Vol. 10, No. 3 JULY, 1972

Helictite

JOURNAL OF AUSTRALASIAN CAVE RESEARCH

Steep talus slope in collapse doline leading down to Weebubbie Cave entrance, Nullarbor Plain. Surface vegetation is semi-arid mallee. See page 60.

Photo: J. Crowle

"H E L I C T I T E"

Journal of Australasian Cave Research

VOLUME 10, NUMBER 3 Published Quarterly JULY, 1972

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Price of this issue: To non-subscribers, A$1. Additional copies to subscribers, 75ç. Included in annual subscription, A$2.50 per year post paid Australia. All foreign subscriptions, A$2.60 per year, post paid. All subscriptions taken on basis of full volume of four numbers. Correspondence, contributions and subscriptions to Editor, "Helictite", Post Office Box 183, Broadway, New South Wales 2007, Australia. "Helictite" is printed and published by E. A. Lane.

ABSTRACTS AND REVIEWS

THE EXPLORATION AND SPELEOGEOGRAPHY OF MAMMOTH CAVE, JENOLAN. By J.R. Dunkley, assisted by E.G. Anderson. Speleological Research Council Ltd., Sydney, 1971. X + 53 pp, 21 maps, 31 photographs, foldout diagram. Price Aust$2.75, incl. postage.

This is the second book to be published by the Speleological Research Council Ltd. and continues a trend towards high-quality production of speleological publications in Australia. Its aim is different from the in-depth multidiscipline approach of the Council's earlier Caves of the Nullarbor and its style suggests it will have more appeal to the general reader. It is, however, intended as a prelude to a more specialised publication on the hydrology and geomorphology of the cave.

In general, production and layout are pleasing and the text well written. The author is not at a loss for superlatives, a simile, or a short quotation when scientific terminology falls short of his needs. An historical introduction to exploration of the cave is followed by more specific notes on the exploration of each section of the cave, routes through the cave, passage details and possibilities of further discovery. Each section is discussed in turn and illustrated with maps and photographs.

An outstanding feature is the quality of the maps, due to the careful work of E.G. Anderson. Perhaps outlines are a little too bold and tend to "run" in places, but otherwise quality of drafting and symbolism of cave features is excellent. The street directory layout is useful, and sectional maps can be located quickly by key maps. A speleologist, interested in a particular section, can readily copy a map and use this as a basis for additions and detailed note-taking in the cave. Tabulation of CRG grades, etc., in an appendix is convenient. However, it is not exhaustive enough to permit adequate assessment of grades in all sectional maps. Some passages need to be added to the maps, including the morphologically significant Waterfall Passage. Some sections can be upgraded and passage detail added.

Particularly impressive is the isometric diagram of the cave. This is an excellent method to convey overall three-dimensional impressions of levels and layout in a basically strike-controlled linear cave. The shortcomings of the technique discussed by Anderson should be kept in mind. Developed longitudinal sections are grave omissions from the maps and their absence greatly reduces the utility of the excellent plan and isometric diagram. Apart from a few printing errors, an odd lapse in the text raises a questioning eyebrow. For example, "a more or less horizontal bedding plane squeeze" seems out of place in steeply dipping beds. Photographs have reproduced well, but numbering of plates and appropriate reference in the text would be an improvement. Some captions could be more descriptive, and that for the plate on p. 30 appears misleading. In general, this is a useful and timely book. Already it has brought to light additional history by jogging memories and has stimulated renewed exploration in likely situations. Revisions will soon be needed.
- G.S. HUNT.

PHASCOLARCTOS (MARSUPIALIA, VOMBATOIDEA) AND AN ASSOCIATED FOSSIL FAUNA FROM KOALA CAVE NEAR YANCHEP, WESTERN AUSTRALIA

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Abstract

A recently discovered fossil fauna from Koala Cave (Yn 118), Yanchep, Western Australia, contains the marsupials *Sthenurus brownei*, *Potorous platyops*, *Phascolarctos* sp., *Perameles* sp., *Vombatus* sp., and a large snake. The fauna is in some respects comparable with the Mammoth Cave and Labyrinth Cave faunas of the Cape Leeuwin-Cape Naturaliste region.

Introduction

In 1971, Mr. S.B. Bennett showed Mr. P.J. Bridge, Mr. and Mrs. B.G. Muir, Mrs. S.J. Hallam and the author a series of caves he had discovered in "Coastal Limestone" near Yanchep, about 48 km north of Perth. One of these, now known as Koala Cave (Yn 118), drew attention when Mr. Bridge discovered a dentary of *Sthenurus brownei* (Western Australian Museum fossil vertebrate specimen 72.1.1139) in a deposit of loose reddish sand well within the cave. Later, Mr. Bridge, Mr. G.W. Kendrick, Mrs. E. Archer and the author returned to the cave to obtain a small sample of the fauna for preliminary analysis. Dr. D. Merrilees and Messrs. Bennett and A. Baynes returned on two further occasions to recover more of the material. The entire collection has been lodged in the Western Australian Museum.

The Nature of the Deposit

The *Phascolarctos*-bearing deposit in Koala Cave consists of a loose reddish quartz sand which is locally lithified. Some of the lithified parts of the deposit adhere to the roof of the cave. This deposit contains bones, limestone fragments, snail shells, charcoal, and root structures of the sort referred to as dikaka (Glennie and Evamy, 1968). The fauna reported in this paper was collected from the unconsolidated parts of this deposit on the cave floor (Figure 1).

In addition to the *Phascolarctos*-bearing deposit, there are at least two other sorts of clastic deposits visible in Koala Cave. The first is a strongly lithified, perhaps intraformational, breccia. It contains no visible bones, charcoal or other non-limestone clasts. It forms at least part of the ceiling to which the lithified parts of the *Phascolarctos*-bearing deposit adhere. The other sort of clastic deposit is an unconsolidated dark sediment which contains some bones and charcoal. This darker deposit covers much of the floor of Koala Cave. Associated with all three clastic deposits are flowstones, dripstones or moonmilk, some of which probably represent episodes of carbonate deposition by vadose waters (Jennings, 1971).

Downslope and northwest of the accumulation of the Phascolarctos-bearing deposit is a depression in the cave floor. Sediments are slowly filtering down through a hole at this point into what may be spaces in underlying limestone rubble. The reddish Phascolarctos-bearing sediments and the darker unconsolidated sediments are both contributing material into this area. A small collection of bones including a premolar of *Sthenurus brownei*(W.A.M. 72.1.1146) was retrieved from sediments removed from the hole. However, because of the mixed origin of the sediments, the material recovered is not discussed in this paper.

Interpreted History of the Koala Cave and its Deposits

Koala Cave is a curved fissure trending approximately northeast by southwest. It is probable that the cave resulted from a collapse producing an inclined fissure of the sort discussed by Bastian (1964). When collapse or subsidence occurs over a weak area, such as an underground cavity, lateral fissures may form. Brain (1958) describes such a process for the development of certain caves of the Transvaal such as Swartkrans Cave. If collapse were to open these fissures to the outside they would receive detritus from the surface. Depending on the size of openings to the surface, the material accumulated in the fissures would consist of varying proportions of externally and internally derived debris.

Because the strongly lithified breccia of Koala Cave contains no bones or charcoal, it probably developed either as the cave formed by collapse (Jennings, 1968), or later after the cave had formed but before it had opened to the surface. The Phascolarctos-bearing deposit appears to have been a wedge-shaped deposit developed in a fissure in the therefore older, strongly-lithified breccia (Figure 2). From the shape of the ceiling and floor, it may be concluded that the bottom of this fissure collapsed, bringing down with it the unconsolidated part of the Phascolarctos-bearing deposit but leaving the lithified parts adhering to the ceiling, which is the top of the original fissure (Figure 3). Sometime after this collapse, the more recent darker unconsolidated sediments accumulated in the cave.

The Fauna

The fossil material was identified as follows (numbers are Western Australian Museum catalogue numbers). The taxonomy is that used by Ride (1970).

Mammalia

Marsupialia

Dasyuridae

phascogaline, indet.(72.1.1129)

Peramelidae

Perameles sp. (72.1.1130)

Isoodon obesulus (72.1.1131)

Tarsipedidae

Tarsipes sp. (72.1.1132)

Phascolarctidae

Phascolarctos sp. (72.1.1133)

Vombatidae

Vombatus sp. (72.1.1140)

Macropodidae

Potorous platyops (72.1.1134)

Bettongia penicillata (72.1.1135)

Macropus eugenii (72.1.1137)

M. irma (72.1.1141)

M. cf. *M. fuliginosus* (72.1.1138)

Setonix brachyurus (72.1.1136)

Sthenurus brownei (72.1.1139)

Muridae

Pseudomys shortridgei (72.1.1147)

P. occidentalis (72.1.1142)

Notomys sp. (72.1.1143)

Reptilia

a large snake, ? boid (72.1.1145)

a lizard (indet.) (72.1.1144)

Mollusca

Bothriembryon bulla (72.110)

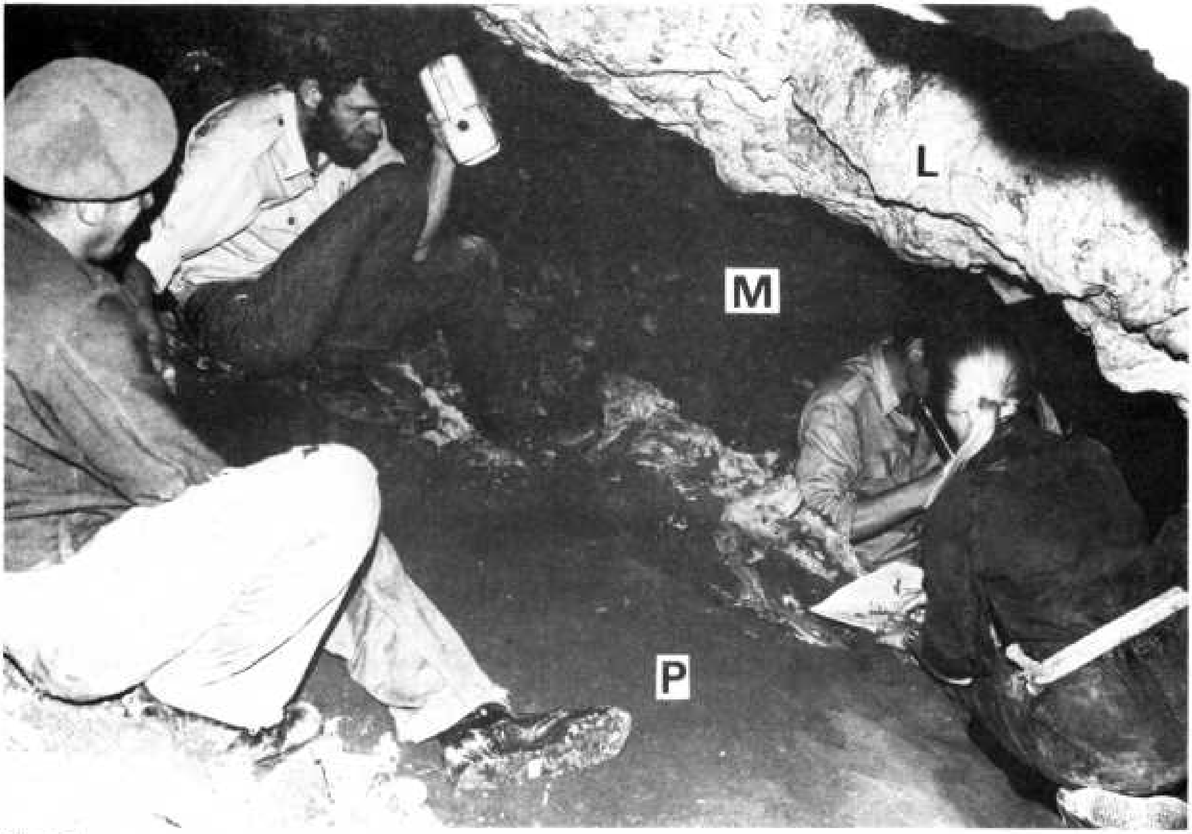

Figure 1

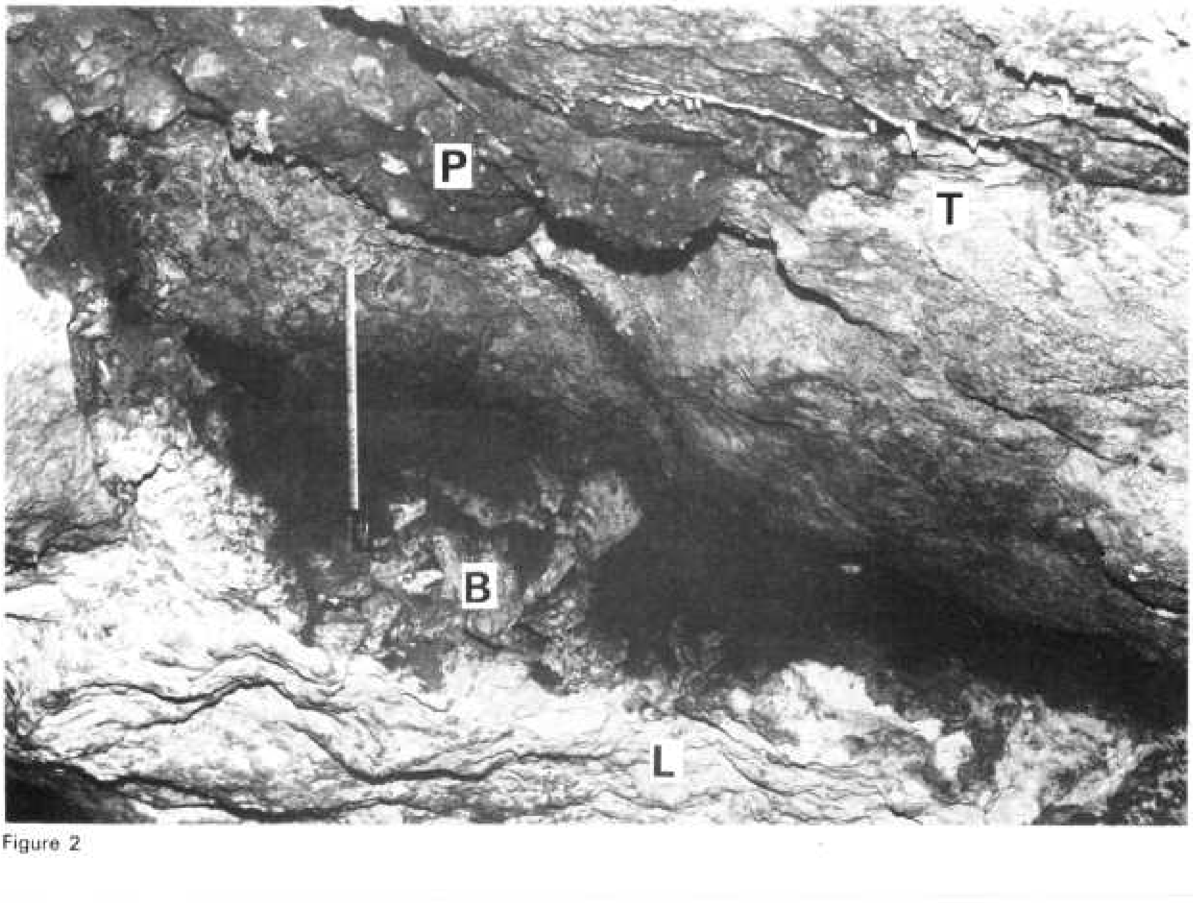

Figure 2

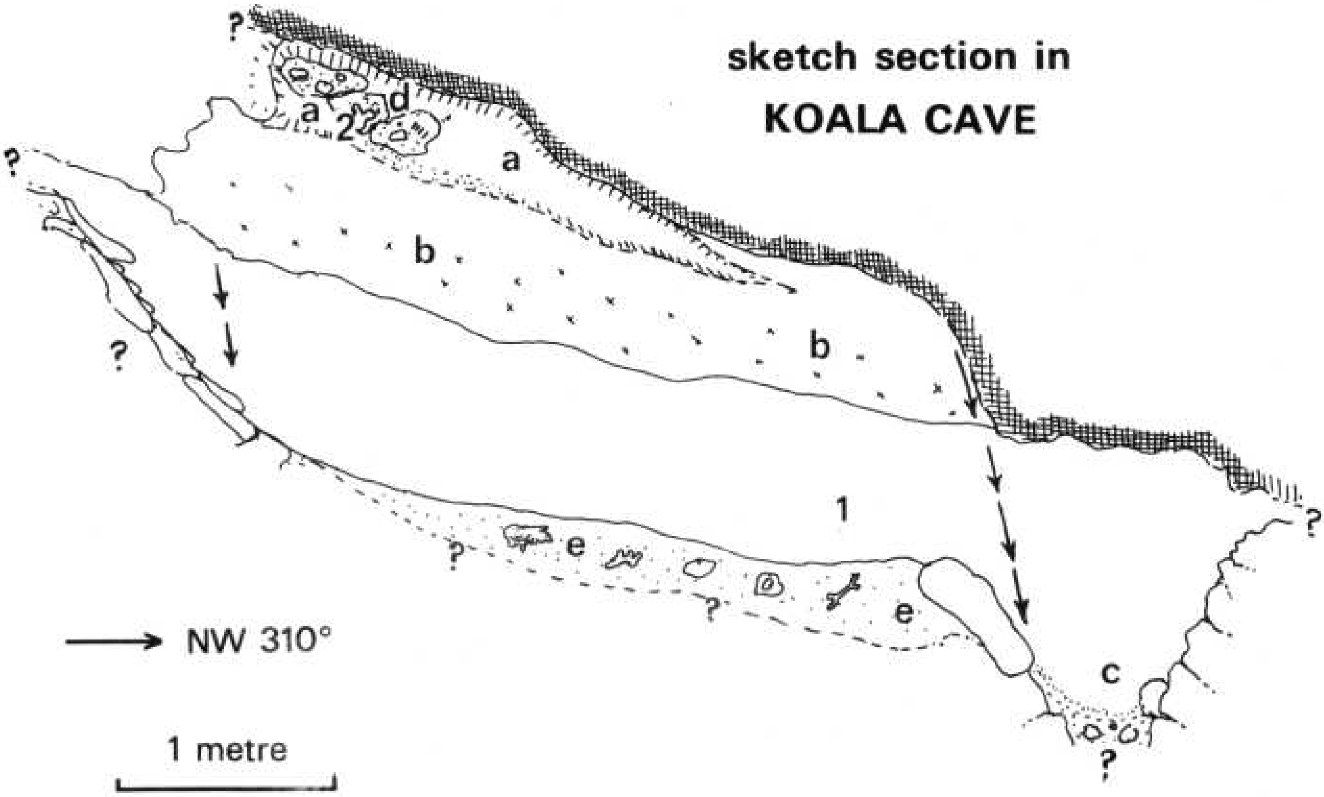

Figure 3

Figure 1. Discovering the <u>Phascolarctos</u>-bearing deposit in Koala Cave. The foot in the centre foreground rests on unconsolidated <u>Phascolarctos</u>-bearing deposit (P). The limestone (L) in the upper right is the inclined ceiling of Koala Cave. The dark sediment (M) in the distance is the relatively more modern unconsolidated deposit. Photo by B. Muir

Figure 2. Remnant of the <u>Phascolarctos</u>-bearing deposit in the original fissure. The rule has 30 cm of tape exposed. The base of the rule rests on the bottom (B) of the original fissure. The limestone (L) below that is the ceiling of Koala Cave. The extended tip of the rule points to consolidated remnants of <u>Phascolarctos</u>-bearing deposit (P) which adhere to the top (T) of the original fissure. Photo by B. Muir

Figure 3. A sketch section through the <u>Phascolarctos</u>-bearing deposit. Centre of figure 1 (1), centre of figure 2 (2), original fissure (a), sheared limestone face (b), funnel (c), consolidated <u>Phascolarctos</u>-bearing deposit (d), unconsolidated <u>Phascolarctos</u>-bearing deposit (e). The arrows indicate the probable direction in which the limestone block fell that exposed the <u>Phascolarctos</u>-bearing deposit. Section interpreted from a sketch by P.J. Bridge.

Discussion

The following seven species in the fauna are of particular interest.

Perameles sp.

Ride (1970) states that Perameles bougainville is only common in Western Australia as a living animal on Bernier and Dorre Islands in Shark Bay, but various fossil occurrences, some of which appear to represent late Recent times, are known (Merrilees, 1968). It occurs in Recent cave deposits from the Moore River-Dongara region to the Cape Leeuwin-Cape Naturaliste region (Lundelius, 1960; Dortch and Merrilees, 1972).

Vombatus sp.

No species of Vombatus is recorded living in Western Australia (Ride, 1970) but three fossil occurrences are known (Merrilees, 1968, 1969). Only two of these fossil occurrences are radiometrically dated and these dates exceed 25,000 radiocarbon years B.P. (Merrilees, 1968).

Phascolarctos sp.

No records of living Phascolarctos are known from Western Australia (Ride, 1970). Fossil occurrences have been reported previously from three Western Australian deposits (Merrilees, 1968, 1969). Only one of these deposits is dated and the date exceeds 31,000 radiocarbon years B.P. (Merrilees, 1968). It is interesting to note that Phascolarctos cinereus has been successfully maintained by man (Ride, 1970) in Yanchep Park within historic times as a tourist attraction.

Tarsipes sp.

The Koala Cave specimen representing this species is a fragment of a pelvis. The record is of interest because Tarsipes has never previously been recorded as a fossil. This is probably in part due to its small size and the fact that its very rudimentary teeth would almost certainly pass through any sieve used to recover bone materials from cave deposits. Vose (1972) mentions that Tarsipes spencerae has been collected live from Yanchep Park.

Sthenurus brownei

All species of Sthenurus are extinct. Three fossil occurrences of S. brownei are known in Western Australia (Merrilees, 1967, 1968). The only deposit which is dated exceeds 31,000 radiocarbon years B.P. (Merrilees, 1968).

Potorous platyops

Ride (1970) records this species as rare, noting that it has not been collected live for almost a century. It may be extinct. Butler and Merrilees (1971) have reviewed knowledge about the known Quaternary distribution of the species. The species has not previously been recorded from the Perth Basin farther south than the Moore River-Dongara region. The Koala Cave specimens represent a south coastal range extension for the species.

The large snake, possibly a boid

The only recorded large fossil snake, probably a species of Python from the southwest of Western Australia is from Mammoth Cave (Merrilees, 1968). Several vertebrae from Koala Cave represent a large snake and are very similar to specimens from Mammoth Cave (e.g., 66.5.1).

All of the other mammal species recorded here from the Koala Cave fauna have been recorded as living within historic times near the Perth or the Swan River area (Shortridge, 1910; Glauert, 1950; Bannister, 1969; Ride, 1970) except Pseudomys shortridgei, P. occidentalis and Notomys sp. P. shortridgei and P. occidentalis have been reported to occur in cave faunas in or near the Yanchep area (Lundelius, 1957). Two species of Notomys were collected live in historic time from or near New Norcia, Western Australia (Ride, 1970). This is the closest modern locality record to Yanchep for species of the genus Notomys. A species of the genus has been recorded by Dortch and Merrilees (1972) from Devil's Lair in the Cape Leeuwin-Cape Naturaliste region and by Lundelius (1960) from Wedge's Cave, about 80 kilometres north of Yanchep.

Considered as a whole, the Koala Cave fauna is best compared with those of Labyrinth and Mammoth Caves. A preliminary note on the Labyrinth Cave fauna has been given by Merrilees (1969), and the most recent review of the Mammoth Cave fauna is that of Merrilees (1968). These faunas are compared in Table 1.

The Mammoth Cave specimens were recovered from a much greater bulk of deposit than were those of Labyrinth and Koala Caves. For this reason the absence of certain species such as Thylacoleo sp., Thylacinus cynocephalus, Sthenurus occidentalis, Protemnodon sp. and others from the Koala and/or Labyrinth Cave deposits may be due to sampling accidents. On the other hand, the absence of certain species from the Mammoth Cave fauna such as Potorous platyops, Bettongia penicillata (see Merrilees, 1968, for comments about the specimens of this species from Mammoth Cave) and Notomys sp. which are represented in the Koala Cave deposit is probably significant. Merrilees (1968) suggested that Bettongia penicillata entered the Cape Leeuwin-Cape Naturaliste region after the time of accumulation of the Phascolarctos-bearing deposit in Mammoth Cave deposit. Ride (1970) and Butler and Merrilees (1971) state that Potorous platyops is not known to have occurred in Quaternary times in the Cape Leeuwin-Cape Naturaliste area. The significance of the absence of Notomys from the Mammoth Cave deposit is not clear, partly because there are relatively few murids in the Western Australian

TABLE 1

A COMPARISON OF VERTEBRATE SPECIES RECORDED BY MERRILEES (1968, 1969) FROM THE MAMMOTH AND LABYRINTH CAVE DEPOSITS WITH THOSE FROM THE KOALA CAVE DEPOSIT

Marsupials	Koala Cave	Labyrinth Cave*	Mammoth Cave
small dasyurid(s)	X	-	X
Dasyurus sp.	-	-	X
Sarcophilus harrisii	-	X	X
Thylacinus cynocephalus	-	-	X
Isoodon obesulus	X	X	X
Perameles sp.	X	-	X
Trichosurus vulpecula	-	-	X
Pseudocheirus peregrinus	-	-	X
Thylacoleo sp.	-	X	X
Phascolarctos sp.	X	X	X
Vombatus sp.	X	X	X
Potorous platyops	X	-	-
P. tridactylus	-	-	X
Bettongia penicillata	X	?	-
Setonix brachyurus	X	-	X
Protemnodon sp.	-	-	X
Wallabia bicolor	-	-	X
Macropus irma	X	-	X
M. eugenii	X	-	X
M. fuliginosus	X	-	X
Sthenurus occidentalis	-	-	X
S. brownei	X	X	X
Zygomaturus trilobus	-	-	X
Tarsipes sp.	X	-	-
Non-Marsupials			
monotremes	-	X	X
Notomys sp.	X	-	-
other murids	X	-	X
bat	-	-	X
bird	-	X	X
large snake	X	-	X
lizard	X	-	-

* species list modified, after Merrilees (1968, 1969).

Museum collections from Mammoth Cave, and partly because these specimens have not yet been examined in detail. It is possible, considering the modern distribution of Notomys species, that the absence of Notomys from the Mammoth Cave deposit reflects an unsuitable environment for this species in the area of Mammoth Cave at the time of accumulation of the Mammoth Cave deposit. The absence of Tarsipes sp. in the Mammoth Cave fauna is not surprising for reasons noted above.

Conclusion

The Koala Cave (Yn 118) fauna contains several poorly known species, some of which may be extinct in Western Australia. Most of these species are present in a similar fauna known from Mammoth Cave. The significance of differences between the two faunas remains to be clarified. A comparison between these faunas as well as those of Labyrinth and Strong's Cave will give a clearer picture of late Pleistocene mammal species and distributions in south-western Australia.

Acknowledgments

The author would like to thank Mr. S. Bennett for initially showing him the cave, and Mr. Bennett and Dr. D. Merrilees, Mr. P.J. Bridge, Mr. G.W. Kendrick, Mr. A. Baynes, Mr. and Mrs. B. Muir, Mrs. S.J. Hallam, and Mrs. M. Archer for help in making initial collections and for stimulating comments. Messrs. Baynes and Kendrick kindly identified respectively the murid and molluscan material. Dr. Merrilees and Mr. Kendrick kindly read and criticised the text of the paper. Mr. Bridge made the diagrams on which Figure 3 is based. The author was supported during the time spent on this project by an Australian Research Grants Committee award to Dr. W.D.L. Ride (Director, Western Australian Museum). General information was obtained about the Quaternary distribution of Western Australian mammals while the author was supported by a Fulbright Scholarship from the Australian American Educational Foundation, and subsequently by a grant from the Explorers Club.

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A B S T R A C T

ROOF MARKINGS IN THE "ORCHESTRA SHELL" CAVE, WANNEROO, NEAR PERTH, WESTERN AUSTRALIA. By Sylvia J. Hallam. Mankind, 8 (2) : 90-103, Plates IV-VII. 1971.

Some "120 odd caves" occur in the Avon Valley area. Geometric and hand stencil designs have been noted in four of these with only Orchestra Shell Cave and Ross's Cave studied to date. Thylacine remains have been excavated in another cave.

Maps and a description of Orchestra Shell Cave are given. Geometric designs are restricted to the entrance area and the eastern side of the cave where hardening of roof, after inscription, by secondary deposition of a thin calcite crust has helped preserve the markings. Roof weathering has presumably obliterated them on the western side. Radiocarbon dates indicate human activity in the cave from 6470 + or - 120 to 1730 + or - 85 years BP.

There are four clear-cut design types: "The stemmed splay" near the entrance, "straight parallel grooves", "short very deep individual cuts", and the "normal curving criss-crossing sets of usually five-fold narrow-spaced parallel grooves". Parallel grooves seem to have been made using a multipronged tool, whereas fingers seem to have been used in the soft "moonmilk" roof deposit in nearby Ross's Cave. Koonalda Cave markings are discussed and compared with those in Orchestra Shell Cave. Markings in Kintore and Cutta Cutta Caves and European caves are briefly mentioned. - G.S. HUNT.

THE MIGRATION OF CAVE ARTHROPODS ACROSS THE NULLARBOR PLAIN, SOUTHERN AUSTRALIA

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Abstract

The Nullarbor Plain is a low plateau of Tertiary limestone covering an area of 194,175 km^2 in southern Australia. It has a semi-arid climate and supports a stunted vegetation. Ninety-five species of arthropods have been recorded from 47 Nullarbor caves, and many of these species are widely distributed across the Plain. Two possible explanations for their distribution are discussed. Subterranean migration may occur through the widespread zone of small interconnecting cavities in the Nullarbor Limestone, but this has not yet been confirmed. While cave arthropods are confined to the cool, moist cave environment during the day, they have been observed at night in cave entrances, in dolines and on the surface of the Plain. Cave "breathing", similarity in cave and epigean climate at night, strong winds, occasional heavy rain and numerous animal burrows all contribute towards favourable conditions for surface migration.

Introduction

The Nullarbor Plain is a low plateau of Tertiary limestone in southern Australia. It originally referred to a semi-arid area of treeless plains with a hot desert climate supporting a ground vegetation of saltbush, samphire and ephemeral grasses some way inland from the Great Australian Bight, and known now as a shrub steppe zone. Today it also includes the wetter coastal strip to the south, with its cover of mallee, myall and mulga, a mixed arid and semi-arid mallee zone of semi-desert aspect. It stretches some 850 km from Ooldea in the east to Balladonia in the west. To the north it is bounded by the Great Victoria Desert, and to the south by the Great Australian Bight. The total area is about 194,175 km^2 making it the most extensive continuous limestone region in Australia. South of the Nullarbor between Twilight Cove and Wilson Bluff lies the Roe Plain, a large coastal lowland of Pleistocene sediments reaching a width of about 40 km south of Madura (Jennings, 1967). Figure 1 (after Jennings) shows the full extent of the Nullarbor Plain as a geomorphological unit.

Below the massive surface crust of the limestone is a widespread zone of Miocene Nullarbor Limestone honeycombed with small interconnecting cavities a few cm in diameter. This is laterally extensive across the Plain, and beneath it is white, chalky limestone - the Upper Eocene Wilson Bluff Limestone. Throughout the whole area numerous cracks and solution tubes lead down through the surface crust to the Nullarbor Limestone.

The limestone contains numerous dolines and caves. The dolines are depressions in the limestone which may have been caused by breakdown of cave roofs. They often lead into caves. The caves vary in size from small blowholes about 30 m in length to large caves up to 4.8 km in length.

The fauna of the Nullarbor caves was virtually unknown before 1966. Since then 114 species have been recorded from 47 caves (Richards, 1971) (Figure 1). They include 19 species of vertebrates and 95 species of arthropods. All vertebrates and 80% of the arthropods have been identified. The arthropods belong to 17 orders and 58 families (Table 1). Troglophiles form over half the arthropod population and show various degrees of cave adaptation. Only six troglobites are known, and five of these are very rare. All are blind. Three are spiders, one a centipede, one an isopod and the sixth a cockroach. All except the cockroach are known only from single caves. The cockroach has been collected from nine caves well distributed across the southern part of the Plain.

Twenty-nine percent of the cave arthropods are widely distributed across the Nullarbor Plain. The species are distributed across the 850 km of Plain in an east-west direction. About 50% of the species have a range between 242 and 403 km and only four species exceed this. Three beetles (Ptinus exulans Erickson, Notospeophonus pallidus Moore and Brises acuticornis Pascoe) extend almost 483 km across the Plain, while the cave cricket (Pallidotettix nullarborensis Richards) extends a distance of about 725 km. Of the 47 caves from which fauna has been collected, 11 occur in the shrub steppe zone, and 36 in the southern mixed arid scrub and semi-arid mallee zone. All 18 species listed in Table 2 occur in the southern zone, while 15 of them are also in the shrub steppe zone. Throughout both zones the cave microclimate is remarkably uniform, so the distribution of species is controlled by the number of caves in the two areas, and the ability of species to find and colonize new caves. So far no troglobites have been discovered in the shrub steppe zone caves.

There are two possibilities to explain the wide distribution of these cave species across the Nullarbor.

Subterranean Migration

Cavernicoles may migrate through the widespread zone of small interconnecting cavities in the Nullarbor Limestone (Plate 1). Numerous cracks and solution tubes lead down through the massive surface crust to this zone which offers conditions similar to those in the larger cave systems. The tubes provide easy access to and from the surface. So far there is no evidence to support this theory.

In North America, Barr (1967) considers there is subterranean dispersal of troglobitic Trechine carabids living under similar conditions, and there is also marked species diversity. In the Nullarbor caves the carabids are all Harpaline or Lebiine troglophiles, so it is necessary to make comparison with other groups of troglobitic arthropods. The apparent isolation of five of the Nullarbor troglobites in single caves suggests that if subterranean migration does occur from one cave system to another, it has not led to the spread of troglobites. This is possibly because of the great distance between some cave systems. The sixth troglobite, the cockroach (Trogloblattella nullarborensis Mackerras), has been observed near cave entrances, and its distribution is probably governed by factors other than subterranean migration.

Surface Migration

During daylight the surface climate is too hot and dry for many arthropods to survive, and cavernicoles die almost immediately on exposure to the surface environment (Table 3). Many arthropods use caves as temporary shelters between nocturnal wanderings across the Plain because they are cool and humid, and some species may in time become permanently established there. At night there is a great similarity between surface and cave climate (Table 4). This has enabled a number of arthropods normally found deep inside caves to explore the entrance doline, or even the surface (Table 5).

In February 1968, cave, doline and surface temperature and relative humidity were taken in several widely scattered cave areas using an Assmann Psychrometer and two thermohydrographs. While little difference in temperature was noted between the regions at night, a humidity gradient of about 10% was sometimes set up between the cave microclimate and the surface environment, and under these conditions cavernicoles moved to the region of higher humidity. When the surface humidity rose to over 90% a number of cavernicoles were observed in the dolines or on the surface of the Plain (Table 6). The most spectacular example of this was at Murra-el-elevyn Cave (N 47) where cave crickets climbed up the steep rocky doline slope from the cave to the surface of the Plain - a distance of over 66 m.

Strong air movements are common in the entrance of many shallow caves or blowholes, and rates of up to 1500 cubic feet/second have been recorded considerable distances inside Mullamullang Cave (N 37), the longest cave on the Plain (Wigley and Wood, 1967). It is possible that arthropods in the vicinity of these air movements may be moved about, or in the case of blowholes, even sucked out of the cave. Under these conditions dispersal would be purely by chance.

As arthropods can cover only a limited area of the surface during the night, and as many caves containing the same species are widely separated, they are going to require assistance to migrate from one cave to another. It is possible that winds and rain may help in this dispersal. Records from

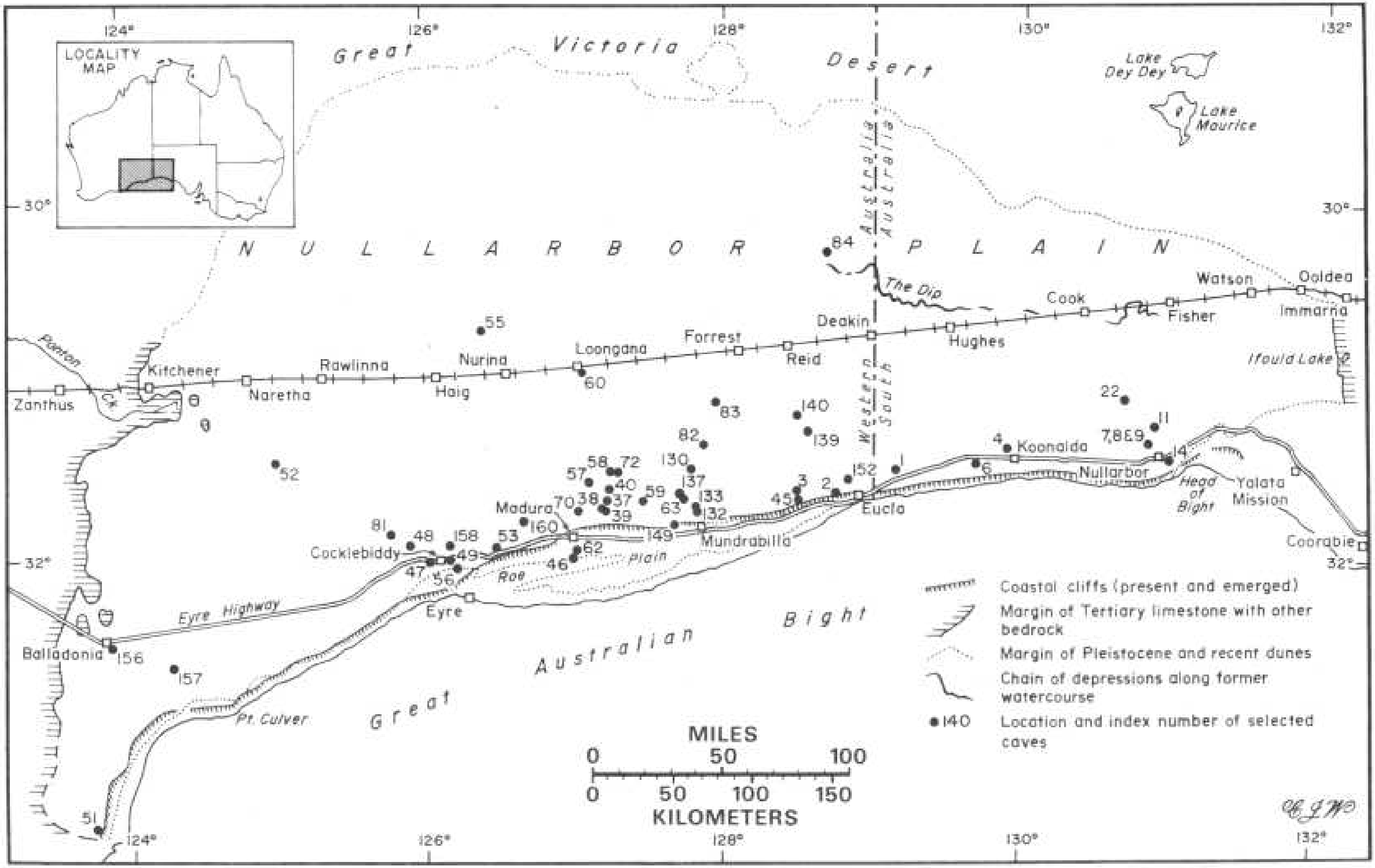

Figure 1

Nullarbor Plain showing approximate boundary of the Nullarbor Limestone, and locations of the 49 caves and dolines from which arthropods have been collected.

the Bureau of Meteorology show that winds blow almost continuously throughout the year, at various strengths and from all directions. Some are hot and dry, others cool and moist. The latter could transport arthropods considerable distances. Although there is a low annual rainfall of from 6 to 10 inches, extremely heavy rain occurs occasionally, and arthropods on the surface at that time may be swept into the nearest hole or cave. Thus colonization of a cave may be accidental. Similar microclimatic conditions in caves in different parts of the Plain make them all suitable for colonization.

Another possibility is the use of animal burrows in migration. Several species of burrowing mammals live on the Plain. The hairy-nosed wombat (Lasiorhinus latifrons (Owen)) is common in the South Australian portion (Plate 2), and its distribution extends to Caiguna 322 km inside Western Australia (Lowry, 1967). Dingoes, foxes and murids also live in burrows, but their distribution and abundance are not known. One of the most recent colonizers, the European rabbit (Oryctolagus cuniculus L.) occurs in large numbers throughout the Nullarbor region. Rabbit warrens are found over most of the Plain, and also in the large entrance dolines of some caves.

Several cavernicolous species of arthropods use the dark, humid burrows as a temporary or permanent habitat. The gryllid (Endacusta sp.) is the commonest inhabitant of rabbit burrows, and is widely distributed all over the Plain. Two beetles (Trox amictus Haaf and Brises acuticornis) have also been taken from burrows. The cockroach (Paratemnopteryx rufa (Tepper)) has been taken from a wombat burrow near Murrawijinie No. 1 Cave (N 7) in the South Australian part of the Plain. Unlike the widely separated caves, burrows are so close together that nocturnal movement from one to another is well within the range of most arthropods. As burrow and surface climates are similar at night (Table 7), these arthropods may move from burrow to burrow during periods of nocturnal activity, and eventually some may become established in caves. The burrow climate during the daytime (Table 7) appears to be intermediate between surface and cave. So far none of the more hygrophilous cavernicoles such as cave crickets have been found there, but it has not been possible to penetrate very deeply into any of the burrows. Cave crickets occur in wombat burrows on Flinders Island in Bass Strait, and in petrel and shearwater burrows on off-shore islands of New Zealand (Richards, 1954, 1958, 1964).

Although rabbits have colonized the Plain only within the past 100 years (de Vos, Manville and Van Gelder, 1956), there is fossil evidence (Lundelius, 1963) that dasyurids, wombats and murids have lived there from Pleistocene times onwards. Thus burrows may have supported arthropod populations for a considerable period. Further investigation of the microclimate and fauna should clarify the role of burrows in arthropod migration.

Not just animal burrows or limestone caves, but any suitable hole which offers protection from unfavourable surface conditions may be colonized

Plate 1. Nullarbor Limestone in Parritappa Doline (N 43) honeycombed with small interconnecting cavities. Photo: A. M. Richards

Plate 2. Wombat burrows on Nullarbor Station. Photo: J. Waterhouse

temporarily by arthropods during periods of migration from one cave system to another. At this stage there is more evidence to suggest that dispersal of Nullarbor cavernicoles is by surface migration and use of animal burrows, rather than by subterranean migration through anastomosing cavities. It must also be remembered that there is no time limit set for the migration of a species from one part of the Plain to another.

Acknowledgments

I am greatly indebted to Mr. D.C. and Mrs. J.W.J. Lowry, Perth, for allowing me access to their large collection of arthropods from the Nullarbor. I should like to thank Dr. J.N. Jennings, Australian National University, Canberra, for permission to reproduce his map of the Plain, Mr. Lowry for plotting on it the exact location of the caves, and Mr. C.J. Wilkinson for drawing the map. I should also like to thank the various specialists who, by identifying the different groups of arthropods, have assisted greatly in this study. I am grateful to the Melbourne branch of the Bureau of Meteorology for wind and rainfall statistics; Messrs. E.G. Anderson and H. Dengate for assistance in the field; Mr. Murray Thomas of Nullarbor Station, Mr. C. Gurnee of Koonalda Station and Mr. D. O'Connor, manager of Madura Station, for allowing access to their properties.

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APPENDIX

Caves and dolines referred to throughout this paper are listed here together with their index number. Figure 1 shows their location

N 1	Warbla Cave
N 2	Weebubbie Cave
N 3	Abrakurrie Cave
N 4	Koonalda Cave
N 6	Koomooloobooka Cave
N 7	Murrawijinie No. 1 Cave
N 8	Murrawijinie No. 2 Cave
N 9	Murrawijinie No. 3 Cave
N 11	New Cave
N 14	White Wells Cave
N 22	Knowles Cave
N 37	Mullamullang Cave
N 38	Walpet Cave
N 39	Joes Cave
N 40	Kestrel No. 1 Cave
N 43	Parritappa Doline
N 45	Winbirra Cave
N 46	Nurina Cave
N 47	Murra-el-elevyn Cave
N 48	Cocklebiddy Cave
N 49	Pannikin Plain Cave
N 51	Gecko Cave
N 52	Unnamed Blowhole
N 53	Moonera Tank Cave
N 55	Haig Cave
N 56	Tommy Grahams Cave
N 57	Unnamed Cave
N 58	Roaches Rest Cave
N 59	Horseshoe Cave
N 60	Lynch Cave
N 62	Madura Cave
N 63	Thylacine Hole
N 70	Firestick Cave
N 72	Unnamed Doline
N 81	Arubiddy Cave
N 82	Skink Cave
N 83	Old Homestead Cave
N 84	Decoration Cave
N130	Unnamed Doline
N132	Webbs Cave
N133	Snake Pit Cave
N137	Unnamed Doline
N139	Unnamed Cave
N140	Unnamed Cave
N149	Unnamed Cave
N152	Unnamed Blowhole
N156	Unnamed Cave
N157	Unnamed Cave
N158	Unnamed Cave
N160	Dingo Cave

TABLE 1

ECOLOGICAL CLASSIFICATION OF NULLARBOR CAVERNICOLOUS ARTHROPOD FAUNA.

	ACCIDENTALS	TROGLOXENES	TROGLOPHILES	TROGLOBITES	NUMBER OF SPECIES
Isopoda		1		1	2
Total Crustacea					2
Chilopoda		1	2	1	4
Total Chilopoda					4
Collembola			2		2
Thysanura			1		1
Blattodea	3		2	1	6
Orthoptera		3	1		4
Psocoptera			2		2
Lepidoptera	2	2			4
Neuroptera	1				1
Siphonaptera		1			1
Diptera	1	3	2		6
Coleoptera	16		15		31
Total Insecta					58
Opiliones			1		1
Acarina		4	12		16
Pseudoscorpionidea	1		3		4
Araneida		1	6	3	10
Total Arachnida					31
Total in each Category	24	16	49	6	
Total number of Species					95
Percentage in each Category	25%	17%	52%	6%	

DISTRIBUTION OF 18 CAVERNICOLOUS SPECIES
ACROSS AND BEYOND THE NULLARBOR PLAIN

TABLE 2

SPECIES	Number of Caves in Shrub Steppe Zone	Number of Caves in Mixed Arid and Semi-Arid Mallee Zone	EAST-WEST DISTRIBUTION ACROSS NULLARBOR IN KILOMETRES								DISTRIBUTION BEYOND NULLARBOR	
			0-80	80-160	160-240	240-320	320-400	400-480	480-560	560-640	SPECIES	GENUS
Paratemnopteryx rufa	3	3					X					X
Trogloblattella nullarborensis	0	10					X					
Pallidotettix nullarborensis	7	20								X		
Psyllipsocus ramburii	0	4				X					X	
Monopis sp.	1	5			X						X	
Notospeophonus pallidus	3	9						X			X	
Thenarotes speluncarius	3	2					X				X	
Speotarus lucifugus	1	8					X				X	
Spectus n.sp.	0	2	X									X
Quedius luridipennis	1	2				X					X	
Choleva sp.	1	1		X								X
Trox amictus	5	3					X				X	
Ptinus exulans	1	4						X			X	
Brises acuticornis	3	20						X			X	
Spinicrus n.sp.	2	3			X							X
Protochelifer cavernarum	2	3				X					X	
Latrodectus mactans	1	3				X					X	
Physocyclus sp.	3	3			X							X

TABLE 3

TEMPERATURE AND RELATIVE HUMIDITY ON THE NULLARBOR PLAIN, JANUARY TO FEBRUARY, 1968.

CAVE	TIME UP TO 24 HOURS	TEMPERATURE °F				% RELATIVE HUMIDITY			
		Max.		Min.		Max.		Min.	
		S.	C.	S.	C.	S.	C.	S.	C.
N 7	1900 - 1900	104	68	60	66	98	95	13	78
§N 2	1000 - 1000	113	67	65	67	92	100	14	100
N62	1930 - 1400	106	70	66	70	90	79	16	73
N60	1100 - 1000	113	68	67	66.5	78	95	17	93
N59	2300 - 1000	72	--	55	--	91	--	48	--

S. = surface reading near cave, C. = inside cave, § = deep cave

TABLE 4

SPOT TEMPERATURE AND RELATIVE HUMIDITY READINGS ON THE NULLARBOR PLAIN

CAVE	DATE	TIME in HOURS	TEMPERATURE °F		% RELATIVE HUMIDITY	
			S.	C.	S.	C.
§N3	28/ 1/68 29/ 1/68	1940 0030	73 68.5	62-63 62-63	80 95	92-94 92-94
§N47	31/ 1/68	2200	61	62-66	98	84-88
N60	3/ 2/68	0400	60.5	64	94	94
N83	5/ 2/68	1400	76	64.5-65.0	51	83
N140	6/ 2/68	1730	73	68	64	85
§N4	7/ 2/68	1200	75	59.5-62.5	64	92-98
N6	7/ 2/68	2200 2400	68 67	66 66	78 95	84 84
N59	19/10/66	----	65	60	64	74
§N48	5/ 1/65	----	--	61	--	94

S. = surface reading near cave, C. = inside cave, § = deep cave

TABLE 5

RANGE OF MOVEMENT IN MORE WIDELY DISTRIBUTED CAVERNICOLOUS ARTHORPODS

SPECIES	KILOMETRES WITHIN CAVE							ENTRANCE TALUS SLOPE	DOLINE
	4.8-4.0	4.0-3.2	3.2-2.4	2.4-1.6	1.6-0.8	0.8-0.4	0.4-0.0		
Paratemnopteryx rufa							N 6,N 9,N60,N62	N 3,N 6	N 3
Trogloblattella nullarborensis	N37	N37	N37	N37	N37	N 3,N 4	N 1,N 2,N46,N58 N63,N81	N 3,N 4	
Pallidotettix nullarborensis					N47 N48	N47 N48	N 2,N 4,N 6,N 7 N 8,N 9,N11,N14 N38,N39,N47,N48 N49,N51,N52,N53 N56,N57,N59,N60 N83,N132,N133, N140,N149,N156, N157,N158	N 6,N47	N47
Monopis sp.							N 3,N37,N53,N63 N160	N 3,N37 N83,N 4	
Speotarus lucifugus						N 3,N4 N47,N53	N 1,N 2,N45,N48 N60		N 1 N139
Notospeophonus pallidus						N 3,N 4 N37,N53	N 1,N 2,N 4,N 6 N22,N39,N60,N62	N 3,N 9 N 4	
Thenarotes speluncarius						N 3	N 4,N11,N60,N84	N 3,N 4	
Quedius luridipennis							N 4,N60		N37
Ptinus exulans						N47	N 1,N 7,N47,N70 N160		N 1 N160
Brises acuticornis		N37	N37	N37	N37	N 3,N37 N47,N53	N 1,N 2,N 3,N 4 N 6,N 7,N 8,N14 N37,N45,N46,N47 N48,N49,N53,N56 N60,N62,N63,N70 N83,N133,N149 N160	N 3,N 4 N 9,N37 N48,N62 N70,N160	N37 N48 N62
Trox amictus		N37				N33	N 7,N60,N82,N83 N84	N 9,N37 N83	N83
Spinicrus n.sp.							N60,N63 N152	N60,N140 N152,N160	N140
Protochelifer cavernarum					N37	N 3,N37	N 1,N 3,N60	N 3,N 9	

TABLE 6

EFFECT OF HUMIDITY GRADIENTS ON MOVEMENT OF CAVERNICOLES, FEBRUARY 1968

CAVE	SPECIES	Number of Specimens Emerged From Cave	TIME	SURFACE		CAVE	
				T. °F	% R.H.	T. °F	% R.H.
N3	*Paratemnopteryx rufa*	10	0030	68.5	95	62.5	93
N62	*Brisea acuticornis*	16	2400	70	90	70	79
N6	*Paratemnopteryx rufa*	4	2400	67	95	66	84
	Pallidotettix nullarborensis	6	2400	67	95	66	84
N47	*Pallidotettix nullarborensis*	12	2200	61	98	62-66	88
	Endacusta sp.	4	2200	61	98	62-66	88
N60	*Pallidotettix nullarborensis*	4	0400	60.5	94	64	94
	Pallidotettix nullarborensis	0	2400	70	78	68	94

TABLE 7

COMPARISON OF CLIMATE ON NULLARBOR PLAIN, IN ANIMAL BURROWS AND CAVE, FEBRUARY 1968

LOCALITY	BURROW	TIME IN HOURS	CLIMATE					
			Surface		Burrow		Cave	
			T. °F	%R.H.	T. °F	%R.H.	T. °F	%R.H.
Murrawijinie No. 1 Cave (N7)	Wombat	2400	62	88	66	86	67	85
Parritappa Doline (N43)	Rabbit	1600	83	56	75	67	—	—
Eucla-Reid Track, 24 km N of Eucla	Rabbit	1330	75	56	70	65	—	—