

The Big Sink Local Fauna: a lower Pliocene mammalian fauna from the Wellington Caves complex, Wellington, New South Wales

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Abstract – This paper describes the mammalian fauna from the Big Sink unit, exposed in the Big Sink, a man-made ‘doline’ or quarry, which forms part of the Phosphate Mine at Wellington Caves, New South Wales. The age of the Big Sink Local Fauna is determined as early Pliocene by biocorrelation with radiometrically and palaeomagnetically dated faunas from Queensland, Victoria and the Murray Basin of N.S.W. Small mammals include a new species of dasyurid of uncertain generic identity, “*Dasyercus*” *worboysi*; and unidentified species of *Antechinus* and *Sminthopsis*; *Perameles bowensis*, known also from the Bow Local Fauna in northeastern N.S.W., as well as an undescribed new genus and species of peramelid; an unidentified species of *Cercartetus*; *Pseudocheirus* sp. cf. *P. stirtoni*, and one conilurin rodent. *Protomnodon* sp. cf. *P. devisi*, a species otherwise known from Pliocene deposits in the Murray Basin, the Lake Eyre Basin and the Chinchilla Sands of Queensland, is the most abundant macropodine. Others include *Protomnodon bandharr* sp. nov.; a species of *Kurrabi*, cf. *K. merriwaensis*; and dental fragments representing four other undescribed macropodine species. Large carnivores are represented by *Thylacinus* sp. and *Thylacoleo crassidentatus*. The high relative abundance of the ghost bat, *Macroderma koppa*, suggests that the site was originally a large cave which may have been occupied by a ghost bat maternal colony, and also acted as a carnivore den. None of the species so far recorded from the Big Sink Local Fauna occurs in historical fossil collections from Wellington Caves, nor in more recent collections from the Pleistocene-aged Mitchell Cave beds in Bone Cave and Cathedral Cave deposits, supporting the hypothesis that the Big Sink deposits differ in age from others in the caves complex. The fauna suggests a mesic climate and forested or woodland vegetation, but does not imply rainforest conditions.

INTRODUCTION

This paper continues a series of reports on the fossil vertebrate faunas from Wellington Caves, Wellington, New South Wales. Dawson (1985) and Ride and Davis (1997) have summarized the historic background and significance of the Wellington Caves deposits, which have been known to science since 1830, and represent one of the classic locations for vertebrate palaeontology in Australia.

The present series of papers (see Dawson and Augee 1997) results from study of bone collections made from the caves between 1982 and 1986 to test the hypothesis, based on the geological studies of Frank (1971) and Osborne (1983), that several episodes of deposition are represented within the caves complex. Collections were made from three specific locations in the caves complex as follows: 1) the floor of Cathedral Cave, 2) the roof and walls of the central area of Bone Cave, and 3) the south wall of the Big Sink quarry. These locations correspond, respectively, to the following

stratigraphic units mapped and described by Osborne (1983) and revised by Osborne (1997): 1) the Upper Red unit of the Mitchell Cave beds, 2) the Bone Cave Breccia unit of the Mitchell Cave beds and 3) the Big Sink unit of the Big Sink beds (Table 1). In the first of these reports, Dawson and Augee (1997) described a late Pleistocene to Holocene fauna from sediments in the floor of Cathedral Cave, which supports the hypothesis that the Upper Red unit contains the youngest sediments in the Caves complex. Of the three units sampled in the present collections, that exposed in the Big Sink was hypothesized by Osborne (1983) to be the oldest. This paper presents faunal evidence supporting that hypothesis.

STRATIGRAPHY

Material described in the present paper was collected from the south wall of the Big Sink, Wellington Caves (Figure 1). The Big Sink was described by Osborne (1983) as being man-made,

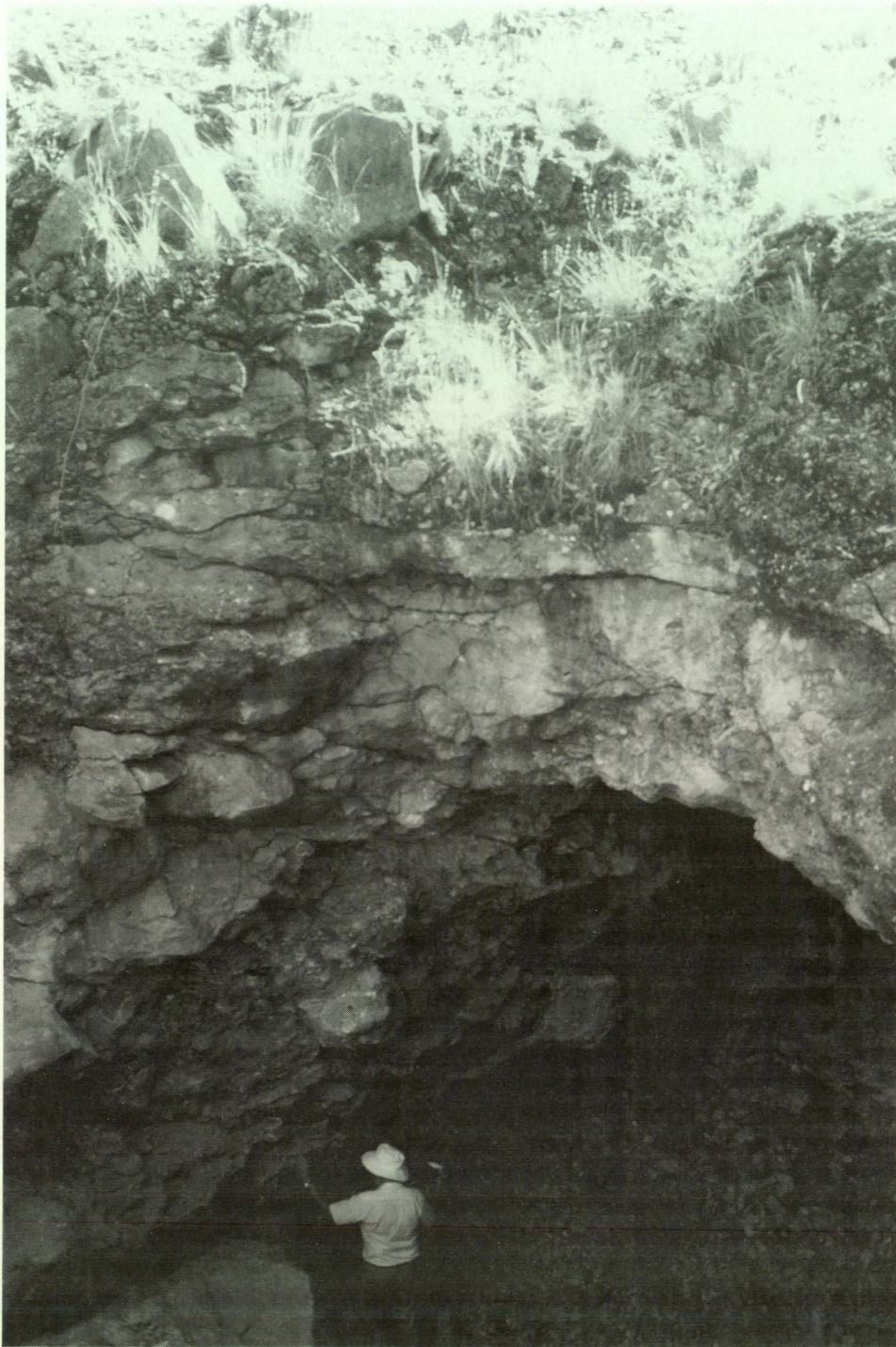


Figure 1 View of the Big Sink, Wellington Caves, facing west. Breccia extends to the present land surface at the top of the photograph. Bones comprising the Big Sink Local Fauna were collected from an area 3–4 m below the surface on the south wall of the sinkhole (left in the photograph).

presumably having been formed as a result of excavation of breccia and sediments between 1914 and 1918, when the Wellington Caves complex was mined for phosphate. Osborne (1997) suggested that the site formed the original entrance to the Phosphate Mine. Weathered rock on the south rim of the 'doline' suggests that there was originally at least a fissure or sinkhole (of unknown depth or configuration) in this position before mining and

bone collection commenced. However, there is no mention of a cave or entrance at this location in any historic documents, supporting the supposition that the 'doline' now known as the Big Sink is artificial. In this paper it will be referred to as a quarry, to avoid any implication that its present form represents a natural karst feature.

At present, the quarry is approximately 10 m in diameter at the surface and 8 to 9 m deep, with

Table 1 Sequence of stratigraphic units in the Phosphate Mine complex at Wellington Caves, N.S.W. (from Osborne 1997).

Mitchell Cave beds	Upper Red unit Bone Cave Breccia unit Flowstone UNCONFORMITY
Big Sink beds	Big Sink unit Conglomerate unit UNCONFORMITY
Phosphate Mine beds	Graded-bedded unit Laminate unit ?UNCONFORMITY Phosphate rim rock UNCONFORMITY Massive limestone (basal stratum)

walls formed almost entirely of sediment and large limestone boulders. At its base a passage extends westward for approximately 10 m. The walls of this passage are partly formed from smooth Devonian limestone bedrock, ornamented with some speleothems, clearly indicating that a natural solution cave was once present, which subsequently filled with breccia. There is no indication of the shape or extent of the original natural cave, but in places the breccia extends to the present ground surface, indicating that the original limestone ceiling of the cave has weathered away. A shaft sunk in the southwestern corner of the floor of the quarry leads in to the lower passages of the Phosphate Mine (Frank 1971, figure 4).

Frank (1971) and Osborne (1983) attempted to unravel the complex relationships of the stratigraphic units exposed in the Big Sink and the Phosphate Mine passages. Osborne (1997) refined earlier interpretations in the light of recent increased exposure of the sediments following restoration of the Phosphate Mine. The south wall of the Big Sink exposes an 8 m deep section of the Big Sink unit, which is the upper member of the Big Sink beds (Osborne 1997; Table 1). An unconformity separates the Big Sink beds from the stratigraphically lower Phosphate Mine beds (which are exposed in the adjacent passages of the Phosphate Mine) and the higher Mitchell Cave beds, which are also exposed in the Big Sink (Osborne 1983).

The sediments of the Big Sink unit were described by Osborne (1983) as 'massive osseous sandstone', interbedded in places with thin layers of structureless mud. The term 'osseous sandstone' derives from the fact that the 'sand' fraction contains a high proportion of microscopic fragments of bone and tooth enamel. The chemical characteristics of the 'osseous sandstones' were described by Osborne (1983), who noted that the

three main components are bone and tooth fragments (up to 55%), equant spar and clay. As well as microscopic bone the massive osseous sandstone exposed in the Big Sink unit contains local concentrations of well-preserved larger bone. It should be noted that the strata described by Osborne (1983) as 'graded-bedded osseous sandstone' is now recognized as belonging to the (stratigraphically lower) Phosphate Mine beds (Osborne 1997) and is not exposed in the quarry's south wall.

The breccia of the Big Sink unit forms a very hard indurated rock. Pieces of bone up to 20 – 25 cm long are present with many smaller fragments of large bones. The larger bones do not appear to be oriented in any consistent manner in the rock. Nor is there sorting of large and small bones in the area sampled — teeth and bones of small species are interspersed throughout the breccia, as are large bones and limestone fragments. The breccia includes many pieces of limestone ranging in size from pebbles to boulders. There is weak evidence of bedding with slightly dipping strata, especially in the lower part of the quarry wall, suggesting that the unit may consist of cemented entrance facies.

To extract the bone, breccia was immersed in weak (10 – 15%) acetic acid. Solution proved to be slow and often incomplete, possibly due to a high phosphate component. After solution, a fine gravelly residue remained which contained many tiny bone fragments.

Abbreviations

Specimen number prefixes are as follows: AM F, AM A and AM MF, palaeontological collection of the Australian Museum, Sydney; QM F, palaeontological collection of the Queensland Museum, Brisbane; SAM P, palaeontological collection of the South Australian Museum, Adelaide; and MoV P palaeontological collection of the Museum of Victoria, Melbourne.

SYSTEMATIC PALAEOLOGY

Higher level classifications of Mammalia conform to authors as follows: Marsupialia, Aplin and Archer (1987); Chiroptera, Koopman (1993); Australasian Rodentia, Musser and Carleton (1993). Within the text, authorities are given at the first mention for all fossil species, and for modern genera or species that are not included in Laurie and Hill (1954) (New Guinea) or Walton (1988) (Australia). Authorities not included in the References may be found in the above papers, Simpson (1945) (Mammalia in general), or Mahoney and Ride (1975) (Australasian fossil Mammalia). Nomenclature for the dentition of

Marsupialia follows Flower (1867) and Lockett (1993), and for Rodentia, Musser (1981). In this paper the term local fauna is used in the informal sense of Tedford (1970) to indicate an association of species which is geographically distinct from other local faunas of comparable stratigraphic position.

Supercohort Marsupialia (Illiger, 1811)

Order Dasyuromorphia (Gill, 1872)

Family Thylacinidae Bonaparte, 1838

Genus *Thylacinus* Temminck, 1824

Thylacinus sp.

A species of *Thylacinus* is represented in the Big Sink Local Fauna by a single left dentary fragment, AM F69875, with M_3 (talonid only) and M_4 . This fragment may represent an immature individual, since the M_4 is not fully erupted and its protoconid is unworn. The lower half of the dentary is missing. The dimensions of these teeth are as follows: M_3 talonid width = 6.2 mm, M_4 length = 15.7 mm. These measurements are slightly below the size range of a sample of *Thylacinus cynocephalus* from stratigraphically uncontrolled early collections from Wellington Caves, but fall within the size range of modern *T. cynocephalus* from Tasmania and of thylacines from other Pleistocene localities (Dawson 1982). They also agree closely with the corresponding dimensions of the Miocene species, *T. potens* from Alcoota, Central Australia (Woodburne 1967), but the few dental characters which can be observed and measured in the Big Sink specimen are not diagnostic for *T. potens*. Nor can the relative depth of the dentary (more robust in *T. potens* than *T. cynocephalus*) be estimated because of the damaged nature of the Big Sink dentary. Another species from the late Miocene or early Pliocene of Central Australia, *T. megiriani*, is also similar in size, but is known from upper dentition only (Murray 1997). More complete material is needed from the Big Sink before any decision can be made on the specific status or phylogenetic relationships of this thylacine.

Family Dasyuridae (Goldfuss, 1820)

Subfamily Dasyurinae Goldfuss, 1820

"Dasycercus" worboysi sp. nov.

Figure 2

Material Examined

Holotype

AM F69805, partial left dentary containing M_{1-4} .

Referred Material

AM F69806, partial crown of right M^1 .

Type Locality and Horizon

South wall of the Big Sink, Wellington Caves, Wellington, New South Wales, Australia. This section of the Big Sink is identified by Osborne (1997) as the Big Sink unit, the upper stratigraphic unit of the Big Sink beds.

Specific Diagnosis

"Dasycercus" worboysi differs from *Dasycercus cristicauda* in its larger size; in possessing shorter talonids relative to trigonid length on M_3 and M_4 ; in its plesiomorphic condition of the talonid of M_4 , in which the transverse hypocristid and cristid obliqua form a clearly rectangular basin; in possessing a strong buccal cingulum on lower molars; and in the possession of a distinct styler cusp B on M^1 . It differs from species of *Parantechinus* in being much larger, with a relatively shorter (antero-posteriorly) talonid on M_3 and slightly less advanced reduction of the M_4 talonid; differs from species of *Pseudantechinus* in its much larger size and lesser reduction of M^1 styler cusp B and M_4 talonid; differs from species of *Dasykaluta* and *Dasyuroides* in showing less reduction of the M_1 metaconid, M^1 styler cusp B and M_4 talonid. *"Dasycercus" worboysi* is much larger than *Dasykaluta rosamondae* and slightly larger than species of *Dasyuroides*. Differs further from species of *Dasyuroides* in the absence of entoconids on posterior lower molars, relatively shorter talonids and the better-developed styler cusp B on the upper molar.

Etymology

The species is named after Arnold Worboys in recognition of his enthusiastic support of the Wellington Caves project when he held the position of Tourist Officer for the Wellington Shire Council.

Description

Holotype

M_1 : Anterior basal portion of trigonid, including paraconid, is broken away. Protoconid is robust and positioned medially on transverse axis. Well-defined protocristid descends anteriorly to the broken edge of the tooth. Metaconid markedly reduced and posterolingual to protoconid. Talonid broader than trigonid. Tiny entoconid represented by slight swelling along continuous crest forming lingual margin of the talonid basin. Hypoconid slightly lower than metaconid. Hypoconulid low, projects posteriorly into notch formed in M_2 anterior cingulid. Posterior cingulid continuous with basal buccal cingulid.

M_2 : Protoconid and hypoconid broken away. Metaconid heavily worn and lower than paraconid.

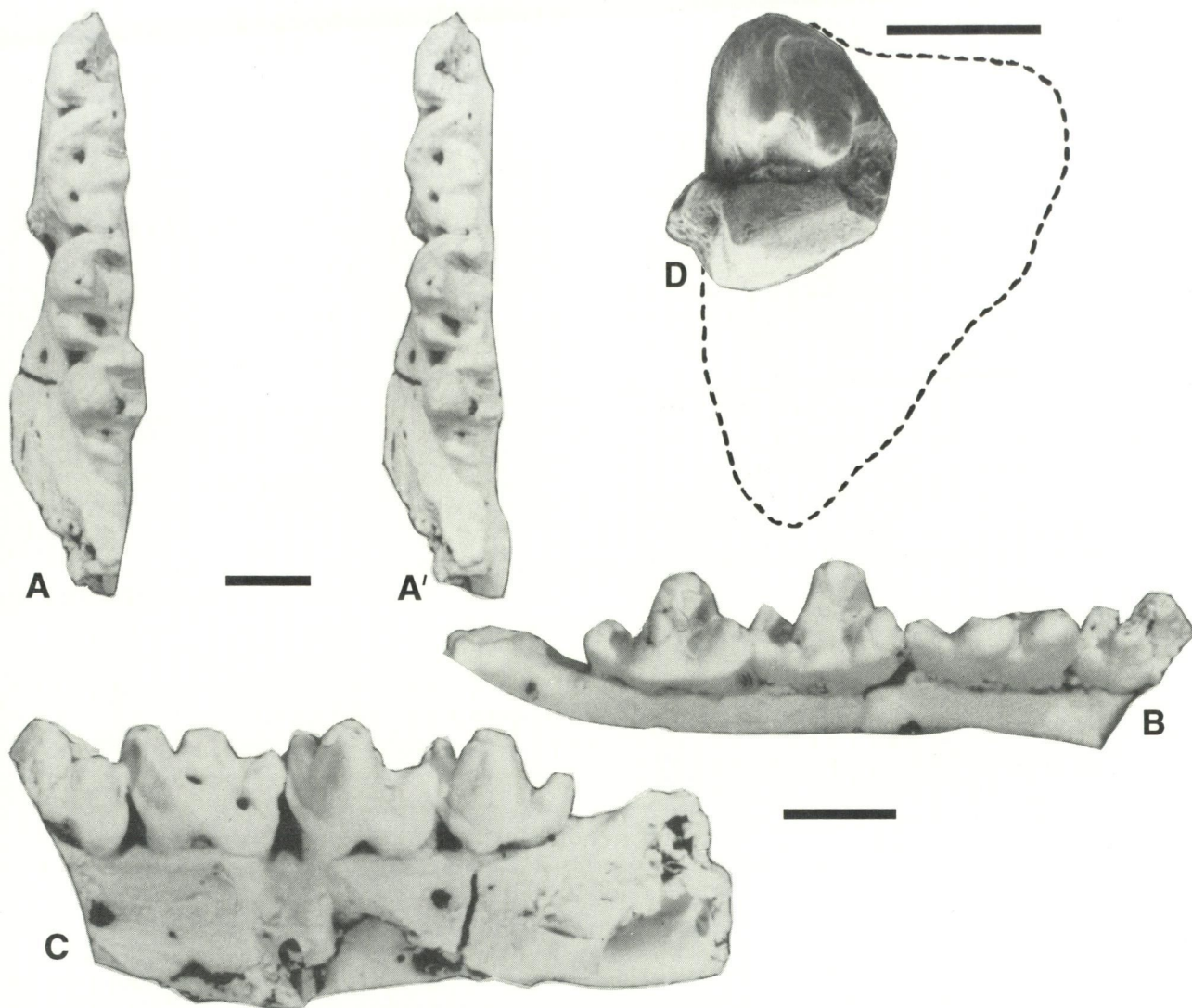


Figure 2 *Dasyercus* *worboysi* sp. nov. from the Big Sink, Wellington Caves. A/A', holotype, partial left dentary containing M_{1-4} (AM F69805), occlusal view (stereo pair), scale bar = 2.2 mm. B, holotype (AM F69805), lingual view, scale bar = 2.1 mm. C, holotype (AM F69805) buccal view, scale bar = 2.1 mm. D, referred specimen, right M^1 fragment (AM F69806), occlusal view (SEM), reconstructed outline of missing portion of tooth indicated by dashed line, scale bar = 150 μ .

Morphology similar to that of M_1 except as follows: trigonid wider than talonid; metaconid larger and more nearly aligned with protoconid; protoconid buccally positioned; entoconid absent; buccal and posterior cingulids present but not continuous.

M_3 : Metaconid tip missing. Morphology similar to that of M_2 but differs as follows: talonid shorter than trigonid along antero-posterior axis; talonid basin rectangular, lingually bounded by low crest; hypocristid a high, straight crest, parallel to the metacristid, forming a 90° angle with lingual crest; cristid obliqua runs anterolingually showing only slight buccal inflection, joins posterior face of trigonid well lingual to metacristid notch; buccal cingulid crosses base of hypoconid and buccal medial valley of tooth.

M_4 : M_4 morphology similar to that of M_3 , but differs from it as follows: trigonid about twice

transverse width of talonid; metaconid and paraconid near equal in height; posterior cingulid absent; cristid obliqua meets posterior face of trigonid beneath metacristid notch.

Referred Specimen

AM F69806, partial crown of right M^1 . Protocone, metastylar corner of tooth, and stylar cusp D broken away. The anterior portion of the tooth remains, including stylar cusp B and paracone, as well as a fragment of the metacone. Paracone discrete from and taller than stylar cusp B, connected to stylar cusp B by short V-shaped paracrista. Near vertical crest runs from anterior face of stylar cusp B to parastylar corner, then passes lingually to form leading edge of anterior cingulum. Anterior cingulum curves gently across paracone base forming a narrow ridge continuous

with preprotocrista. Because most of the stylar shelf is broken away the position and orientation of the metacone fragment, as shown in Figure 2D, is an artefact of damage and does not indicate actual alignment.

Remarks

Five features, derived within Dasyuridae, have been identified in "*Dasyercus*" *worboysi*. These are: approximation of the paracone and stylar cusp B in M^1 ; reduction of the M_1 metaconid; posterior placement of the M_1 metaconid; reduction of the entoconid; and reduction of the posterior cingulid. These features are common to most dasyurines (*sensu* Krajewski *et al.* 1994), excepting *Neophascogale* and *Phascolosorex*. Within Dasyurinae "*D.*" *worboysi* is less derived than all other dasyurines, except *Neophascogale* and *Phascolosorex*, for three of these features, i.e., approximation of M^1 paracone and stylar cusp B, reduction of the M_1 metaconid and reduction of the posterior cingulid. This is also true regarding posterior placement of the M_1 metaconid, excepting *Dasykaluta rosamondae* which shows the plesiomorphic condition for Dasyuridae. One derived feature in "*D.*" *worboysi*, loss of the entoconid, is shared by *Parantechinus apicalis*, *Pseudantechinus bilarni*, *Pseudantechinus ningbing* Kitchener, 1988 and *Dasyercus cristicauda* among dasyurines.

Relationships between dasyurine taxa have, historically, proven extremely resistant to elucidation and many widely disparate interpretations have been voiced. This holds true for both morphology- and molecule-based investigations. Krajewski *et al.* (1997) suggested that problems in resolving dasyurine relationships may be linked with an inferred rapid cladogenesis and a relatively recent origin of the clade. Certainly no palaeontological evidence contradicts this claim. As noted by Wroe (in press), no confirmed dasyurids are known before the early Miocene and the oldest taxon which can be placed within Dasyuridae with any certainty, *Barinya wangala* Wroe, in press, represents the sister taxon to a monophyletic clade which includes the three extant dasyurid subfamilies. Although sufficient data are available to place "*Dasyercus*" *worboysi* within the Dasyurinae with reasonable certainty, it is felt that confident allocation to any known or new genus cannot be supported without further evidence. Hence this new species has been assigned to *Dasyercus* Peters, 1875, the earliest available generic name in its clade.

With only a partial dentition known, inference of dietary preference in "*D.*" *worboysi* must be treated with circumspection. However, some features are shared with other marsupial taxa which take both insect and vertebrate prey, i.e., reduction of the metaconid on the M_1 and of the paracrasta on

M^1 . Moreover, although the M_1 paraconid itself is not preserved in "*D.*" *worboysi*, enough of the M_1 is known to demonstrate that the cusp must have been small. This represents a derived feature associated with P_3 reduction or loss and brachycephalization, a character complex typical of dasyurids which take relatively large prey. Another feature, which may have some bearing on the biology of the species, is loss of the entoconid. As observed by Archer (1981), loss of this cusp is associated with adaptation to an arid environment in dasyurids, although the reason for this is not clear.

Subfamily Phascogalinae Archer, 1982

Antechinus sp.

Figure 3

Material Examined

A plesiomorphic species of *Antechinus* is represented in the Big Sink Local Fauna by five isolated molars, as follows: AM F69807, a right M^1 ; AM F69808, a left M^2 ; AM F69809, a damaged right M^2 , lacking the protocone region; AM F69810, a right M_1 ; AM F69811, a right M_3 . These teeth represent a species similar in size to *Antechinus stuartii* or *Phascogale calura*. Dimensions of these teeth are given in Table 2.

Description

M^1 : This tooth (AM F69807) shows many plesiomorphic characters of dasyurids, including a distinct stylar cusp B, a paracrasta that runs to stylar cusp B, and presence of a complete anterior cingulum. Distinctive features of this tooth from the Big Sink are: the anterior cingulum is extremely broad for its entire length; the parastyle is correspondingly long; the paracone approximates stylar cusp B in height, and is less than half the height of the metacone; stylar cusp D is very large,



Figure 3 *Antechinus* sp. from the Big Sink, Wellington Caves. A, right M^1 (AM F69807), occlusal view, scale bar = 360 μ . B, left M^2 (AM F69808), occlusal view, scale bar = 360 μ .

Table 2 Dimensions (in mm) of teeth of *Antechinus* sp. from the Big Sink Fauna, Wellington Caves. pmc = postmetacrista; ppc = preparacrista

	M ¹	M ²	M ₁	M ₃
	AM F69807	AM F69808	AM F69810	AM F69811
L	2.3	2.1	1.9	2.0
AW	1.8	1.9	1.0	1.2
PW	—	—	0.9	1.0
L. pmc	1.2	?	—	—
L. ppc	0.5	0.8	—	—

conical in shape and only just shorter than the metacone — it is much higher than the reduced paracone; the postprotocrista terminates on the posterolingual face of the metacone; there is no posterior cingulum across the base of the metacone.

While the basic morphology of this tooth is close to M¹ of *A. stuartii* and the closely allied *A. flavipes*, it differs from those species in the extremely wide anterior cingulum, the absence of a posterior cingulum, the enlarged stylar cusp D and very reduced paracone. In this combination of features, AM F69807 most closely resembles an M¹ (QM F10626) described by Archer (1982) from Floraville, Queensland, as *Antechinus* sp. (probably a new species). The Big Sink and Floraville specimens also agree closely in size. The loss of the posterior cingulum on M¹ is possibly a synapomorphic feature shared by the Big Sink taxon, the Floraville tooth, and the modern species *Antechinus leo* (Van Dyck 1980). Although similar to *Phascogale calura* in the condition of the anterior cingulum, the Big Sink M¹ differs from that species in lacking stylar cusps C and E as well as a posterior cingulum.

M²: This tooth is represented by two specimens (AM F69808, AM F69809). It has a deep anterior cingulum, which is continuous with the preprotocrista. The protocone is equal in height to the paracone, which is higher than stylar cusp B. Stylar cusp D is a discrete conical cusp about equal in height to the paracone, and much lower than the metacone. There is no sign of stylar cusps C or E. A faint posterior cingulum is discernible on AM F69808, but not on AM F69809. This tooth differs from M² in *Phascogale calura* in lacking stylar cusps C and E and in the weaker (or absent) posterior cingulum. It differs from *A. stuartii*, *A. flavipes* and other similar species in its stronger, complete anterior cingulum.

M₁: On this tooth (AM F69810) the protoconid is high and medially situated. The preprotocristid bears a carnassial notch at approximately 2/3 of the distance from the protoconid to the strong parastylid. A broad anterior cingulum curves from the parastylid across the base of the protoconid to

join a cingulum crossing the buccal extreme of the median valley between the hypoconid and the protoconid. The metaconid is reduced and is close to the protoconid. The entoconid is well defined and has a blade-like crest passing anteriorly towards the base of the metaconid. It has no posterior connection with the hypoconulid. A strong posterior cingulum continues buccally to join the medial cingulum, completing a continuous buccal cingulum. This tooth is broad relative to its length. Its robust nature, strong anterior cingulum and complete buccal cingulum resemble M₁ of *Phascogale calura* more closely than that of *A. stuartii* or *A. flavipes*. The condition of the blade-like entoconid is most similar to that in *A. stuartii*.

M₃: The trigonid of AM F69811 is slightly wider than the talonid. The anterior cingulum is deep antero-posteriorly, and extends from the paraconid to the buccal extreme of the base of the protoconid. However, there is no buccal cingulum as in M₃ of *P. calura*. The hypoconid is much higher than the hypoconulid. The entoconid is large and blade-like. Its base is rounded posteriorly and free from any contact with the hypoconid. An elongate pre-entocristid extends anteriorly from the apex of the entoconid, passing forwards in a slightly buccal direction to the base of the metaconid. In this feature the M₃ from Big Sink most closely resembles *A. stuartii* and plesiomorphic species such as *Murexia longicaudata*, rather than *A. flavipes* or *Phascogale calura*.

Remarks

The four teeth described here from the Big Sink have been compared with the following taxa: *Antechinus stuartii*, *A. flavipes*, *Murexia longicaudata*, *Phascogale calura* and with *A. leo* in so far as the teeth were described by Van Dyck (1980). They have also been compared with descriptions of the fossil species *Antechinus puteus* Van Dyck, 1982a from the Pleistocene of Queensland, and with unnamed species of *Antechinus* from the Hamilton Local Fauna and from Floraville in Queensland (Archer 1982).

The Big Sink teeth differ from all taxa considered in having a much broader and longer anterior cingulum on upper molars, especially M¹, and apparently share with *A. leo* and the Floraville *Antechinus*, the derived loss of the posterior cingulum on M¹ (Van Dyck 1980).

The condition of the entoconid on the lower molars most closely resembles that of *A. stuartii* rather than *A. flavipes*; however, the entoconid state of *A. stuartii* appears to be the plesiomorphic condition among dasyurids (Van Dyck 1982b). Although in the size range of the fossil species *Antechinus puteus* for molar length (Van Dyck 1982a), the Big Sink teeth differ in having markedly narrower molars with a less reduced paraconid on

M_1 . The metaconid of M_1 is more reduced in the Big Sink teeth.

The Big Sink *Antechinus* sp. differs in M^1 morphology from the Hamilton species, which has a distinctive narrow styler cusp D and a full posterior cingulum. The Hamilton species is apparently close to *A. naso*, a modern species from the New Guinea highlands (Archer 1982). *Antechinus* species have also been reported from late Pliocene or early Pleistocene faunas from Dog Rocks and Fisherman's Cliff in southeastern Australia (Appendix 1 in Rich 1991), but these specimens were not available for comparison.

It seems probable that the Big Sink teeth represent a new species of *Antechinus*. However, the description of a new species should await the discovery of more complete remains with associated teeth.

Subfamily Sminthopsinae Archer, 1982

Sminthopsis sp. 1

Figure 4

Material Examined

The similar size and some other common characteristics of a small dentary fragment and five isolated molars suggest that they may represent a single species of *Sminthopsis* in the Big Sink Local

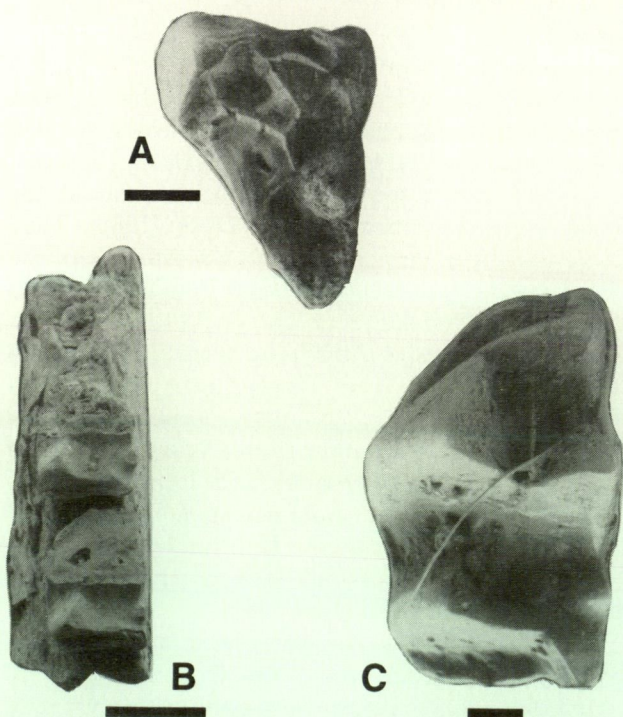


Figure 4 *Sminthopsis* sp. 1 from the Big Sink, Wellington Caves. A, left M^1 (AM F69816), occlusal view, scale bar = 450 μ . B, damaged left dentary with M_2 and M_3 (AM F69812), occlusal view, scale bar = 1 mm. C, left M_3 (AM F69813), occlusal view, scale bar = 230 μ .

Fauna. These specimens are as follows: AM F69812, a damaged dentary fragment with M_2 and M_3 , both lacking the trigonid cuspids, but retaining the talonids undamaged; AM F69813, a left M_3 ; AM F69814, a right M_4 ; AM F69815, a right M_4 ; AM F69816, a damaged left M^1 with paracone and metacone broken off; AM F69817, a damaged left M^1 lacking the metastylar corner of the tooth. Measurements of these teeth are given in Table 3.

Description

The M_3 of this species has a low but conspicuous, conical entoconid which has no contact with the hypoconulid, nor with the hypocristid. There is a faint crest extending anteriorly from the apex of the entoconid to the posterior base of the metaconid. The high paraconid is compressed antero-posteriorly. The hypoconid is much higher than either the hypoconulid or the entoconid. The talonid of the M_4 lacks an entoconid. Rather, the lingual edge of the rectangular talonid basin is enclosed by a high narrow crest which descends from the base of the metaconid to a medial low point, then ascends to the hypoconulid, which is nearly equal in height to the hypoconid. There is a short transverse hypocristid. The buccal limit of the talonid basin is formed by the cristid obliqua, which terminates below the carnassial notch of the metacristid. A short, broad, buccal cingulum extends from the base of the hypoconid anteriorly to the base of the protoconid.

The only upper molars available are two M^1 s, both damaged. They have the proportions characteristic of *Sminthopsis* species, and are in the correct size range to be associated with the lower molars described above. The preprotocrista is particularly 'Sminthopsis-like' in being transverse to the long axis of the tooth. These teeth lack a posterior cingulum, but have a narrow but continuous anterior cingulum. Styler cusp D is a high conical cusp with weak crests extending anteriorly and posteriorly to styler cusp B and the metastyle, respectively. The paracone is approximately twice the height of styler cusp B but much lower than styler cusp D.

Remarks

The specimens are allocated to the genus *Sminthopsis* mainly because of the transverse orientation to the long axis of the tooth of the metacristids and hypocristids; the relatively compressed condition of the trigonid; the entoconid morphology; and molars which are wide relative to their length.

On the basis of the morphology of the lower molars, and particularly of the entoconids, these teeth most closely approximate a species of the *S. macroura* - *S. virginiae* - *S. douglasi* group of modern species and also agree closely with the

Table 3 Measurements (in mm) of teeth of *Sminthopsis* sp. 1 from the Big Sink, Wellington Caves.

	M ₃ AM F69812	M ₃ AM F69813	M ₄ AM F69814	M ₄ AM F69815	M ¹ AM F69816
L	1.5	1.7	1.5	1.6	1.8
AW	0.9	1.0	1.0	1.0	1.2
Talonid W		0.9	0.6	0.6	
Talonid L			0.5	0.6	

fossil species *S. floravillensis* Archer, 1982. The Big Sink material represents a species larger than *S. macroura*, but smaller than *S. douglasi* and *S. floravillensis*, and (if association of upper and lower molars is correct) differs from all these species in having a complete anterior cingulum on the upper molars. In this character, as well as size and lower molar morphology it agrees most closely with *S. virginiae*. Unfortunately these isolated teeth from the Big Sink exhibit insufficient diagnostic features for confident allocation to any species. It is interesting to note that Archer (1982) considered *S. floravillensis*, the only Tertiary species to be described so far in the genus, to be the sister taxon of the *S. virginiae* group, which is today confined to monsoonal regions of northern Australia and lowland New Guinea, where it inhabits mainly savannah woodland (Woolley 1995).

Sminthopsis sp. 2

Figure 5

An isolated right M₁, AM F69818, represents a second species of *Sminthopsis* in the Big Sink Local Fauna. This tooth is similar in size to that described above as *Sminthopsis* sp. 1, but differs from it in having no trace of an entoconid. The tooth is similar in size and morphology to M₁ of members of the *S. murina* complex. However, species allocation has not been attempted here on the basis of this single tooth.

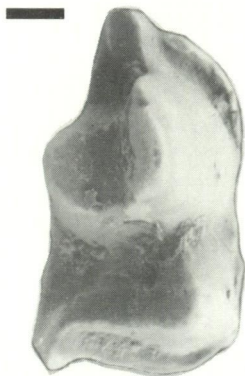


Figure 5 *Sminthopsis* sp. 2 from the Big Sink, Wellington Caves. Right M₁ (AM F69818), occlusal view, scale bar = 250 μ .

Order Peramelemorphia (Kirsch, 1968)

Family Peramelidae (Gray, 1825)

Perameles bowensis Muirhead, Dawson and Archer, 1997

Perameles bowensis is represented in the Big Sink Local Fauna by three isolated teeth, a right M₁ (AM F69804) and two broken right M₃s (AM F69887 and AM F69899). These specimens have been described by Muirhead *et al.* (1997). In all respects, accounting for differences in wear, these teeth duplicate the morphology described in the type material for this species from the Bow Local Fauna. This taxon thereby provides a species correlation between the Big Sink and Bow Local Faunas. *Perameles bowensis* is phenetically closest to the modern species *P. eremiana*, but appears to be more plesiomorphic than any modern representative of the genus (Muirhead *et al.* 1997). It is more derived than the only previously described Tertiary species in the genus, *P. allinghamensis* Archer, 1976. At present *P. bowensis* is too poorly known to establish its relationships to other species of *Perameles*; similarly, no conclusions can be drawn about its ecological significance.

Peramelemorphia family indet.

Unnamed new genus and species

Material Examined

A second, smaller species of bandicoot is represented in the Big Sink Local Fauna by three isolated molars, as follows: a left M², AM F69801; a broken left M³, AM F69802; a left M₁, AM F69803. These specimens are currently being studied and will be described fully in a future publication.

Remarks

This taxon is plesiomorphic compared to all modern Australian bandicoots in the small size of the hypocone, poor development of anterior and posterior cingula and connection of the paracrista on M². These specimens reveal no apomorphic features that could justify inclusion of the taxon in any of the currently recognized peramelemorphian families. The taxon shares some features with *Peroryctes*, *Microperoryctes* and *Echymipera*, but these

are plesiomorphies also found in many Tertiary bandicoots (Muirhead 1994), and therefore do not indicate a special relationship to any particular genus. Some features of these teeth do represent specializations (e.g. distance between cusps on the lower molar, shape of the entoconid, shape of the cristid obliqua), that are shared with some Tertiary bandicoot taxa as well as various modern bandicoots. However, none of these features is exclusive to any particular genus or family, so again they do not appear to elucidate the taxon's relationships.

The specimens from the Big Sink Local Fauna closely resemble undescribed paramelemorphian specimens from both the Hamilton and Bow Local Faunas (Turnbull and Lundelius 1970:11; Muirhead 1994). Direct comparison of specimens from all three local faunas is not possible because corresponding teeth are not available from all three locations.

The M_1 is represented in the Big Sink and Bow Local Faunas, but not the Hamilton Local Fauna. The degree of similarity between available specimens suggests that they are not outside the range of a single species.

The M^2 and M^3 are represented in the Big Sink and Hamilton Local Faunas, but not the Bow Local Fauna. These teeth from Big Sink and Hamilton are similar except in the following respects:

1) The paracrista on the M^2 of the Big Sink specimen (AM F69801) connects to the parastylar tip, while in the Hamilton specimens it connects to stylar cusp B. The Big Sink specimen is apomorphic in this feature, arguing against these specimens being conspecific. However, variation in paracrista termination on this tooth is known within *Microperoryctes longicauda*, demonstrating that although rare, this variation is possible within a species.

2) The metastylar region of the M^3 is slightly smaller in the Big Sink specimen (AM F69802), and the termination of the paracrista is farther from the stylar cusp B than in the Hamilton specimen. This degree of difference is considered to be within the range expected for a single species.

3) The M^2 and M^3 from the Big Sink are slightly larger. The small size difference is within the range expected for a single species.

Other minor morphological variations between specimens can be attributed to wear. In all other respects these specimens appear to be within the morphological range exhibited by single species of bandicoots in the modern fauna.

It is possible, therefore, that the teeth from the Big Sink Local Fauna may represent a single species which also occurs in the Bow and Hamilton Local Faunas. However, due to limited representation of the dentition from Big Sink, and the differences pointed out above, this suggestion

must remain tentative until more complete material is discovered.

Order Diprotodontia Owen, 1866

Suborder Vombatiformes Woodburne, 1984

Family Thylacoleonidae Gill, 1872

Thylacoleo crassidentatus Bartholomai, 1962

Figure 6

Material Examined

This species is represented in the Big Sink Local Fauna by two isolated teeth: AM F69820, a right I^3 , and AM F69819, a right M_1 .

Description

I^3 : In AM F69820 the crown is triangular in basal outline as in I^3 of *Thylacoleo carnifex* Owen, 1858. The base of the triangle forms the anterior edge of the tooth. The crown is highest at its anterior edge, where it abuts against I^2 . A single median crest ascends gently to the posterior base of the tooth, curving slightly lingually. The tooth has a single robust root. Of the various species of *Thylacoleo*, I^3 has only been known previously for *T. carnifex*. The tooth from the Big Sink was compared with I^3 of two specimens of *T. carnifex* from Wellington Caves old collections (AM F16641 and AM F16481), with I^3 of AM F52398, a complete skeleton of *T. carnifex* from Moree, New South Wales, and with I^3 of a cast (AM A9849) of MoV P1902, a syntype of *T. carnifex* from Lake Colongulac, Victoria.

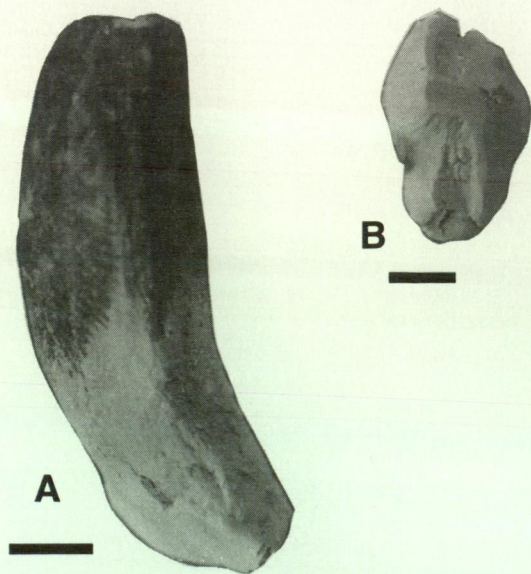


Figure 6 *Thylacoleo crassidentatus* from the Big Sink, Wellington Caves. A, right I^3 (AM F69820), buccal view, scale bar = 5 mm. B, right M_1 (AM F69819), occlusal view, scale bar = 5 mm.

Table 4 Measurements (in mm) of I³ of specimens of *Thylacoleo carnifex* and *T. crassidentatus* identified in the text.

	AM F69820	AM F52398	AM F16641	AM F16481	MoV P1902
L*	10.8	14.5	15.0	16.0	16.6
W*	8.4	10.5	10.0	10.0	11.0
L/W	1.2	1.4	1.5	1.6	1.5

* Length = greatest crown length

* Width = maximum anterior width

Measurements for all these specimens are given in Table 4. These data indicate that the Big Sink incisor is slightly smaller than the equivalent tooth of *T. carnifex*, and that the length of the main crest of the Big Sink tooth is shorter relative to the width of the tooth than I³ of *T. carnifex*.

M₁: The M₁, AM F69819, agrees in general morphological detail with M₁ of the holotype of *T. crassidentatus*, QM F3565. The crown is roughly subtriangular in basal outline. The apex of the metaconid forms the highest point. A broad median wear facet descends from this point anteriorly to the anterior edge of the crown, which is damaged in this specimen. There is a pronounced swelling on the buccal face of the metaconid and a well-defined enamel ridge descends the buccal face of the metaconid from apex to base. Another buccal ridge descends posteriorly from the apex of the metaconid to join the buccal edge of the talonid. A weak talonid basin is defined buccally by this ridge. Lingually, it is defined by a weak ridge that runs forward to the base of the metaconid from the well-developed hypoconid.

Apart from the holotype of *T. crassidentatus*, from the Chinchilla Fauna of Queensland, the M₁ (AM F69819) has been compared in detail with QM F7762 from the Bluff Downs Local Fauna of north Queensland; with several specimens of *T. carnifex* from Wellington Caves old collections (AM F62525, AM MF21, AM MF734); and with the M₁ of *Wakaleo oldfieldi* Clemens and Plane, 1974 (SAM P17925) from the Miocene Kutjamarpu Local Fauna of South Australia. Measurements for various dimensions of M₁ for all these specimens are given in Table 5.

Table 5 Measurements (in mm) of M₁ of species of *Wakaleo* and *Thylacoleo*. Specimens listed by museum numbers are identified in the text.

	Basal L (A)	Talonid L (B)	Max. W	Post. W	Ratio B:A
SAM P17925	11.4	8.2	8.9	7.3	0.72
QM F7762	17.0	12.7	10.0	7.2	0.75
AM F69819	17.5	12.5	11.8	8.0	0.71
QM F3565	16.5	10.0	10.0	7.0	0.61
AM MF734	16.0	9.0	10.8	7.0	0.56
AM F62525	15.6	8.8	10.2	6.0	0.56
AM MF21	15.7	9.2	9.8	6.4	0.59

Remarks

The expected relative size of the I³ of *T. crassidentatus* can be estimated from QM F10622, a skull fragment from Bluff Downs, Queensland, which preserves alveoli for all incisors as well as the full maxillary dentition (see Archer and Dawson 1982). In that specimen the size of the I³ alveolus (greatest 'diameter' approximately 8.0 mm) suggests a tooth similar in size to the Big Sink tooth, supporting reference of the I³, AM F69820, to *T. crassidentatus*. The I³ of *T. carnifex* is relatively small compared to the size of its postcanine teeth. Relative shortening of the incisive cutting edge from *T. crassidentatus* to *T. carnifex* is possibly consistent with the increased emphasis on the shearing crest of the cheekteeth (Archer and Rich 1982).

The data indicate that the M₁ of *T. crassidentatus* is larger than that of *T. carnifex* and has a proportionately longer talonid relative to the total tooth length. A morphocline of decreasing M₁ talonid length is apparent from the Miocene *Wakaleo oldfieldi* through *T. crassidentatus* from Bluff Downs, *T. crassidentatus* from Chinchilla to *T. carnifex* from Wellington Caves. This morphocline exactly mirrors the progressive increases in the lengths of the posterior ends of the crowns of P₃ and P³ reported by Archer and Rich (1982). In all specimens of M₁ of *T. crassidentatus* the posterior face of the metaconid (main cuspid) does not descend as abruptly down to the talonid as in M₁ of *T. carnifex*, but forms a more gradual slope.

The Big Sink M₁ (AM F69819) is morphologically more similar to M₁ of QM F7762 from Bluff Downs than to the holotype of *T. crassidentatus* from Chinchilla, in the relatively more elongate talonid, in having a more prominent cuspid (hypoconulid)

on the posterolingual corner of the talonid, and in the stronger development of the buccal ridges descending from the metaconid.

Although this species is represented in the Big Sink Local Fauna by two isolated teeth only, there is little doubt as to their specific identity. The M_1 is particularly diagnostic for *T. crassidentatus*. The fact that the M_1 from the Big Sink most closely resembles that tooth in the specimen from the Bluff Downs Local Fauna in proportions and morphology may be significant in estimating the age of the Big Sink Local Fauna. It should be noted that two species, *T. crassidentatus* and the much smaller *T. hilli* Pledge, 1977, occur in the Bow Local Fauna, however at present there is no suggestion that *T. hilli* was present in the Big Sink Local Fauna, despite its geographic proximity to Bow. The stratigraphic range of *T. hilli* is not yet clear, and no biochronological implications should be drawn from its absence from the Big Sink.

Suborder Phalangerida Aplin and Archer, 1987

Family Macropodidae Gray, 1821

Subfamily Macropodinae (Gray, 1921)

Protemnodon sp. cf. *P. devisi* Bartholomai, 1973

Figure 7

Material Examined

The following specimens are referred to *Protemnodon* sp. cf. *P. devisi*: AM F69835, left premaxillary fragment with I^{1-3} ; AM F69836, left premaxillary fragment with I^{2-3} ; AM F69837, left I^1 ; AM F69838, left I^1 ; AM F69839, right I^1 ; AM F69840, associated left and right P^3 , left M^1 ; AM F69841, left P^3 , M^1 ; AM F69842, left P^3 ; AM F69843, right P^3 ; AM F69844, left P^3 ; AM F69845/F69846, associated right maxillary with M^{2-4} and right dentary with M_4 ; AM F69847, maxillary fragment with M^{2-4} ; AM F69848, maxillary fragment with M^{1-4} ; AM F69849,

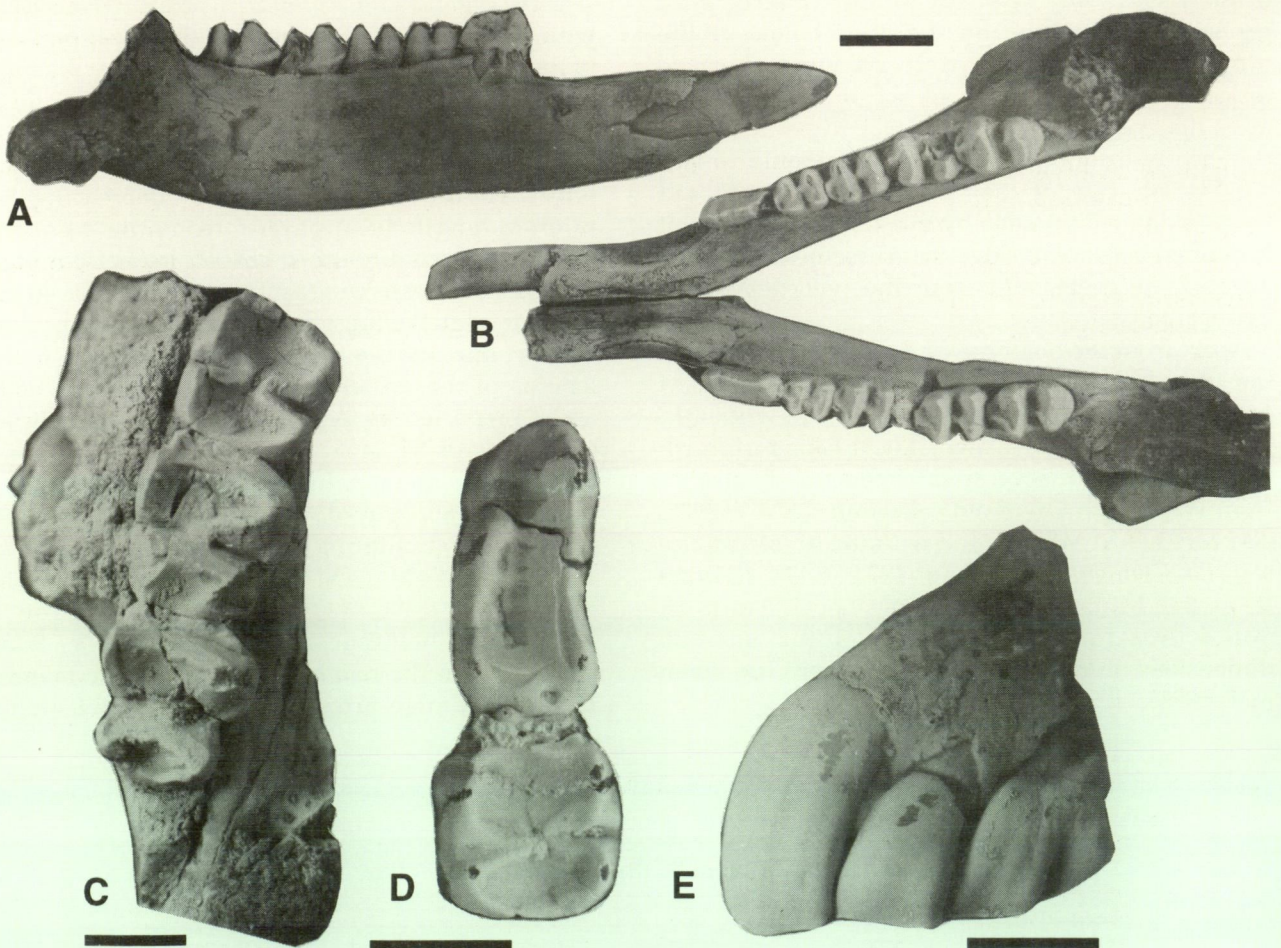


Figure 7 *Protemnodon* sp. cf. *P. devisi* from the Big Sink, Wellington Caves. A, right dentary (AM F69858), buccal view scale bar = 20 mm. B, associated right and left dentaries (AM F69858/9), occlusal view, scale bar = 20 mm. C, right maxillary fragment with M^{2-4} (AM F69845), occlusal view, scale bar = 10 mm. D, left P^3 , M^1 (AM F69841), occlusal view, scale bar = 10 mm. E, left I^{1-3} (AM F69835), buccal view, scale bar = 10 mm.

M⁴; AM F69850, M²⁻³; AM F69851, M²⁻³; AM F69852, M⁴; AM F69853, protoloph M³ or M⁴; AM F69854, protoloph M³ or M⁴; AM F69855, M² or M³; AM F69856, left P³; AM F69857, right P³; AM F69858/AM F69859, associated right dentary with I₁, P₃, M₁₋₄ and left dentary with P₃, M₁₋₄; AM F69860, left dentary with P₃, M₁₋₄; AM F69861, left dentary with M₄; AM F69862, left dentary with M₃₋₄; AM F69863, left M₂; AM F69864, left M₄; AM F69865, left M₂₋₃; AM F69866, right P₃, M₁₋₂; AM F69867, right I₁; AM F69868, left I₁; AM F69869, right I₁; AM F69870, left I₁; AM F69871, right I₁.

Description

The material referred to *Protemnodon* sp. cf. *P. devisi* from the Big Sink comprises the full upper dentition, including the incisors. The I¹ faces anterolaterally, enamel covers only the buccal surface. Although the enamel is about 10% wider than that of I², the occlusal wear facet of I¹ is about the same width as that of I². The I³ has an elongated occlusal surface bearing a deep vertical groove approximately 1/2 to 2/3 of the distance back from the anterior edge of the tooth. All teeth are deep bucco-lingually, resulting in a broad wear facet transverse to the long axis of the tooth. The upper incisors have not previously been described for *P. devisi*, so no comparisons for the Big Sink material are available.

Eight upper permanent premolars are available; two of these are left and right of the one individual. They are all alike, with three sets of vertical ridges behind the paracone, producing three cusps along the main crest. In this they are less variable than the topotypical population of *P.*

devisi from Chinchilla, in which the P³ has three or four vertical ridges and corresponding cusps (Bartholomai 1973). The lingual cingulum reaches forward to a point just posterior to the apex of the paracone where it is separated by a notch from an anterolingual swelling at the base of the paracone. The basin formed by the lingual cingulum is not crossed by ridges as in *P. devisi* from Chinchilla. The lingual cingulum of the P³ is somewhat variable in the Big Sink sample. One specimen, AM F69844, differs from all others in having a short pronounced buccal cingulum extending posteriorly from the base of the paracone to the midline of the tooth. It is connected by three vertical ridges to the cusps on the main crest.

The I₁ is a short-bladed, dorsoventrally-deep tooth, spatulate in shape, rather than lanceolate. It resembles the I₁ of *Protemnodon anak* in size and morphology, particularly in having a slight crest or ridge along its ventral edge. A deep vertical wear facet is produced at the tip. This tooth has not been described for *P. devisi* from the Chinchilla Sand, so comparison cannot be made.

The Big Sink mandibles agree closely in morphology and proportions with *P. devisi* from the Chinchilla Sands as described by Bartholomai (1973). Lower premolars and molars of the Big Sink sample agree with the topotypical sample of *P. devisi* in size and proportions, but the lower molars from the Big Sink lack a posterior cingulum, having only a basal swelling on the posterior face of the hypolophids.

Measurements of the upper and lower dentitions of *Protemnodon* sp. cf. *P. devisi* from the Big Sink are given in Tables 6 and 7, respectively.

Table 6 Dimensions (mm) of the upper dentition of *Protemnodon* sp. cf. *P. devisi* from the Big Sink Local Fauna of Wellington Caves. L = length (for upper incisors, L = antero-posterior length at the occlusal edge of enamel), AW = anterior width, PW = posterior width, a = approximate.

	I ¹	I ²	I ³	P ³	P ³	P ³	M ¹	M ¹	M ¹	M ²	M ²	M ²	M ³	M ³	M ³	M ⁴	M ⁴	M ⁴	
	L	L	L	L	AW	PW	L	AW	PW	L	AW	PW	L	AW	PW	L	AW	PW	
AM F69835	9.5	8.2	13.5																
AM F69836		7.8	12.5																
AM F69838	10.0																		
AM F69837	10.2																		
AM F69849																16.2	13.2	11.5	
AM F69840				18.8	8.0	9.5	11.0		11.0										
AM F69841				20.0	8.0	9.4	14.0	11.5	12.5										
AM F69842				20.0	8.7	9.3													
AM F69843				19.4	8.3a	10.0a													
AM F69844				21.0	6.5	9.8													
AM F69845										13.5	14.0	12.5	15.5	14.8		15.5	14.2	10.8	
AM F69848							11.4	10.7	10.4										
AM F69847										14.2	13.0	11.7	15.7	13.7	12.3	15.4	13.5	10.9	
AM F69849																16.0	12.9	11.5	
AM F69850										13.6	13.5	11.6				15.6	13.0	11.3	
AM F69851										13.2	13.5	12.6		12.9					
AM F69852																15.1	12.5	10.0	

Table 7 Dimensions (mm) of the mandibular dentition of *Protomnodon* sp. cf. *P. devisi* from the Big Sink Local Fauna, Wellington Caves. L = length (for lower incisors L = length on enamel from alveolar edge to tip), D = depth, AW = anterior width, PW = posterior width, a = approximate.

	I ₁ L	I ₁ D	P ₃ L	P ₃ AW	P ₃ PW	M ₁ L	M ₁ AW	M ₁ PW	M ₂ L	M ₂ AW	M ₂ PW	M ₃ L	M ₃ AW	M ₃ PW	M ₄ L	M ₄ AW	M ₄ PW
AM F69858	23.0	14.7	16.3a	6.2	-	11.7	8.3	8.7	14.2	10.0	9.5	15.2	11.4	-	17.9	11.9	10.3
AM F69859			17.2	6.5	5.8	11.4	8.2	8.5	13.0	9.8	9.6	15.2	11.2	10.9	17.7	11.5	10.5
AM F69860			18.0	6.4	5.8				15.2	-	-	16.0	-	-	16.2	-	-
AM F69861															17.2	12.0	12.0
AM F69846															17.2	11.8a	10.2
AM F69870	-	16.4															
AM F69862														11.2	17.5	12.0	11.1
AM F69871		15.5															
AM F69869	25.0	15.8															
AM F69868		15.6															
AM F69867		17.0															

Remarks

The material here referred to a species close to *Protomnodon devisi* is also similar in size to the Pleistocene species *Protomnodon anak* Owen, 1874. It is smaller than *Protomnodon brehus* (Owen, 1874) and *Protomnodon roechus* Owen, 1874 and has lower crowned teeth with weaker links, and a much more gracile mandible with a shorter diastema. It differs from *P. anak* in having much lower crowned molars, with weaker midlinks; in having the mandibular diastema shorter and more robust relative to the length of the molar row; in that I₁ is shorter relative to depth; in having M₃ and M₄ broader relative to length; in having P₃ relatively longer and wider with higher lingual cingulum, and lingual valley not crossed by transverse ridges; and in having broader upper molars, especially the protoloph which is more swollen at its base.

Among Pliocene species of *Protomnodon*, the Big Sink material differs from the slightly smaller *Protomnodon otibandus* Plane, 1967 and *Protomnodon sneuwini* Bartholomai, 1978 in having molars that are larger relative to the size of the premolars; in a more robust dentary; and in the form of I₁, which is not lanceolate. It differs from *Protomnodon chinchillaensis* Bartholomai, 1973 in having much shorter premolars relative to molar length. It differs from *Protomnodon tumbuna* Flannery, Mountain and Aplin, 1983 in being slightly smaller, in the shape of P₃, in having a less lanceolate I₁ and in lacking any posterior cingulum on the lower molars. It is much larger than *Protomnodon nombe* Flannery, Mountain and Aplin, 1983, *Protomnodon bululoensis* Plane, 1967 and *Protomnodon bandharr* sp. nov. (this paper).

Although similar to *P. devisi* from the Chinchilla Sand in Queensland in premolar and molar morphology, size and proportions, the Big Sink material exhibits the following differences from the former population: the lower molars lack a

posterior cingulum; upper molars lack any premetacristae; upper molars also lack any secondary link across the lingual edge of the median valley; and the P₃ has weaker vertical ridges lingually. All these features are known to be variable, especially in Pleistocene species of *Protomnodon* (see Bartholomai 1973). However, the larger samples on which that observation has been based do not necessarily represent single populations, thus the taxonomic significance of the variation is unclear. The material from the Big Sink represents a species very close to *P. devisi* as described from the Chinchilla Sands of Queensland. A better understanding of the provenance of the Chinchilla samples and of other elements of the skeleton of both the Queensland and Big Sink taxa, is required to determine whether the observed differences represent inter-population variation or warrant recognition of a new species from the Big Sink.

Both *P. devisi* and *P. chinchillaensis* occur in the Chinchilla Fauna, but *P. devisi* is otherwise reported from the medial Pliocene Kanunka and Fisherman's Cliff faunas of southern Australia (Tedford *et al.* 1992; Tedford 1994) and Krui River, a deposit of unknown age close to the Bow locality in eastern New South Wales (Appendix 1 in Rich 1991).

Protomnodon bandharr sp. nov.

Figure 8

Material Examined

Holotype

AM F69830, a damaged right dentary with M₄ (Figure 8A-C).

Referred Material

AM F69827, an isolated left I₁; AM F69828, a left maxillary fragment with M³ and M⁴; AM F69829, a right maxillary fragment with P³ and M¹. The

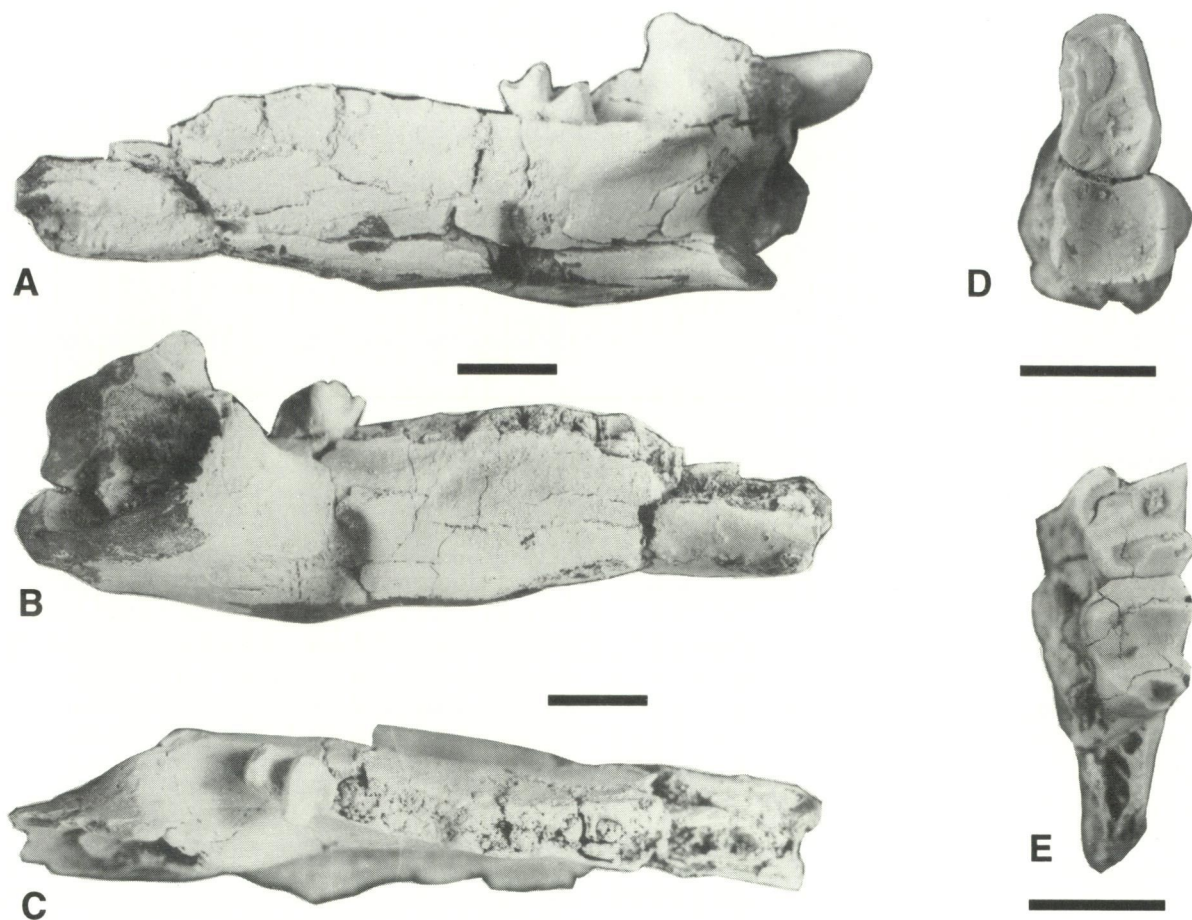


Figure 8 *Protemnodon bandharr* sp. nov. from the Big Sink, Wellington Caves. A, holotype, right dentary with M_4 (AM F69830), lingual view. B, holotype (AM F69830), buccal view. C, holotype (AM F69830), occlusal view. D, maxillary fragment with left P^3 , M^1 (AM F69829), occlusal view. E, left maxillary fragment with M^3 and M^4 (AM F69828), occlusal view. All scale bars = 10 mm.

association of upper and lower dentition has been made on the basis of similar size, good occlusion of the fourth molars, and morphology compatible with reference to other species of *Protemnodon*.

Type Locality and Horizon

South wall of the Big Sink, Wellington Caves, Wellington, New South Wales, Australia. This section of the Big Sink is identified by Osborne (1997) as the Big Sink unit, the upper stratigraphic unit of the Big Sink beds.

Diagnosis

The smallest species of *Protemnodon* yet described, being smaller than *P. nombe* and *P. buloloensis*. Molars are in the size range of *Dorcopsoides fossilis* Woodburne, 1967 among similar extinct taxa. Premolars are approximately equal to fourth molar in length and are shorter relative to molar length than any other species of *Protemnodon*. Distinguished from the similar *Dorcopsoides fossilis* by the more extensive lingual cingulum and broad lingual valley of P^3 and by the absence of

postparacristae on the upper molars. Distinguished from species of *Wallabia* by the extremely robust dentary compared with the size of the molar teeth and the absence of postparacristae and premetacristae on the upper molars.

Etymology

The specific name *bandharr* is a word meaning 'kangaroo' (species unknown) from the Wiradjuri language which was spoken over much of central New South Wales, including the catchments of the Murray, Murrumbidgee, Lachlan and Macquarie Rivers (McNicol and Hosking 1994); noun in apposition.

Description

Dentary

The dentary preserves only M_4 and is badly damaged in the diastemal region, however the alveoli for the missing teeth are discernible. Compared with the size of M_4 the mandible is robust, being 30% to 40% deeper below M_4 than in

species of *Wallabia* which have molars in the same size range. In this it resembles *Protemnodon nombe* which was described by Flannery *et al.* (1983) as being 'microdont'. The tooth row is horizontal and slightly bowed outwards. The mandible is swollen buccally below P_3 and the diastemal region is robust, not slender as in species of *Wallabia*. There is a long postalveolar shelf proximal to M_4 which terminates abruptly in an obtuse angle. Although the ascending ramus of the dentary is broken off, the contours of the post-alveolar shelf and the remains of the anterior edge of the ascending ramus indicate that it rose almost perpendicular to the tooth row. The masseteric fossa is unusual in opening well below the level of the molar alveoli, with the anterobuccal margin of the fossa slanting posteroventrally away from the leading edge of the ascending ramus. There is a strong horizontal ridge below the masseteric crest and this region of the jaw is robust but apparently not as markedly swollen as in *P. nombe*. A very weak buccinator groove runs horizontally below the cheekteeth from below M_1 to the anterior limit of M_3 . The diastema is short, relative to the length of the cheektooth row (approximately half) being similar to *P. buloloensis*, rather than *P. nombe* in which the diastema is approximately 2/3 the length of the cheektooth row. Judging from the alveoli, the permanent premolar was approximately equal in length to M_4 , i.e. relatively short for a species of *Protemnodon* (P_3 is longer than M_4 in *P. nombe* and *P. buloloensis*).

Measurements: Depth dentary below M_3 = 19.0 mm; alveolar length of cheek tooth row = 39.0 mm approximately; length post-alveolar shelf = 7.5 mm; thickness of dentary at P_3 = 9.4 mm; length diastema = 18.0 mm approximately. Dental dimensions for *P. bandharr* are given in Table 8.

M_4 : Low crowned, lophids are broad, bowed strongly outwards particularly on the buccal side, slightly concave anteriorly. The anterior cingulum is low and narrow. A weak forelink (preprotocrisid) runs from the apex of the protoconid to a point buccal to the midline of the anterior cingulum. The hypoconid is broken off. The

midlink was apparently very weak and is largely obliterated by wear. The posterior face of the hypolophid is vertical and there is no discernible posterior cingulum or basal swelling on the hypolophid.

I_1 : This tooth, represented by AM F69827, has been referred to *P. bandharr* on the basis of size and its similar morphology to the I_1 of the New Guinean species of *Protemnodon*. The tooth is moderately worn, and distinguished by a near vertical wear facet on the anterior extremity of the tooth. A similar vertical wear facet is characteristic of I_1 of species of *Baringa* Flannery and Hann, 1984, but there do not appear to be any other teeth referable to that genus in the fauna. Dorsal and ventral margins are sub-parallel, with a sharp enamel flange on the dorsal edge and a weaker ventral flange. The lingual face bears only a narrow ventrolingual band. Maximum dorso-ventral depth of the enamel = 9.8 mm. This tooth resembles the I_1 of *P. nombe*, *P. buloloensis* and *P. otibandus* in having a ventral enamel flange (not smoothly rounded as in the larger species of *Protemnodon*).

Upper Dentition

P^3 : Known only from a worn example (AM F69829), with the paracone broken off, this tooth is low crowned. The main crest is slightly concave buccally and bears two low vertical ridges between paracone and metacone (which is higher). A weak cingulum runs along the buccal base of the crown, with small cusplules at the base of each vertical ridge. The posterolingual cusp (hypocone) is very worn so that the median valley is open posteriorly. A low, non-cusplate lingual cingulum runs anteriorly from the hypocone to the base of the paracone, enclosing a wide median, longitudinal valley.

M^1 : This tooth (AM F69829) is approximately square in outline, but is too worn in the only known specimen for description.

M^3 : The only known example of this tooth, (in AM F69828) is worn, with the protoloph broken buccally. It is low crowned with nearly straight lophs. The protoloph is much wider than the metaloph. There is no sign of an anterior cingulum due to heavy wear. The very weak midlink is almost completely worn away.

M^4 : This tooth, represented in AM F69828, has the protoloph much wider than the metaloph. The anterior cingulum is wide, low and very short antero-posteriorly. The median valley is transverse, open buccally and lingually, with no sign of a midlink; there is no postparacrista as in species of *Wallabia*; a weak postlink ascends diagonally from the hypocone.

Remarks

Protemnodon bandharr from the Big Sink is slightly larger than *Dorcopsoides fossilis* from the Alcoota

Table 8 Dental dimensions (mm) of *Protemnodon bandharr* sp. nov. from the Big Sink, Wellington Caves. L= length, AW = anterior width, PW = posterior width, a = approximate.

	L	AW	PW	
AM F69830	M_4	9.8	6.9	-
	P_3 alveolus	8.0a	-	-
AM F69829	P^3	11.0a	6.0	6.5
	M^1	8.5a	8.2a	8.4a
AM F69828	M^3	9.0a	8.5	7.5
	M^4	10.1	8.0	6.5

Fauna, but resembles that species in morphology of the molar teeth, proportions of the dentary, and in size of the permanent premolars relative to molar size. *Protemnodon bandharr* differs from *D. fossilis* in lacking a posterior cingulum on M_4 and in that M_4 is not situated so far forward from the anterior edge of the coronoid process (cf. Woodburne 1967, figure 13), although this could be related to the ages of the animals represented by these two specimens. If referral of the upper premolar is correct, it also differs in having P^3 with a more extensive lingual cingulum enclosing a broad medial valley. *Protemnodon bandharr* differs from all known species of *Dorcopsis*, *Dorcopsulus* and *Dendrolagus* in the small P_3 relative to molar size, in having a molar row that is bowed, rather than straight, and in being larger. However, it is similar to species of those genera in having the protoloph wider than the metaloph in upper molars (more so than in other species of *Protemnodon*). It is much larger than two small fossil species of *Dorcopsis* and *Dendrolagus* from the Hamilton Local Fauna of Victoria (Turnbull and Lundelius 1970; Flannery *et al.* 1992), and differs in the morphology and relative sizes of P^3 and I_1 . *Protemnodon bandharr* differs from *Wallabia bicolor* and *W. indra* (De Vis, 1895) in the much more robust mandible, the morphology of P^3 , the lower-crowned molars and in lacking any sign of postparacristae or premetacristae on the upper molars.

Of the named species of *Protemnodon*, *P. bandharr* most closely resembles *P. nome* in its small size and in the 'microdont' nature of the molars relative to the size of the mandible. The lower incisor of *P. bandharr* resembles that of *P. otibandus* and *P. buloloensis* in size and distribution of enamel, but those species have a slightly more horizontal wear pattern on I_1 . *Protemnodon bandharr* also resembles *P. nome* and *P. tumbuna* in the apparent near vertical leading edge of the ascending ramus of the dentary, features which Flannery *et al.* (1983) considered to be derived within *Protemnodon*.

Overall this is a very plesiomorphic species. The most derived features of the dentition (as known from the fragmentary specimens available) are the P_3 , which, although smaller, most closely resembles that of *P. tumbuna* from the Pleistocene of New Guinea, and the lower incisor with its distinctive wear pattern. The species also appears to resemble *P. nome* from New Guinea in the robust nature of the proximal portion of the mandible.

Species of *Protemnodon* have been described from many Pliocene-aged deposits in mainland Australia, but most are large, derived forms compared with the present species. Currently the smaller, most plesiomorphic forms of the genus are only known from Pliocene and Pleistocene deposits in New Guinea. Smaller, plesiomorphic macropodines from the Pliocene Bow and

Hamilton Local Faunas have been referred to either *Dendrolagus* or *Dorcopsis*. Flannery *et al.* (1992) referred a single M^1 from the Hamilton Local Fauna to *Protemnodon* sp. This tooth is in the approximate size range of *P. bandharr*, but the worn state of the Big Sink specimen prohibits direct comparison. The larger *P. chinchillaensis* is the only species of *Protemnodon* recorded from the Bow Local Fauna by Flannery and Archer (1984). However, a maxillary fragment with M^3 and M^4 , which was referred by Flannery and Archer (1984) to *Dendrolagus* sp. 2, is also similar in size and morphology to *P. bandharr* and may represent this taxon in the Bow Local Fauna.

Kurrabi sp. cf. *K. merriwaensis* Flannery and Archer, 1984

Figure 9A

AM F69831 is an isolated right P^3 . The main crest of this tooth has two weak vertical ridges between the paracone and metacone, culminating in weak cusps along the main crest. The hypocone is half the height of the metacone; there is a moderate-sized posterior fossette. The lingual cingulum is low and extends nearly the full length of the tooth, terminating below the protocone. Dimensions are length = 11.5 mm, posterior width = 6.0 mm, anterior width = 3.5 mm. This tooth resembles the P^3 of the various species of *Kurrabi*, and is most similar in size to *K. merriwaensis* as described by Flannery and Archer (1984) from the Bow Local Fauna.

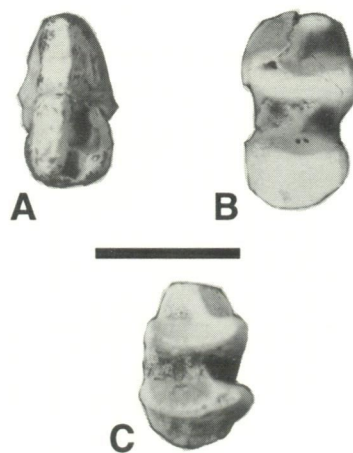


Figure 9 Isolated macropodine teeth from the Big Sink, Wellington Caves. A, *Kurrabi* sp. cf. *K. merriwaensis*, isolated right P^3 (AM F69831), occlusal view. B, Macropodinae gen. et sp. indet., isolated right M_4 (AM F69834), occlusal view. C, Macropodinae gen. et sp. indet., isolated right M_4 (AM F69833), occlusal view. Common scale bar = 10 mm.

Macropodinae gen. et sp. indet.

Figures 9B,C; 10

Two isolated teeth and one mandibular fragment from the Big Sink represent three as yet unidentified macropodine species.

AM F69834 is an isolated right M_4 (Figure 9B). This tooth represents another plesiomorphic macropodine, possibly also a species of *Protemnodon*. The tooth is low crowned, but unique in being very long relative to its width (length = 13.2 mm, anterior width = 7.8 mm, posterior width = 7.0 mm). The anterior cingulum is low and elongate, and both lingually and buccally extensive. The forelink meets the anterior cingulum at the midline. The median valley is narrow transversely, but is also long antero-posteriorly and there is a moderately strong midlink. The posterior hypolophid face is vertical, but swollen at the base. There is no posterior cingulum.

AM F69833 is an isolated right M_4 (Figure 9C). This tooth is generally plesiomorphic among macropodines, being low crowned, with lophids that are near vertical lingually, but strongly bowed outwards on the buccal side. The hypolophid is subequal in width to the protolophid. The posterior face of the hypolophid is almost vertical near the apex, but is swollen at the base. The anterior face of each lophid is slightly concave, and a moderately strong midlink descends from the hypoconid directly to the buccal side of the midline in the median valley. The forelink (preprotocristid) curves gently down from the protoconid to the middle of the low, horizontal anterior cingulum. In this respect the tooth resembles a species of *Protemnodon*. However, it differs from the similarly-sized M_4 of *P. bandharr* in having stronger links and higher lophids. In many ways it closely resembles the M_4 of species of *Wallabia*. Dimensions are length = 11.0 mm, anterior width = 7.1 mm, posterior width = 7.6 mm.

AM F69832 is a mandibular fragment with right P_3 (Figure 10). This represents a previously

unknown macropodine species, characterized by the very small premolar tooth relative to the mandibular depth. The blade of this tooth is also unusually short antero-posteriorly, relative to the crown height. The main crest is non-cusate, near horizontal and slightly deflected posterolingually. There is no lingual or buccal cingulum. Anterior to P_3 the diastemal crest descends gradually. The buccal side of the mandible is smoothly convex and the lingual side is concave immediately below the diastemal crest. Dimensions of P_3 are length = 5.5 mm, posterior width = 3.0 mm, crown height = 4.5 mm; mandible depth below P_3 = 17.0 mm. No previously described fossil species has such a small premolar. Among modern macropodine species *Macropus (Notamacropus) rufogriseus* and *M. (Osphranter) rufus* have (convergently) reduced lower premolars relative to dentary size (Dawson and Flannery 1985), but neither of these closely resembles the fragment from the Big Sink Local Fauna.

Family Burramyidae (Broom, 1898)

Cercartetus Gloger, 1841

Cercartetus sp.

Figure 11

Two isolated molars appear to represent a species of *Cercartetus* in the Big Sink Local Fauna. These teeth are AM F69825, a left M^1 and AM F69826, a left M_2 . The dimensions of these teeth are as follows: M^1 (AM F69825) length = 1.5 mm, anterior width = 1.4 mm, posterior width = 1.5 mm; M_2 (AM F69826) length = 1.2 mm, anterior width = 0.9 mm, posterior width = 0.9 mm. The M^1 represents a species close to *C. nanus* in size, and is generally similar to that species in morphology, although it appears not to be conspecific. The

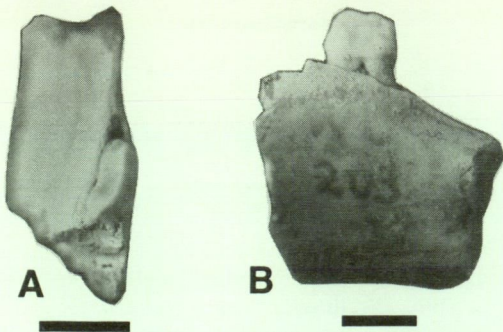


Figure 10 Macropodinae gen. et sp. indet. from the Big Sink, Wellington Caves. Right dentary fragment with P_3 (AM F69832). A, occlusal view, scale bar = 5 mm. B, buccal view, scale bar = 5 mm.

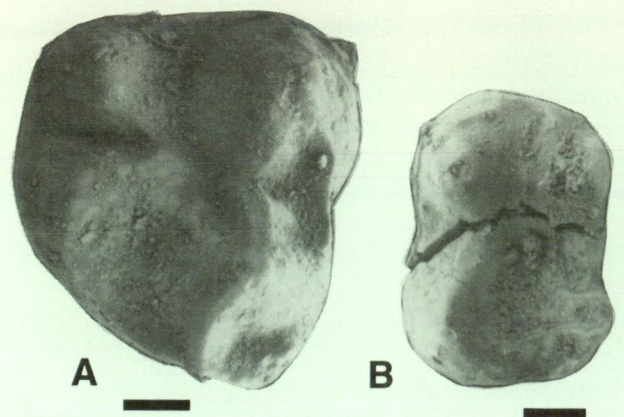


Figure 11 *Cercartetus* sp. from the Big Sink, Wellington Caves. A, left M^1 (AM F69825), occlusal view, scale bar = 250 μ . B, left M_2 (AM F69826), occlusal view, scale bar = 200 μ .

posterobuccal corner of the tooth differs from that of *C. nanus* in being considerably more swollen and in lacking a buccal cingulum across the base of the hypocone. Also, the protocone and metacone are relatively higher than in *C. nanus*. The M_2 is also similar to M_2 of *C. nanus*, but smaller. It also differs in minor morphological details such as a shorter anterior cingulum, relatively smaller protoconid, and lower, more lingually shifted, metaconid.

Since only two teeth are known so far from the Big Sink, exhaustive comparisons with all modern species of *Cercartetus* have not been undertaken. Species of *Cercartetus*, as yet undescribed, are known from several Miocene faunas and from the Hamilton Local Fauna (Woodburne *et al.* 1985). Until descriptions of these taxa are available it is not possible to determine the affinities of the Big Sink species.

Family Pseudocheiridae (Winge, 1893)

Pseudocheirus sp. cf. *P. stirtoni* Turnbull and Lundelius, 1970 Figure 12

This taxon is represented in the Big Sink Local Fauna by four isolated upper molars, as follows: AM F69821, a left M^3 ; AM F69822, a left M^3 ; AM F69823, a left M^3 ; and AM F69824 a damaged right M^2 . Dimensions are given in Table 9.

The specimens from the Big Sink have been assigned to a species close to *Pseudocheirus stirtoni* on the basis of similar size and morphology to the type series and referred material of *P. stirtoni*, from the early Pliocene-aged Hamilton Local Fauna of

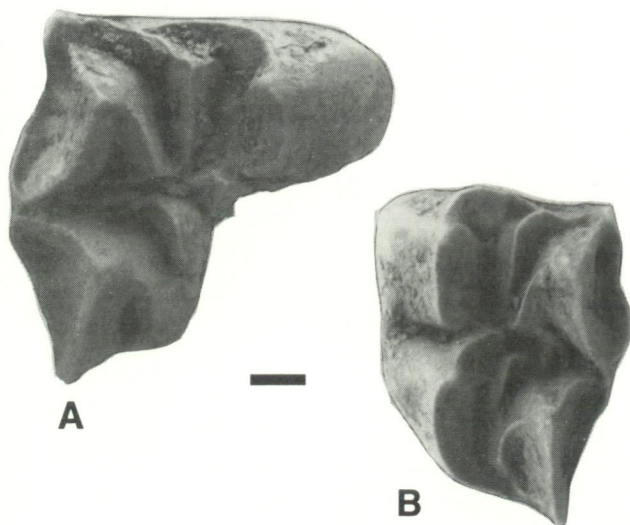


Figure 12 *Pseudocheirus stirtoni* from the Big Sink, Wellington Caves. A, right M^2 (AM F69824), occlusal view. B, left M^3 (AM F69821), occlusal view. Common scale bar = 450 μ .

Table 9 Dimensions (in mm) of teeth of *Pseudocheirus stirtoni* from the Big Sink.

	M^3		M^2	
	AM F69821	AM F69822	AM F69823	AM F69824
L	2.6	2.8	2.7	2.9
AW	2.4	2.3	2.4	2.8
PW	2.1	1.9	2.1	—

Victoria (Turnbull and Lundelius 1970; Turnbull *et al.* 1987). They differ from the equivalent teeth in the Hamilton population of *P. stirtoni* in being slightly smaller; in having lower, less prominent, parastyles; and in the condition of the anterior crest of the protoconule on M^2 , which appears to be relatively stronger in the Big Sink teeth with a more definite connection to the anterior cingulum. Since the sample of teeth from the Big Sink is small, it is not clear whether these differences represent inter-populational variation or if they warrant recognition at the species level.

The teeth from the Big Sink resemble *P. stirtoni* and differ from *Pseudocheirus marshalli* Turnbull and Lundelius, 1970, in having more robust paracones and metacones with strong 'buttresses' (posterolingual paracrista and metacrista, respectively), and greater reduction of the parastyle.

Pseudocheirus stirtoni from Hamilton and the similar Big Sink specimens resemble the modern *Petauroides volans* more closely than species of *Pseudocheirus*, in the relatively reduced parastyles, the prominent posterolingual paracristae and posterolingual metacristae, the lack of accessory ridges from any of the crests, and the absence of the anterolingual paracone and metacone crests. This similarity prompted Archer (1984) to suggest that *stirtoni* should belong in the genus *Petauroides*. However, Turnbull *et al.* (1987) argued for retention of the species in *Pseudocheirus* and the teeth from the Big Sink add nothing to clarify or resolve that debate.

Supercohort Placentalia Owen, 1837

Order Chiroptera Blumenbach, 1779

Family Megadermatidae Allen, 1864

Macroderma koppa Hand, Dawson and Augee, 1988

A species of ghost bat, *Macroderma koppa*, was described from the Big Sink Local Fauna by Hand *et al.* (1988) on the basis of a partial skull with associated dentaries and at least 13 other specimens. This species differs from the Pleistocene and modern species, *M. gigas*, in several features

which have been interpreted as being more plesiomorphic. The most consistent diagnostic feature of *M. koppa* is the presence of a double infraorbital foramen, which is single in *M. gigas*. It also differs from *M. gigas* in having a less well developed nose shield, larger incisors and premolars, and longer anterior part of the tooth row. *Macroderma koppa* differs from the Miocene species, *M. godthelpi* Hand, 1985, in being larger, lacking P², having a stronger P⁴ heel, higher tooth crowns and reduced pre-entoconids.

Next to the large macropodine, *Protemnodon* sp. cf. *P. devisi*, this ghost bat is the most abundant mammal in the Big Sink deposit, and it is the most abundant small mammal. It is probable that the other small mammal remains in the deposit represent the prey of *M. koppa*, which may have inhabited the original cave. It is also possible that the 'yellow phosphorite' material, described as part of the Phosphate Mine sediments by Osborne (1983), is derived from guano accumulated by an ancient bat colony. Because of the mining operations, only a remnant of this material is retained on the north wall of the Big Sink opposite the bone breccia of the Big Sink unit. However, it may once have occupied much of the cavity which is now the Big Sink and been the main source of phosphate retrieved in the mining operations (R.A.L. Osborne pers. comm. 1996).

Two species of ghost bat are known from Pliocene-aged deposits: *Macroderma koppa*, so far known only from the Big Sink, and *M. gigas*, from Rackham's Roost in north Queensland (Hand 1996). The more plesiomorphic condition of *M. koppa* (Hand *et al.* 1988), suggests that the Big Sink Local Fauna is older than that of Rackham's Roost.

Order Rodentia Bowdich, 1821

Family Muridae Illiger, 1815

Subfamily Murinae Illiger, 1815

Gen. et sp. indet.

Figure 13

A conilurin rodent is represented in the Big Sink Local Fauna by 35 isolated molar teeth, as follows: three M¹s, four M²s, nine M³s, four M₁s, five M₂s and nine M₃s. Most are poorly preserved with only two complete and one partial (posterior half only) M¹s present. That this rodent is one of the group of 'old endemics' (Ride 1970) is indicated by the cusp morphology of M¹ and M² (e.g. AM F69900), which shows close morphological similarity to species of the genus *Pseudomys*. The M¹ and M² appear to differ from all modern conilurin species in the retention of the posterobuccal cusp, T9, which is plesiomorphic (Misonne 1969). Dimensions of representative teeth are as follows: M¹ (AM

F69872) L = 2.6 mm, W = 1.5 mm; M² (AM F69873) L = 2.0 mm; W = 1.4 mm; M³ (AM F69874) L = 1.2 mm, W = 1.2 mm. Although only isolated teeth are represented, it is estimated that the length of M¹ would be less than the combined length of M² and M³ (*in situ*), another feature characteristic of the genus *Pseudomys* (Watts and Aslin 1981). Godthelp (1990) has indicated that the genus *Pseudomys* will probably prove to be polyphyletic. For this reason it is here considered unwise to assign these isolated teeth to that genus on the basis of the fragmentary material available at present.

Resolution of the generic and specific identity of these specimens must await additional, more complete material. However, these teeth from the Big Sink appear to represent a new species of *Pseudomys*, similar in size to *P. vandycki* Godthelp, 1990, the only other Tertiary species of *Pseudomys* so far described, from the Chinchilla Sands of southeastern Queensland. They differ from *P. vandycki* in retention of cusp T9 on M¹ and M². These teeth also closely resemble another undescribed taxon from the Chinchilla Sands, but there are enough minor differences to indicate that they are probably not conspecific (H. Godthelp pers. comm. August 1996).

To date, only one other Australian Tertiary murid has been described. This species, *Zyzomys rackhami* Godthelp, 1997, is from the Pliocene Rackham's Roost deposit. However, rodents have been recorded as present in several other Australian deposits of Tertiary age, including Bluff Downs, Fisherman's Cliff, and Dog Rocks (Appendix 1 in Rich 1991). Tedford (1994) also reported the possible presence of a murid from the early Pliocene at Parwan, Victoria, but this has not been confirmed. Although detailed comparison of the Big Sink rodent with specimens from these deposits is not yet complete, preliminary investigation suggests that they do not contain species in common (Godthelp pers. comm. August 1996).

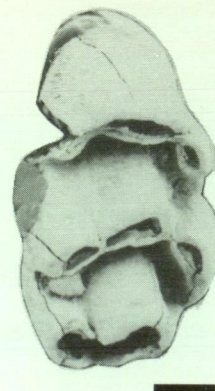


Figure 13 Murid rodent from the Big Sink, Wellington Caves. Right M¹ (AM F69900), occlusal view. Scale bar = 400 μ .

The Big Sink rodent taxon also differs from those that occur in all other stratigraphic units of the Wellington Caves system (see Introduction), including those which are abundantly represented in the (probably) early Pleistocene Bone Cave deposits.

BIOCHRONOLOGY

Current understanding of the biochronological relationships of late Tertiary deposits containing vertebrate fossils in eastern Australia and the Lake Eyre basin has been recently reviewed by Tedford *et al.* (1992) and Tedford (1994). While only two of the deposits reviewed are dated radiometrically, additional information, obtained largely from palaeomagnetic studies, has allowed otherwise undated vertebrate faunas to be assigned a relative age. Increasing understanding of evolutionary polarity of morphological features, particularly trends in dental adaptation to vegetation and climatic changes, has also allowed more confidence to be placed in decisions on relative ages of otherwise undated faunas. Table 10 (see p. 000) compares the fauna of the Big Sink with other faunas in eastern Australia with which it shares species. Of these faunas, two are radiometrically dated to the early Pliocene.

Strongest evidence that the Big Sink Local Fauna predates the medial Pliocene comes from the presence of *Thylacoleo crassidentatus*, and species of *Perameles* and *Protemnodon* that are either unique or shared by other faunas of known early Pliocene age (Table 10). Further support comes from the suggested occurrence of a species of *Kurrabi*, a genus only known from the early Pliocene of south-eastern Australia (Tedford 1994), and from *Pseudocheirus* sp. cf. *P. stirtoni* and a new genus and (very probably) species of peramelemorphian shared with the Hamilton Local Fauna.

In overview, the greatest similarity in terms of shared species is with the faunas that are geographically closest to Wellington, and which were probably in the same climatic province even in the early Pliocene, i.e. Chinchilla and Bow. The next closest similarity is with the Hamilton Local Fauna of southeastern Victoria, and then with the more geographically remote Bluff Downs Local Fauna (north Queensland), and Fisherman's Cliff and Kanunka Faunas of the Murray Basin and the Lake Eyre region, respectively. The age of the Chinchilla Local Fauna is surmised to be early to middle Pliocene, but younger than the Bluff Downs Local Fauna, on the basis of the stage of evolution of taxa shared between these two faunas (Appendix 1 in Rich 1991). On the same tenuous basis, particularly with respect to macropodine taxa, the Bow Local Fauna appears to be closer in age to the Bluff Downs Local Fauna and Hamilton Local Fauna than it is to the Chinchilla Local Fauna

(Flannery and Archer 1984). These considerations suggest that the Big Sink Local Fauna may predate the Chinchilla Local Fauna, and have a maximum age of 4–4.5 Myr.

A possible minimum age for the Big Sink Local Fauna is also difficult to establish because of the poor knowledge of Pliocene biochronology in New South Wales. Compared with the Big Sink Local Fauna, those from the palaeomagnetically bracketed medial Pliocene deposits of the Murray Basin and Lake Eyre Basins (see Tedford 1994) contain a higher diversity of macropodine and rodent taxa, and this might suggest that they are younger than the Big Sink deposit. A minimum age for the Big Sink might therefore be set at around the late early Pliocene, or somewhat greater than 3.5 Myr.

Because the main agent for accumulation of small mammal bones in the Big Sink was probably the ghost bat, which could be expected to thoroughly sample the small mammal fauna of the surrounding area, the absence of a diverse rodent fauna may be chronologically significant. While individual rodent teeth are relatively common in the deposit, these appear to represent only one species. This contrasts with the occurrence of several genera and species of rodent in the Fisherman's Cliff Local Fauna (Marshall 1973; Appendix 1 in Rich 1991; Tedford 1994) and with the occurrence of more than two species in the Chinchilla Local Fauna (Appendix 1 in Rich 1991). The plesiomorphic nature of the Big Sink conilurin (indicated by the retention of the T9 cusp on the first molar) also supports the hypothesis that this may represent the earliest occurrence of a rodent in southern Australia.

The ghost bat, *Macroderma koppa*, also hints at a possible early Pliocene age, since it represents a more plesiomorphic stage of evolution (Hand *et al.* 1988) than *Macroderma gigas*, which is first recorded from the north Queensland Rackham's Roost deposit. This latter deposit is undated but may also be early Pliocene in age, based on biocorrelation (Appendix 1 in Rich 1991; Godthelp 1997).

PALAEOENVIRONMENT

The palaeoenvironmental significance of the various eastern Australian early Pliocene faunas is difficult to assess because of the different modes of accumulation of the deposits. Of the various faunas available for comparison, the Big Sink and Rackham's Roost alone appear to represent ghost bat accumulations in caves; these are likely to sample a different spectrum of the surrounding fauna from the other deposits which are predominantly alluvial. The Big Sink does not appear to represent a pit fall trap, but was evidently a large cavern, probably a maternity

colony for ghost bats (inferred from the large amount of guano which most likely formed the source of the subsequently-mined phosphate). Such a cavern would occasionally trap larger marsupials which wandered in or sought shelter in it, and also attract carnivores which scavenged on the remains of trapped animals, or used the cavern as a den site. This accords well with the limited spectrum of larger mammals found in the deposit, which includes two large carnivores (*Thylacinus* sp. and *Thylacoleo crassidentatus*), but is very depauperate in macropodids (with only about six taxa) and contains no diprotodontids or vombatids.

Two species from the Big Sink Local Fauna (*Pseudocheirus* sp. cf. *P. stirtoni* and a new genus and species of bandicoot) are taxonomically very close to species from the Hamilton Local Fauna. The composition of that Local Fauna, along with analysis of fossil pollens from the Hamilton Grange Burn sediments, has suggested a mosaic of habitats, including rainforest patches, in southeastern Victoria in the early Pliocene (Flannery *et al.* 1992; Macphail 1997).

Of the four species of small dasyurid present, two have their closest affinities with species from the far north of Australia. Of these, one is close to the "Floraville *Antechinus*" (Archer 1982) from the late Pliocene or early Pleistocene of north Queensland. Of the two species of *Sminthopsis* present, one, *Sminthopsis* sp. 1, is close to *Sminthopsis virginiae*, an inhabitant of northern Australia, while the other, *Sminthopsis* sp. 2, exhibits entoconid reduction, a feature considered by Archer (1982) to be linked with adaptation to increased seasonality and aridity. Phylogenetic analysis of the new dasyurid species "*Dasyercus*" *worboysi* shows it to be tenuously included in a clade containing *Parantechinus*, *Pseudantechinus*, *Dasykaluta*, *Dasyercus* and *Dasyuroides*. These taxa share marked entoconid reduction, while several modern species in this group also display life history 'Strategy 1' or 'Strategy 2' of Lee *et al.* (1982), both of which are associated with seasonal climates. Environmental evidence from the Big Sink Dasyuridae is therefore equivocal, but also tends to support a mosaic of vegetation types, including moist forest microhabitats, some more sclerophyllous woodland, and at least some seasonal aridity.

The presence of a species of ghost bat in the Big Sink Local Fauna is not helpful in palaeoenvironmental reconstruction. Despite the fact that *Macroderma gigas* is now confined to tropical northern Australia, it is known to have occurred in widely differing locations in central and southern Australia, as well as in the Mitchell Cave beds in Cathedral Cave at Wellington Caves in the late Pleistocene (Molnar *et al.* 1984; Dawson and Augee 1997). Ghost bat distribution may be

more affected by the availability of prey and of caves with a suitable internal configuration and microclimate, particularly for maternity colonies. Within such caves they appear to require an ambient temperature between 20°C and 26°C (Nelson 1989).

While there are no taxa in the Big Sink Local Fauna which directly imply rainforest, the overall impression is of a woodland to moist forest environment, lacking extensive areas of grassland. This is most clearly indicated by the fact that the six macropodine taxa present all have low-crowned browsing grade dentitions.

Evidence from fossil pollen studies indicates that there may have been a short period in the early Pliocene when the climate of southeastern Australia, including the catchments of the Lachlan and Macquarie Rivers (and hence the Wellington Valley), returned to the warmer, wetter conditions characteristic of the Miocene, including the return of *Nothofagus* species to the Wellington area (Martin 1991; Macphail 1997). However, there is insufficient faunal evidence to associate this period with the interval of deposition of the Big Sink Local Fauna. Macphail (1997) concluded that there is no evidence from the pollen record to indicate grassland in the early Pliocene of the Grange Burn region of Victoria, nor in the Lachlan River catchments; but some grassland elements are indicated in the pollen records of the palaeovalleys of rivers in far northern New South Wales. The Macquarie River valley at Wellington lies between these regions, and the faunal record from the Big Sink reflects its biogeographic position between the more seasonally arid summer rainfall regimes of northern New South Wales and Queensland and the 'remnant' moister rainforest which apparently returned to southern New South Wales and Victoria for a period associated with relatively high sea levels in the early Pliocene (Macphail 1997).

CONCLUSION

The fauna of the Big Sink unit of the Big Sink beds differs from all other bone assemblages so far described from the sediments in the Wellington Caves. Further collection from the Big Sink unit may enlarge the list of species, but the present list contains no species in common with those previously recorded from these caves in early fossil collections (Dawson 1985) or in more recent studies of the fauna from the Mitchell Cave beds in Cathedral Cave (Dawson and Augee 1997) and Bone Cave (Dawson 1995). However, one species, *Perameles bowensis*, has also been recorded from the Graded-bedded unit of the Phosphate Mine beds (see Table 1) (Muirhead *et al.* 1997). The faunal data therefore support the stratigraphic sequence described by Osborne (1997) and provide further

Table 10 Biocorrelation of taxa in the Big Sink Local Fauna (source of other faunal lists: Rich *et al.* 1991)

	Bluff Downs	Chinchilla	Bow	Big Sink	Fisherman's Cliff	Hamilton	Kanunka
Thylacinidae							
<i>Thylacinus</i>	-	<i>cynocephalus</i>	-	sp.	-	-	-
Dasyuridae							
" <i>Dasyercus</i> "	-	-	-	<i>worboysi</i> sp. nov.	-	-	-
<i>Antechinus</i>	-	-	-	sp.	sp.	sp.	-
<i>Sminthopsis</i>	-	-	-	sp. 1, sp. 2	-	-	-
Peramelemorphia indet.	-	-	?new genus	new genus and sp.	-	? new genus	-
Peramelidae							
<i>Perameles</i>	-	?	<i>bowensis</i>	<i>bowensis</i>	-	-	-
<i>Perameles</i>	<i>allinghamensis</i>	-	<i>allinghamensis</i>	-	-	-	-
Thylacoleonidae							
<i>Thylacoleo</i>	<i>crassidentatus</i>	<i>crassidentatus</i>	<i>crassidentatus</i>	<i>crassidentatus</i>	-	-	-
<i>Thylacoleo</i>	-	-	cf. <i>hilli</i>	-	-	-	-
Macropodidae							
<i>Protemnodon</i>	<i>snewini</i>	<i>devisi</i>	sp.	cf. <i>devisi</i>	cf. <i>devisi</i>	sp.	<i>devisi</i>
<i>Protemnodon</i>	-	<i>chinchillaensis</i>	<i>chinchillaensis</i>	-	-	-	-
<i>Protemnodon</i>	-	-	?cf. <i>bandharr</i>	<i>bandharr</i>	-	?cf. <i>bandharr</i>	-
<i>Kurrabi</i>	-	-	<i>merriwaensis</i>	?cf. <i>merriwaensis</i>	-	-	-
<i>Kurrabi</i>	-	-	<i>mahonyi</i>	-	-	<i>plechenorum</i>	-
Burramyidae							
<i>Cercartetus</i>	-	-	-	sp.	-	-	-
Pseudocheiridae							
<i>Pseudocheirus</i>	-	-	-	cf. <i>stirtoni</i>	-	<i>stirtoni</i>	-
Megadermatidae							
<i>Macroderma</i>	-	-	-	<i>koppa</i>	-	-	-
Muridae							
<i>Pseudomys</i>	-	<i>vandycki</i>	-	-	-	-	-
Muridae indet.	sp.	spp.	-	sp.	spp.	-	-

confirmation of a long and complex history of sediment accumulation in the various chambers of the cave system. Although many of the early bone collections from the caves are unprovenanced (Dawson 1985), it is clear that they, and the bulk of the more recent collections, were taken from the stratigraphically higher red earth of the Mitchell Cave beds which occur in all chambers of the cave system and the Phosphate Mine.

The fauna of the Big Sink unit provides an important contribution to understanding the zoogeography of the late Tertiary in eastern Australia, linking faunal elements from the tropical north with those of the temperate southeast. Although collections from the younger sediments in the cave system contain some arid adapted taxa (Dawson 1985), none of the species in the Big Sink deposit appears to be strictly arid adapted. Absence of grazing grade macropodines suggests that the deposit may predate the spread of extensive areas of grassland into the southeast (Tedford 1994).

The deposit may also represent the earliest known occurrence of rodents in southern Australia. Comparison with the more diverse assemblages of rodents in the medial Pliocene deposits from Fisherman's Cliff in southwestern N.S.W. and in the early Pleistocene (?) fauna from Bone Cave (Dawson 1995) suggests that rodents radiated rapidly following their arrival from the north. Arid-adapted rodent genera such as *Notomys* are present in the younger Bone Cave Breccia unit at Wellington Caves, but are absent from the Big Sink beds.

The findings of this study suggest that the Wellington Caves sediments have accumulated sporadically over a period of at least 4 million years, from the early Pliocene until the Holocene (Dawson and Augee 1997). Further study of fossil mammal bones from this system will provide a unique opportunity to document faunal and environmental change in one locality in eastern Australia.

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