocene levels from 7500 to 5000 BP. In the early-middle Holocene, this area thus appears to have been effectively wetter than at any time during the previous 15 000 years. Because temperatures by then had already risen from their glacially-depressed values, a real increase in precipitation is indicated. Moreover, vegetation histories from several widespread pollen sites in Australia and New Guinea show that temperatures then were slightly higher than at present throughout the region. To maintain higher lake levels despite increased temperatures, rainfall along the southern fringe of the continent during the early-middle Holocene must have been significantly higher than at present. Although small oscillations have occurred in recent millennia, there is no evidence to suggest that southeastern Australia during the past 10 000 years has ever been more than marginally drier than it has been in the last 100 years.

The presence at Seton from more than 16 000 to about 10 000 BP of both semi-arid grassland species and species now restricted to more southerly areas, such as Tasmania and southern Victoria, is consistent with the cooler and drier climate proposed for southern Australia at this time. The fauna also indicates that some form of open water or marshy condition persisted throughout this time. If the small Seton lagoon continued to hold water, even seasonally, other larger lagoons on Kangaroo Island must have done so as well. This is in contrast to the evidence for the drying-up of most lakes in southeastern Australia in the late Pleistocene.

The late Pleistocene geography offers an explanation for this seeming paradox. When Seton was first occupied by man, Kangaroo Island was part of an extensive shelf of land exposed by lower sea levels, with broad plains stretching away to north, south and east (Fig. 1). To the west, however, the proximity of the edge of the continental shelf brought the Pleistocene coast at the time of greatest sea level retreat within a mere 10–20 km of the west coast of the modern island. At that time also, the highest point of Kangaroo Island, just north of Seton, was about 400 m above sea level. Given this height, and the closeness of the west coast, persistent westerly winds at the time Seton was first occupied (Bowler, 1975) would have ensured that the western sector was the wettest part of the island, just as it is today. Winds from W to SW would have brought the wettest weather, but NW winds from the arid interior of the continent would have blown wholly over land, not across the waters of Spencer Gulf as they do today, bringing with them dry conditions. This combination of wet and dry winds may have resulted in a steeper rainfall gradient than exists today, with a consequent greater range in vegetation type.

Finally, the possible effect of man on the past environment must be taken into account. The archaeological evidence suggests that during the late Pleistocene Kangaroo Island had a long history of human occupation, which ended sometime after the island was cut off from the mainland. Exactly when man disappeared from Kangaroo Island is unknown, but as yet there is no direct evidence for human occupation there within the last 4000 years.

The maintenance of open grassland or woodland by aboriginal fire pressure has been well-documented for Australia and Tasmania (Jones, 1969; Hallam, 1975). The dense mallee scrub and shrublands of Kangaroo Island can be contrasted with early reports of, presumably, man-induced vegetation in the Adelaide district, which was described as ‘like an English park, with long grass in abundance, and fine trees scattered about’ (Hope, 1968: p. 114). Poor soils on the island may contribute to this contrast, but the density of the vegetation on Kangaroo Island may be partly due to reduced fire frequency after the human population had disappeared.

Occasional intense fires could be expected to increase the density of some mallee associations rather than to open them up, and this in fact seems to have happened in parts of the island since its occupation by Europeans. Burning by aborigines is usually a more
regular and frequent pattern of cooler fires, giving rise in many areas to patches of grassland. Thus the inhabitants of the island may have played some part in the development or maintenance of areas of grassland in the late Pleistocene. The effects of firing would have been reinforced by a drier climate.

The major climatic change during the deposition of the Seton site was the beginning of warmer and wetter conditions at about 10,000 BP, probably during the deposition of the top few levels. Unfortunately any effect of this on the fauna at Seton is masked because deposition at the site changed from the multi-species refuse of Sarcophilus, to an archaeological midden containing fewer species. There is very little bone in the deposit above subunit e, dated at 11,000 BP, so any change in the local small mammal fauna after this time is not obvious, unless represented by the remains of Trichosurus vulpecula, which is found only in Unit I, and by the increase in abundance of Isoodon obesulus relative to Perameles bougainville.

The fauna of the island, however, did change. Within the last 10,000 years, the number of vertebrate species has declined markedly, resulting in the modern depauperate fauna. Excluding genera extinct throughout Australia, such as Sthenurus, and modern introductions to the islands, the number of marsupial species has dropped from twenty or so to ten, and of those ten, three are known only from historical records. The number of rodent species has dropped from seven to two. Eight species of land birds have been lost (though some of these are now re-invading the island), and three lizards have gone.

On Kangaroo Island, many of the mammal species which disappeared were those of more open environments, such as Lastorhinus latifrons and Lagorchestes leporides. Their extinction presumably reflects the development of dense vegetation over the entire island during the Holocene, in response to increasing rainfall, accompanied possibly by a reduction in burning. Similar declines in non-forest animals in terminal Pleistocene time have been recorded from elsewhere in southern Australia, notably in Devil’s Lair, in the lower southwest of Western Australia (Baynes et al., 1975). Some of these species were widespread in semi-arid areas on the mainland in historic times, but were among those most immediately and worst hit by European settlement, mainly because their open grassland habitat was the first to be used for farming. Relict populations tend to occur in semi-arid areas, but some species survive only on very small islands off Western Australia.

Other species, however, some of which prefer or tolerate vegetation types persisting on Kangaroo Island, had disappeared not only from the island but from much of their Pleistocene range, before the arrival of Europeans in Australia. For example, the youngest remains of Sarcophilus harrisii known from the mainland are about 400–600 years old, from Western Australia (Archer & Baynes, 1972), and the species is now restricted to Tasmania. Mastacomys fuscus now occurs only in Tasmania and in isolated pockets on the mainland, but was widespread throughout southeastern Australia in the late Pleistocene and early Holocene. It is unlikely that the disappearance from Kangaroo Island of either the species of semi-arid habitats, or those now restricted to Tasmania and the wetter parts of southeastern Australia, is related to the island situation alone. On the other hand, it must be pointed out that Kangaroo Island, like Tasmania, has acted as a refuge for some species, notably Macropus eugenii and Cercartetus lepidus.

The reduction in numbers of species of larger herbivorous mammals from Kangaroo Island, however, does parallel that recorded for the islands of Bass Strait (Hope, 1973b). In Bass Strait, two species of macropodid, one large and one small, still persist on the two largest islands, King and Flinders. These are the red-necked wallaby (Macropus rufogriseus) and the Tasmanian pademelon (Thylologale billardierii). The smaller islands in Bass Strait support only one or other of these species, and neither survives on islands whose area is less than 1 km². The eastern grey kangaroo (Macropus giganteus) died out on the islands (it is recorded fossil on Flinders Island at more than 8000 BP), but survives in Tasmania.

Kangaroo Island, at 4400 km² much larger than either King (1100 km²) or Flinders Island (1330 km²), also supports only two macropods now, but in this case the larger species to survive was the western grey kanga-
Faunal remains from Seton rock shelter

roo (Macropus fuliginosus), while M. rufo-griseus died out, along with the toolache (M. greyi). The only small macropodid surviving on Kangaroo Island, the tammar wallaby (Macropus eugenii) is similar in size and habitat to Thylogale billardierii.

The absence of certain birds species from Kangaroo Island might be due to insularity, or to the lack of suitable habitats. Abbott (1974) has argued that on distributional grounds, some bird species, including Lathamus discolor and Pezoporus wallicus, may once have occurred on Kangaroo Island and subsequently died out, while others, including Grallina cyanoleuca may not have moved into areas of the nearby mainland until after the island was cut off. He considered that Strepera graculina superspecies might fall into either category, but saw no way of testing this. Ford & Paton (1975) argued that the lack of suitable habitats, especially of open savannah woodland and grassland on Kangaroo Island, rather than the presence of a water barrier, had prevented colonization by many species, citing as evidence the recent establishment of several grassland species in man-made clearings on the island.

The records from Seton show that several of these species did in fact once occur on the island and have subsequently died out there. Their recent re-colonization suggests that the original extinctions were due to the development of unfavourable vegetation formations. The distribution patterns of several species of birds, however, resemble Mastacomys fuscus and Sarcophilus harrisii, in being now restricted to Tasmania only, or to Tasmania and the adjacent southeastern mainland. Their disappearance from Kangaroo Island may also be part of a more general withdrawal to the southeastern corner of Australia.

The reptilian fauna, too, shows the same pattern. Of three medium-sized (adults c. 200 g) omnivorous lizards, not one has survived. The present ranges of the three species overlap only in a small region of the southeast of South Australia. One of them, Trachydosaurus rugosus, is generally considered to be an inland, semi-arid country species (Worrell, 1963). Its disappearance from Kangaroo Island parallels that of the open country mammals and birds, and may also be linked to Holocene vegetation change. Tiliqua nigrolutea, however, is a cool-temperate species, which is now found only in Tasmania and southeastern Australia, and its extinction on the island matches that of the Tasmanian birds and mammals. Island size alone seems an unlikely explanation for the disappearance of these reptile species. Although all three died out on Kangaroo Island, Trachydosaurus rugosus lives on many Western Australian islands and Tiliqua nigrolutea occurs on some of the Bass Strait islands (Rawlinson, 1974).

In summary, the faunal assemblage recorded from Seton, containing species that do not occur sympatrically today, suggests an environmental regime for the late Pleistocene that no longer exists in southeastern Australia. The disappearance of many species from Kangaroo Island within the last 10 000 years can be explained most simply in terms of climatic change, that is following the development of warmer and wetter conditions. The activities of aborigines, and the relaxation of these activities within the last 5000 years also may have contributed to these changes, as also may the effect of isolation after the postglacial rise in sea level.

Acknowledgments

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