The distribution of fossil and sub-fossil records of the Eastern Pygmy-possum *Cercartetus nanus* in Victoria

Jamie M Harris[1] and Ross L Goldingay[1]

Abstract
The Eastern Pygmy-possum *Cercartetus nanus* has a variable status throughout its current geographic range. Investigating its prehistoric range may provide some perspective into its current distribution and abundance. We reviewed available information from the published literature and museum databases to document the fossil and sub-fossil sites in Victoria where bones of the species have been reported. This revealed 17 sites of late Pleistocene and Holocene age ranging from ca. 780 ± 100 to >33 000 years. The fossils from five sites (Bridgewater Caves South; Clogg's Cave; McEachern's Cave; McEachern's Deathtrap Cave and Pyramids Cave) are dated at >10 000 years, and extend from the far south-west to the far east of Victoria. The Steiglitz Cave (<6 000 years), located in south-central Victoria, provides evidence that Eastern Pygmy-possums were also present in that area in the mid-Holocene. The apparent prehistoric distribution of the species is likely to be an artifact of the availability of fossil sites. The fossil localities for the Eastern Pygmy-possum appear to be within the distribution of extant populations, and the available evidence does not suggest a contraction of geographic range. This may suggest that the available habitat for Eastern Pygmy-possums has not changed to any great extent during the last 10 000 years. Thus, this study provides a preliminary basis for examining modern contractions in the range of the Eastern Pygmy-possum, whether due to climate change, proximate anthropogenic disturbances, or other factors. (*The Victorian Naturalist* **122** (4), 2005, 160-170)

Introduction

The Eastern Pygmy-possum *Cercartetus nanus* (family Burramyidae) is a small (15-38 g) marsupial occurring along the south-eastern seaboard of mainland Australia and in Tasmania. It inhabits a range of vegetation communities including wet and dry eucalypt forest, *Banksia* woodland and heathland. Currently, it is officially classed as 'Vulnerable' in New South Wales (NSW) and in South Australia (SA), but 'not threatened' in Victoria, Queensland and Tasmania. Information on the modern distribution of the species in Victoria, NSW and SA (Menkhorst 1995; Bowen and Goldingay 2000; van Weenen 2002) has been assessed more recently and thoroughly than in Queensland (Van Dyck and Longmore 1991) and Tasmania (Rounsevell *et al.* 1991). However, data on its fossil distribution are poorly documented and have not been reviewed for any State.

This situation contrasts with the Mountain Pygmy-possum *Burramys parvus*, which has a famous history as a 'living fossil' (Anon 1966a,b; Lane and Richards 1967).

The Mountain Pygmy-possum was first discovered as a fossil in 1895 at Wombeyan Caves in NSW (Broom 1896; Ride 1960) and subsequently collected from Pyramids Cave in eastern Victoria (Wakefield 1960a). It was believed extinct until one was captured alive in 1966 in a ski hut at Mount Hotham, Victoria (Epstein 1981). Apart from its celebrated discovery, the species is also well known because of its endangered status, and because it is an example of how the fossil record can be used to inform conservation perspectives (Broome and Mansergh 1989; Brammall 1993; Mansergh and Broome 1994). Archer *et al.* (1991) noted that *Cercartetus* Pygmy-possums also appear to have declined in distribution. However, whether the Eastern Pygmy-possum specifically has suffered a range decline of a similar magnitude to that reported for the Mountain Pygmy-possum is unclear. Therefore, the primary aims of this study were to: (1) map the point occurrences of Victorian fossil and sub-fossil Eastern Pygmy-possum *Cercartetus nanus*; and (2) relate these localities to its modern distribution. Secondary aims were to document the reported ages for the fossil material, the agent/s responsible for their accumulation, and the frequency of Eastern Pygmy-possums collected from each of the sites.

[1]School of Environmental Science and Management, Southern Cross University, Lismore, NSW, 2480.
Corresponding author, Email: jharri11@scu.edu.au

Methods

A literature search of lists of mammalian fossil and sub-fossil deposits was conducted to obtain records of the Eastern Pygmy-possum. Papers by Archer and Hand (1984) and Rich (1991) assisted with this. Enquiries were also made at Museum Victoria and the Australian Museum to ascertain the source of Victorian Eastern Pygmy-possum material held in their palaeontological collections (642+ specimens and 0 specimens respectively). The co-ordinates of the cave sites were determined using the Geoscience Australia online mapping place-name search and by correspondence with members of the Australian Speleological Federation (ASF). However, the co-ordinates for one Victorian cave remain unknown.

Beehive Cave, as it is referred to in the Museum Victoria database, apparently occurs in the Bats Ridge area, near Portland, but we found no mention of it in the literature reviewed. The Karst Index Database (KID), maintained by the ASF, has no entry for a 'Beehive Cave' from Victoria, therefore it may be a local name or one assigned at the time on account of a beehive being at the entrance (M Pierce 2004 pers. comm. 11 December). It is likely that the cave is one of the now numbered caves, but to suggest which one would require more information on the whereabouts of the subject cave and/or other nearby features. The fossil material collected from Beehive Cave forms part of the Wakefield collection at Museum Victoria. The Curator of Vertebrate Palaeontology, Tom Rich, advised that Wakefield provided brief, often cryptic, labelling of specimens, and the only locality data available are those with the specimens, as recorded in the museum database, and with the papers that Wakefield published. Therefore, for Beehive Cave we have had to assign approximate co-ordinates.

There may, potentially, be some confusion associated with the Natural Bridge (H-10) locality, referred to by Wakefield (1964a) as near Mount Eccles. In the speleological literature (Matthews 1985), this cave is referred to as 'Natural Arch' and/or 'Gothic Cave', and the term 'Natural Bridge' seems mainly to appear on Parks Service (Parks Victoria) maps (M Pierce 2004 pers. comm. 11 December). It could easily be mistaken for Bridge Cave (H-13), which is at Byaduk, and the Australian Karst Index records that Bridge Cave 'contains bones; important for paleontology' (Matthews 1985). However, Byaduk is a distinct and separate locality from Mount Eccles with the lava flows originating from separate volcanoes (Mount Napier and Mount Eccles respectively).

Definitions of Holocene (10 000 ya – present), Pleistocene (1.75 mya – 10 000 ya), and Tertiary (1.75 mya – 65 mya) follow Long *et al.* (2002). The body mass of small mammals referred to follows Menkhorst and Knight (2001). Modern records of Eastern Pygmy-possums were extracted from the Atlas of Victorian Wildlife (maintained by the Department of Sustainability and Environment), and use of a Geographic Information System (GIS) allowed the estimation of distances between modern and fossil records.

Results

Fossil and sub-fossil Eastern Pygmy-possums have been reported from 17 sites (Table 1). These were caves and/or rock shelters varying in size and origin. M-27, M-28 and Pyramids are caves formed within Early Devonian limestone in the vicinity of the Murrindal River, and Mabel Cave and Clogg's Cave are within similar substrates at East Buchan (Matthews 1985). The Victoria Range site, in the Grampians, is a rock shelter around 1 m wide and 3 m long occurring in sandstone (Wakefield 1963d). Black Range is also in the Grampians sandstone (Wakefield 1963d, 1969a), but its features have not been systematically recorded by cavers/speleologists in Victoria (M Pierce 2004 pers. comm. 11 December). Fern Cave, near Portland, occurs in Tertiary limestone and the dimensions of its chamber are approximately 18 m long, 12 m wide, and 9 m high (Matthews 1985). Also derived from Tertiary limestone is Amphitheatre Cave (Baird 1992), which has a vertical range of around 18 m, and a horizontal extent of 50 m long and 30 m wide (Matthews 1985). McEachern's Cave is formed in an Oligocene-Miocene Limestone, and is approximately 60 m long (Hope and Wilkinson 1982). The

Table 1. Location and frequency of Eastern Pygmy-possum remains in Victorian Holocene and Late Pleistocene cave deposits.

Cave No. = Alphanumeric identification system assigned to caves by the Australian Speleological Federation (Matthews 1985). Origin: OP= Owl Pellet, MS= Mammal Scat, PF= Pitfall. Total = Minimum number of individuals of all non-volant mammals in the deposit, and ( ) = number of terrestrial mammal species present. MNI = Minimum number of individual Eastern Pygmy-possums present. % = Percentage occurrence of Eastern Pygmy-possums calculated as MNI/Total x 100. The sites are listed in approximate order of age, with undated sites listed first. A dash (-) indicates that the data are unknown or not available. The age of the material is years before present (yr BP) ascertained either by radiocarbon dating as detailed by Lundelius (1983), or as provided by the source indicated. Sources: [1] W Gerdtz (Museum Victoria) pers. comm., [2] Wakefield 1963d, [3] Wakefield 1964a, [4] Wakefield 1964b, [5] Wakefield 1963b, [6] Wakefield 1972, [7] Baird 1991, [8] Baird 1992, [9] Wakefield 1960a, [10] Hope 1973, [11] Peake *et al.* 1993, [12] Kos 2001, [13] Kos 2003, [14] Godwin 1980, [15] Lourandos 1983, [16] Lundelius 1983, [17] Wakefield 1967b, [18] Wakefield 1969a, [19] Wakefield 1969b, [20] Link 1967, [21] Hope and Wilkinson 1982, [22] Wakefield 1960b, [23] Wakefield 1967a.

Site Name	Cave No.	Origin	Total	MNI	%	Age (yr BP)
Beehive Cave[1]	-	-	-	100+	-	-
Victoria Range[2]	-	OP	402 (19)	75	18.7	-
Natural Bridge[3,4]	H-10	OP, MS	1573 (24)	28	1.8	-
Flowerpot Cave[3]	H-19	OP	89 (18)	2	-	-
Harman Two[3]	H-12	OP, MS	323 (22)	16	-	-
Black Range[2]	-	-	- (5)	1-2	-	780 ± 100
Fern Cave[5,6]	KB-1	PF, OP	1552 (33)	18	1.2	3 000 to 4 000
Amphitheatre Cave[1,7,8]	G-2	PF	-	102	-	4 670 ± 90
M-27[9,10]	M-27	MS	878 (-)	43	4.9	<5000
M-28[9,10]	M-28	MS	552 (-)	16	2.9	<5000
Mabel Cave[7,9,10]	EB-1	OP, MS	1380 (-)	69	5.0	<5000
Steiglitz Cave[11]	-	OP	90 (20)	2	2.2	<6000
McEachern's Deathtrap Cave[12,13]	G-49	PF	- (29)	18	-	11 700 ± 160 to 9 840 ± 290
Bridgewater Cave South[14,15]	P-9	OP	611 (13)	45	7.4	<11 390 ± 310
Clogg's Cave[10,16]	EB-2	OP, MS	1374 (29)	26	1.9	22 980 ± 2 000 to 13 690 ± 350
McEachern's Cave[13,17,18,19,20,21]	G-5	PF	2260 (47)	67	3.0	25 580 ± 850 to 15 200 ± 320
Pyramids Cave [6,9,10,16,18,22,23]	M-89	OP, MS	10796 (31)	1125	10.4	>33 000 to 2 530 ± 90

nearby McEachern's Deathtrap Cave has a total surveyed length of about 122 m, although this is only about 80% of the total length (Ackroyd 1994). The Harman Two and Flowerpot Cave (part of the Byaduk Caves system near Hamilton) and Natural Bridge (near Mount Eccles) occur on the volcanic plains (Tertiary basalt), while Beehive Cave in the Bat Ridges Area, west of Portland, is formed on Quaternary aeolian limestone (Matthews 1985). Bridgewater Cave South is essentially an open rock shelter developed in an exposed calcarenite bluff (M Pierce 2004 pers. comm. 11 December). Steiglitz Cave in the Brisbane Ranges of southern Victoria is formed within an anticline of tightly folded and uplifted Ordovician shale, and is approximately 8 m deep by 6 m wide (LE Conole 2004 pers. comm. 12 October).

The minimum number of individuals (MNI) contained in the cave/rockshelter bone deposits was typically ascertained by counts of dentaries (lower jaw bones) or their fragments, and/or other skeletal elements. This permitted the size and frequency of the Eastern Pygmy-possum collection to be compiled for most sites (Table 1). For example, at Pyramids Cave, an extensive deposit was collected (31 terrestrial mammal species; 10 796 individuals), and the Eastern Pygmy-possum was present in large numbers (MNI=1125). Fourteen caves produced >10 individual Eastern Pygmy-possums, although the percentage occurrence for each cave differed considerably. At only

two caves (Pyramids and Victoria Range) did the percentage occurrence exceed 10%.

None of these fossils was pre-Pleistocene, but the reported age of the material ranges from 780 ± 100 years (Black Range deposit) to >33 000 years (Pyramids Cave). There are also five undated deposits (Table 1). The oldest deposits from five sites are reported to be older than 10 000 years (Bridgewater Caves South; Clogg's Cave; McEachern's Cave; McEachern's Deathtrap Cave and Pyramids Cave). The caves occur in the far southwest and near Buchan in eastern Victoria (Fig. 1).

The deposits were reported to be the result of a natural pitfall where animals fell into the cave and became trapped (e.g. McEachern's Deathtrap Cave), or accumulations of regurgitated owl pellets (e.g. Bridgewater Cave South), or as a result of accrual of coprolites (fossil scats) of mammalian predators (e.g. some material from Clogg's Cave) (Table 1). Owls were attributed as the principal accumulating agent for most caves, but the identity of the owl species concerned for the various roost sites is ambiguous. For Pyramids and Mabel Caves, the late John Calaby considered that the Barn Owl *Tyto alba* and the Masked Owl *T. novaehollandiae* were the only candidates (correspondence cited in Wakefield 1960b). However, Wakefield (1960b) thought it unlikely that the smaller Barn Owl would be capable of handling some of the larger mammals found in the deposits, such as Short-nosed Bandicoot *Isoodon obesulus* (500-1500 g) and Common Ringtail Possum *Pseudocheirus peregrinus* (660-900 g). Other owls were considered, such as the Powerful Owl *Ninox strenua*, Barking Owl *N. connivens* and Sooty Owl *T. tenebricosa*, but were rejected on the basis of available information on their habitat and diet (Wakefield 1960b). Also considering the proportions of various species represented, Wakefield deduced that the owl responsible was the Masked Owl.

At the Flowerpot Cave and Victoria Range, the Masked Owl was also considered to be the accumulating agent (Wakefield 1963d, 1964a, 1969a). In contrast, Fern Cave was noted as both a death-

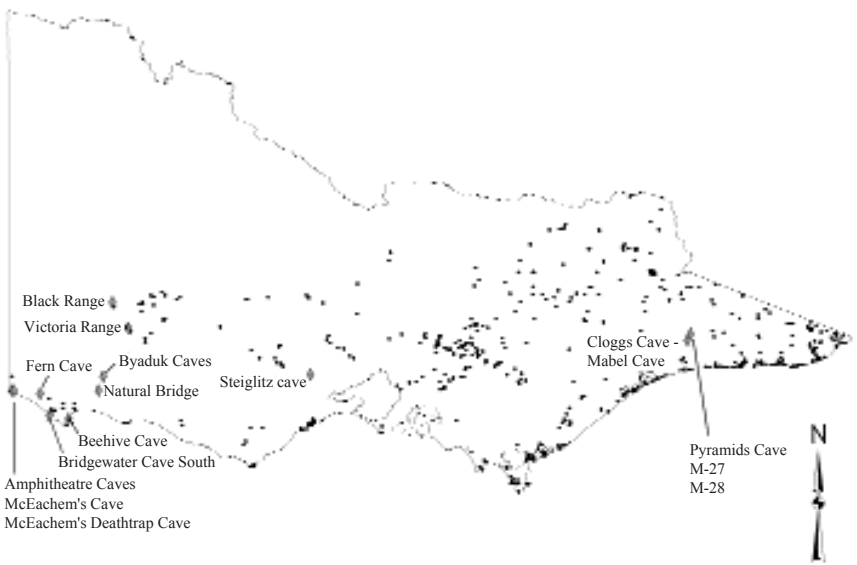

Fig. 1. Prehistoric and modern distribution of the Eastern Pygmy-possum in Victoria. Modern records are derived from the *Atlas of Victorian Wildlife*. Black dots indicate modern records. Diamonds indicate fossil sites with Eastern Pygmy-possum.

trap and an owl roost, but Wakefield (1963b) suggested that the Eastern Pygmy-possum and other small agile species such as the Feather-tailed Glider *Acrobates pygmaeus* (10-14 g) and the Sugar Glider *Petaurus breviceps* (90-150 g) would have been able to escape.

For Fern Cave, Wakefield more cautiously implicated owls of the genus *Tyto*, rather than specifically identifying the owl species concerned. This was probably because of the discovery of both Masked Owl and Barn Owl cave deposits in south-western Victoria (Wakefield 1963b). In relation to Harman Two and Natural Bridge, Wakefield (1964a) notes them as mixed prey assemblages, resulting from the action of both owls and quolls (*Dasyurus* spp.), but suggests that the main part of the deposits may have been the responsibility of the Barn Owl (see also revision of the published article in Wakefield 1969a). However, whether avian or mammalian predators, or both, were responsible for the remains of Eastern Pygmy-possum specifically was not addressed, and cannot be determined without re-examination of the material.

The fossil localities identified for the Eastern Pygmy-possum allows its known paleodistribution to be mapped (Fig. 1). This reveals the tendency for the fossil sites to occur in groups, with the main groupings being from the limestone formation near Buchan in eastern Victoria, and the basalt/limestone caves and sandstone rock shelters of southwestern Victoria. There was also a fossil site (Steiglitz Cave, Brisbane Ranges) reported for south-central Victoria, which was well separated from those in eastern and western Victoria. There are many fossil cave sites in southern Victoria where the Eastern Pygmy-possum appears to be absent. The fossil sites identified for Eastern Pygmy-possum coincide with its present distribution, as modern records are present within 0 - 27 km of the fossil records. That is, there is a modern Eastern Pygmy-possum population in the immediate vicinity of McEachern's Deathtrap Cave (AM Kos 2005 pers. comm. 9 January) and both McEachern's Cave and Amphitheatre Cave are nearby. The nearest modern record to Pyramids and Clogg's Caves is at Nowa Nowa, which is 22 km SSW. Other nearby records include Balmoral (6 km SSE of Black Range), Cavendish (2 km W of Victoria Range), Mount Richmond (10 km ESE of Fern Cave), Cashmore (5 km NNE of Bridgewater Cave South), Portland (near Beehive Cave), Heywood (41 and 27 km SW from Byaduk Caves and Natural Bridge respectively), and Dereel (28 km WNW from Steiglitz Cave).

Discussion

Accumulating agents and biases of the assemblages

Animal remains may accumulate in caves by: (1) animals living and dying in caves; (2) animals falling in by accident; (3) animals taken into caves by predators; or (4) animal bones transported into caves after death (Andrews 1990). The McEachern's Cave (G-5) and the similarly named McEachern's Deathtrap Cave (G-49) contain examples of fossil assemblages where animals have fallen into the cave by accident and been trapped. These natural pitfalls have claimed numbers of the Eastern Pygmy-possum, and many other species of small mammals (Wakefield 1967b; Kos 2003). However, the fossil samples recovered from these caves are biased and as such may not reflect the presence or abundance of animals that have lived in that area over a defined period of time. Pitfall caves are selective in capturing fauna, and some taxa may be over-represented or under-represented, depending on factors such as the size and nature of the entrance holes, the ground cover immediately surrounding them, and on various aspects of the life history and activity patterns of the different species (Andrews 1990).

The Eastern Pygmy-possum appears to be susceptible to capture in pitfall caves. evidenced by its common occurrence in G-5 and G-49, and during pitfall trapping or in pipeline trenches in some modern fauna surveys (Bennett *et al.* 1988; Bowen and Goldingay 2000; Doody *et al.* 2003).

The fossil investigators suggested that for 11 caves, most of the small mammal bones were brought in by predators such as cave-dwelling owls and carnivorous marsupials (see also Lundelius 1966; Hope 1973; Andrews 1990; Baird 1991). However, the composition of the prey assemblages may

be highly biased and not representative of the true relative abundance of the constituent species from a past community. This is because of the selectivity of different predators (Dodson and Wexlar 1979; Baird 1991), by the different ways in which predators eat and digest their prey (Andrews and Evans 1983; Marshall 1986; Andrews 1990; Geering 1990), differential fragmentation and disappearance rates of the remains of different prey species (Garvey 1999) and temporal variability of populations (Peterson 1977). There are other taphonomic (preservation) biases in the fossil record as well, but limitation of space precludes detailed discussion. Due to the biases and/or limitations, in this study we have not attempted to make comparisons between the various assemblages or to interpret the reported abundance of Eastern Pygmy-possums retrieved from the deposits. We note that for several caves (EB-2; G-5; G-49; M-89; P-9), the recovery of fossil material accounted for the frequency of small mammals in different stratigraphic units. Wakefield (1963a, 1969a, 1972) advanced an hypothesis in which the taxonomic composition and proportions of species present in various layers could be attributed to climatic and vegetation changes, which have occurred in the localities during the period of deposition of the bones (see also Hope 1973; Hope and Wilkinson 1982; Lundelius 1983). The accumulating agent may have shown a consistent bias, and temporal changes in composition may reflect real changes.

Identity of the predatory accumulators

Owls are known to be major contributors to the fossil record of small vertebrates, and it is likely they were responsible for much of the bone recovered from the cave sites referred to, because of the characteristic sausage-like 'casts' (Drummond 1963) and the presence of whole skulls (Wakefield 1960a). The recording of rock ledges used as daytime roosting places for owls in Mabel Cave, Pyramids Cave, Flowerpot Cave and Victoria Range (Wakefield 1960b, 1963d, 1964a) and the observation of a live Masked Owl in Clogg's Cave (McKean 1963) and a Southern Boobook *N. novaeseelandiae* in both Flowerpot Cave and Natural Bridge (Wakefield 1964a), also tend to support this conclusion.

The specific identity of the owls responsible is unclear. Baird (1991) re-examined quantitative data from Pyramids Cave (and several other cave deposits) and contrary to Wakefield (1960a, 1960b), concluded that the Barn Owl was most likely responsible for many of the cave deposits in south-eastern Australia. However, the Eastern Pygmy-possum has not been reported from studies of the contemporary diet of the Barn Owl (Morton 1975; Rose 1996a; Higgins 1999), and as the Barn Owl mainly forages in open country for terrestrial prey, we believe that it would rarely encounter the Eastern Pygmy-possum, which seems to prefer dense habitats (Wakefield 1963c; Harris and Goldingay 2005).

At Steiglitz Cave, the Masked Owl was reported responsible for the small mammal remains found there (Peake *et al.* 1993). This deposit was compared with a Masked Owl assemblage from Tasmania (Geering 1990), and a strong correlation between the two assemblages was found in terms of prey size and age structure. Peake *et al.* (1993) considered the Barn Owl but excluded the likelihood of this species being responsible for the fossilized pellets, based on the range and size of prey recovered from the cave. They also made a reappraisal of the Pyramids Cave data set (Wakefield 1960a, 1960b), and based on knowledge of the habits of the prey species, and the foraging and dietary preferences of the owls, they supported Wakefield's view that the Masked Owl was responsible for the deposit at Pyramids Cave. However, Peake *et al.* (1993) may have been unaware of the quantitative analyses undertaken by Baird (1991), as his research was not specifically referred to.

As Eastern Pygmy-possums are arboreal and nocturnal, they would be favoured prey for many owl species that occur within the forest, woodland and heath habitats of the subject species. For example, there are modern records of the species falling prey to the Masked Owl (Mooney 1992, 1993), Sooty Owl (Loyn *et al.* 1986; Hollands 1991; Lundie-Jenkins 1993; Kavanagh and Jackson 1997; Kavanagh 2002), Barking Owl (Menkhorst *et al.* 1984), and Southern Boobook (Green *et al.* 1986; Rose 1996b; S.

Debus pers. comm.). The Eastern Pygmy-possum is clearly susceptible to predation by these species and they are all known to roost in caves, albeit to varying extents (McKean 1963; Marshall 1986; Hollands 1991; Chafer 1992; Higgins 1999).

The authors feel that the possible involvement of any or all of these species in accumulating the deposits should not be immediately discounted, as it has previously, and that positive identification of the avian accumulator/s for each of the deposits remains equivocal. Hence, as noted by Chafer (1992) and other authors, caution should be exercised if attempting to assign a cave deposit of owl pellets to any particular owl species.

Several caves (M-27, M-28, Mabel Cave, Harman Two, Natural Bridge and Flowerpot) contained some highly fragmented bone material that was characteristic of prey of a small carnivore, such as the Eastern Quoll *Dasyurus viverrinus* (syn. *D. quoll*) (0.7-2.0 kg) or the Spotted-tailed Quoll *D. maculatus* (1.5-7 kg) (Wakefield 1960a, 1964a, 1964b; Baird 1991). The bones of these predatory species were also found in a number of the deposits, although the Eastern Quoll was collected more frequently than the Spotted-tailed Quoll (Mansergh 1983). Both species have been implicated as accumulators of the fossil material, but it is difficult to substantiate whether one or both species were involved at the relevant deposits. It appears that an introduced predatory species (e.g. the Red Fox *Vulpes vulpes*) (3.5-8.0 kg) was not involved because of the absence of other introduced species (e.g. the European Rabbit *Oryctolagus cuniculus*) (1.0-2.4kg) (Drummond 1963), but the possibility remains that parts of some deposits were due to the Tasmanian Devil *Sarcophilus harrisii* (7.0-9.0 kg). Remains of this species were also found in several deposits (Wakefield 1963b, 1967a), and it is believed that the Tasmanian Devil was responsible for at least part of the accumulation from Clogg's Cave (Hope 1973; Flood 1974). While there are modern records of the Eastern Pygmy-possum falling prey to both Quolls and Devils (Guiler 1970; Belcher 1995), the published accounts of the fossil deposits do not permit assessment of the relative contribution of these predators to the accumulations.

Past and present distribution of the Eastern Pygmy-possum

As far as is known, the 17 cave deposits referred to comprise the Victorian Eastern Pygmy-possum fossil record. The localities are well separated between far south-western Victoria, the Brisbane Ranges and near Buchan in eastern Victoria. The record suggests that in the Holocene and late Pleistocene, the Eastern Pygmy-possum was widely distributed in southern Victoria, as it is today, or alternatively, the species may have had a disjunct range in prehistoric times. This raises questions about the areas of origin of this species and its subsequent dispersal through Victoria. It would appear that present evidence is insufficient to allow definitive answers, and we emphasise that fossil localities for the Eastern Pygmy-possum are dependent on the presence of suitable caves as preservation sites, and consequently the fossil record is both incomplete and biased. In addition, more information on its distribution is obviously available for modern than for prehistoric populations. However, the available information does not indicate that the northern plains are part of the present or past distribution, although this probably reflects the paucity of caves in northwestern Victoria, as well as the unsuitability of modern habitats for the species in that region.

It would appear that the fossil localities identified have nearby records from extant populations, and at this juncture, the evidence does not suggest any striking contraction of geographic range as reported for the Mountain Pygmy-possum (Broome and Mansergh 1989). This could be due to wider ecological tolerances and/or a wider geographic range of the Eastern Pygmy-possum than that of the Mountain Pygmy-possum.

Although more than 700 caves of varying dimensions have been recorded for Victoria (Matthews 1985), only a small proportion contain mammal bones, and fewer still contain the remains of the Eastern Pygmy-possum. At the time of this study, it appears that Eastern Pygmy-possums have not been collected from deposits other than those of Holocene and Late Pleistocene age reported in this paper. Without documenting the distribution and composition of all fossil-bearing caves in Victoria (but see Horton 1984 p. 645; KID;

Museum Victoria database), it appears that the Eastern Pygmy-possum is absent from the much older Tertiary mammal fauna localities (Rich 1991).

An example of a cave where the species was not found, but may have been expected to be present, is the main lava cave at Mount Hamilton, 177 km west of Melbourne. Wakefield (1963a, 1963b) reported that Mount Hamilton is believed to have been a death-trap cave, 'similar in operation' to Fern Cave. The reason why the Eastern Pygmy-possum was found at Fern Cave but not at Mount Hamilton is unknown. Both were primarily death-trap caves, and both have yielded a variety and abundance of small mammals, including representatives of the families Dasyuridae, Peramelidae, Phalangeridae, Potoroidae, Macropodidae, and Muridae (Wakefield 1963b). The discrepancy may indicate that the Eastern Pygmy-possum was absent from the Mount Hamilton area during the period of deposition, that this natural pitfall was catch-deficient for the species, or neither of these hypotheses.

The age of the fossil and sub-fossil material ranges from late Pleistocene to recent. Several deposits (McEachern's Cave, McEachern's Deathtrap Cave; Pyramids Cave, Clogg's Cave and Bridgewater Cave South) are dated at more than 10 000 years. However, the accuracy and reliability of some of the reported radiocarbon dates requires qualification. For example, the age of the Bridgewater Cave South material (Godwin 1980; Lourandos 1983) was later shown to be 8000 years too young (Bird and Frankel 1991). The dates for Pyramids Cave may also be unreliable and should be treated with caution (Wakefield 1969a; Lundelius 1983). The Clogg's Cave date can be considered reliable (Ride and Davis 1997), but the majority of other dates may be inaccurate (Baynes 1999) and needs to be corroborated by other methods (as advocated by Moriarty *et al.* 1999).

Although we have limited our report to the fossil records from Victoria, further insight might be achieved by review of the fossil records outside Victoria. Records of the Eastern Pygmy-possum, of late Pleistocene or younger age, have been found from caves or archaeological deposits extending from south-eastern South Australia (Tidemann 1967; Smith 1971; Williams 1980; Wells *et al.* 1984; Pledge 1990; Brown and Wells 2000; Moriarty *et al.* 2000; Reed and Bourne 2000), through eastern NSW (Ride 1960; Drummond 1963; Turnbull and Schram 1973; Gorter 1977; Hope 1982; Recher *et al.* 1993; Morris *et al.* 1997), and into south-eastern Queensland (Archer 1978). Fossil deposits in Tasmania have also revealed the species (Bowdler 1984; Cosgrove 1995; Garvey 1999). A cursory examination of the distribution of the fossil sites outside Victoria appears to represent largely the known modern range for the species. These sites are reported to contain mainly cave accumulations of regurgitated owl pellets, as in Victoria.

Conclusion

This study has provided valuable data on the past distribution of the Eastern Pygmy-possum, and some insight into the long susceptibility of the species to predation by owls and carnivorous marsupials, as well as its propensity to capture by pitfall. Further research should involve closer study of the museum collections, as Wakefield's material held at Museum Victoria is at present only partly sorted. Microscopic reappraisal of the collection might be profitable in terms of identifying diagnostic taphonomic signatures of the predatory species, such as skeletal element representation and breakage, digestive corrosion patterns or tooth markings, which could allow specific attribution to predatory species or verification of pitfall origin.

Re-examination and refinement of the age limits of the materials are also desirable, and this would provide an opportunity to examine chronological aspects of the occurrence of the species, and to generate and test palaeobiogeographical hypotheses on dispersal or vicariance events. Further knowledge of the habitat requirements and of the limiting factors on distribution of modern populations are also necessary, to aid and inform interpretations of the temporal abundance of the Eastern Pygmy-possum in past vegetation communities, and to assess the effects of climatic fluctuations on the species. In this regard, further research on the plant communities that may have been associated with the fossil

deposits is also important. It is hoped that this review will serve as an introduction to the literature on the relevant cave deposits, and promote further interest and understanding of the Eastern Pygmy-possum throughout its range.

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One hundred years ago

SOURCE OF THE YARRA RIVER

by Mr AE Kitson, FGS

… that our present maps of the source of the Yarra and Thompson Rivers were incorrect, as it had been found that the stream which had hitherto been regarded as the furthest source of the Yarra was really the head of the Thompson. The mistake had occurred through the latter river flowing first west, then north, and east, before taking its southerly course. It was probable that at one time the portion flowing westerly had belonged to the Yarra, but it had been captured by the stream flowing to the north, and was thus lost to the Yarra watershed. The country where this occurred was covered with very dense vegetation, and without the aid of instruments it was quite impossible to ascertain the positions of ridges and trends of the valleys.

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