

ECOLOGICAL SUCCESSION DURING THE LATE CAINOZOIC OF CENTRAL EASTERN QUEENSLAND: EXTINCTION OF A DIVERSE RAINFOREST COMMUNITY

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New late Cainozoic faunal assemblages are preliminarily identified and described from central eastern Queensland. Biocorrelation of the sites has determined that the oldest faunal assemblages are Early Pliocene in age, with younger faunas from the Plio-Pleistocene, late Pleistocene and Holocene. Pliocene faunal assemblages are characterised by rainforest-specialist frog, squamate and mammalian taxa. These include new Pliocene records for frogs; *Kyarranus*, *Lechriodus*, *Nyctimystes* and microhylids, squamates; *Cyclodomorphus gerrardii*, a new species of *Tiliqua* and typhlopids, and mammals; *Bohra* sp., *Pseudochirulus* spp., new petaurids and dasyurids, *Dactylopsila*, petauroid *incertae sedis*, *Acrobates*, *Cercartetus*, *Uromys/Melomys*, *Mesembriomys* and *Pogonomys*. Ecological signals derived from the faunal assemblages correlate well with dated palynological records from central eastern and northern Queensland (ODP815, Aquarius Well and Lynch's Crater). Combined Early Pliocene palynological and faunal records strongly indicates a nonseasonal, mesothermal, angiosperm-dominant rainforest with emergent gymnosperms at Mount Etna. A Plio-Pleistocene seasonal, open ecology indicated by the palynological record is corroborated by fauna from similar-aged sites, although several rainforest taxa persist. Increasing aridity during the late Pleistocene is suggested by a distinctly arid-adapted faunal assemblage in late Pleistocene sites, including eastern-most records of *Tympanocryptis*, *Macrotis lagotis*, *Chaeropus ecaudatus*, *Perameles bougainville*, *Sminthopsis macroura* and *Notomys*. Faunal succession from the Early Pliocene to Holocene is characterised by the extinction of most rainforest groups by the late Pleistocene, being replaced by more xeric-adapted forms. Several of the Early Pliocene taxa show resilience to extinction by remaining, albeit rare, in the late Pleistocene fauna, probably in local refugia. These include *Dendrolagus* sp., a new petauroid, *Thylogale*, *Macroderma gigas*, *Sarcophilus laniarius* and *Thylacinus*. Presence of rainforest murids in the Early Pliocene of Australia significantly predates previous estimates for their dispersal onto mainland Australia. □ *Pliocene, Pleistocene, ecological succession, rainforest fauna, Queensland, Australia, fossil vertebrates.*

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The succession of faunal assemblages during the late Cainozoic of Australia is unknown for large parts of the continent. Where present, the records are extremely patchy when compared to similar-aged faunal records for other continents (e.g. North America (Stirton, 1936); Africa (Bishop et al., 1971); China (Flynn et al., 1991); and Eurasia (Azzaroli et al., 1988)). A majority of the Australian late Cainozoic Local Faunas have either been the focus of long term, low yield, sporadic collecting with little systematic documentation or once-off, large-scale excavations of a single fossil specimen, site or horizon (Rich, 1991). Typical examples of these sites include the Plio-Pleistocene sites of the Darling Downs southeast Queensland, which, for over 150 years have yielded large collections of specimens with little or no field data due to the ad

hoc nature of the collecting (Molnar & Kurz, 1997). These specimens are usually collected as single miscellaneous finds from along creek banks and riverbeds and have, until recently, possessed little documentation associated with the specimen. Such specimens are mostly out of stratigraphic context making them basically useless for detailed palaeoecological reconstruction and biostratigraphy.

In contrast, one-off large-scale excavations have either occurred in response to a major find, such as a complete skeleton(s), or the impending destruction of a fossil site by human impact (Archer, 1978; Long & Mackness, 1994). Material recovered from these sites usually possesses good field data, however, very rarely spans the temporal scale needed to document the

succession of faunas for a single region over large periods of time.

There have been several attempts to tie together Pliocene and Pleistocene sites in an effort to develop a biochronological and evolutionary framework for the late Cainozoic fossil communities of Australia (Archer & Wade 1976; Lundelius, 1983, 1989; Woodburne et al., 1985; Rich, 1991; Tedford et al., 1992; Tedford, 1994; Archer et al., 1995a; Archer et al., 1999; Dawson et al., 1999).

A review of literature for Australian Plio-Pleistocene faunas show some distinctive trends: 1) The majority of sites determined as Pliocene in age are considered to be from the Early Pliocene (5.2-3.4 Mya); Bluff Downs (Mackness et al., 2000); Chinchilla (Tedford et al., 1992); Rackham's Roost (Archer et al., 1995b): QLD; Curramulka (Pledge, 1992; Tedford, 1994), Tirari Formation (Tedford et al., 1992), Sunlands (Pledge, 1987): SA; Forsyth's Bank (Tedford, 1994); Hamilton (Rich, 1991); Parwan (Tedford, 1994); Boxlea (Tedford, 1994); Coimadai (Turnbull et al., 1992) VIC; Big Sink (Dawson et al., 1999); and Bow (Flannery & Archer, 1984) NSW. These sites include the only radiometrically or magnetostratigraphically dated sites of the Pliocene: Bluff Downs 3.6 Mya; Hamilton 4.5 Mya and the Tirari Formation 3.4-3.9 Mya. 2) When Early Pliocene faunas are compared with the few identified Late Pliocene sites (3.4-2.0 Mya): Dog Rocks in Victoria (Tedford, 1994); Bone Gultch and Fisherman's Cliff in New South Wales (Tedford, 1994); and Quanbun in Western Australia (Flannery, 1984; Rich, 1991), there is a distinct 'modernisation' of the fauna as suggested by Tedford (1994). These faunas possess several extant and extinct genera and species that become dominant during the Pleistocene and are the typical suite of taxa found in the late Pleistocene (Bartholomai, 1977; Archer, 1978; Hope, 1978; McNamara, 1990; Dawson & Augee, 1997; Molnar & Kurz, 1997; Reed & Bourne, 2000). The apparent faunal mixing of plesiomorphic and stratigraphically older taxa with younger, derived taxa, makes biochronology of the Late Pliocene and early Pleistocene difficult via stage-of-evolution criteria. Direct dates are needed to calibrate the timing of faunal changeover from the Pliocene to Pleistocene.

One notable near absence from the Pliocene to Pleistocene record is that of the diverse rainforest communities that distinguished many of the older

Oligo-Miocene faunas of Australia (Archer et al., 1995a; Archer et al., 1999). A palaeoecological succession for the Pliocene through medial Pleistocene of southeastern Australia has been proposed by Tedford (1994). This includes the Early Pliocene Hamilton Fauna (Turnbull & Lundelius, 1970; Flannery, 1992; Rich, 1991; Macphail, 1996), the only representation of a post Early Miocene rainforest community in southern Australia. Additional Pliocene and Pleistocene faunas from southeastern Australia support several rainforest components, however, these accounts are usually interpreted as part of a patchy assemblage and do not dominate the ecological reconstruction (Tedford, 1994; Archer et al., 1999).

Tedford (1994) concluded that the rainforest communities of southeastern Australia are missing by the Late Pliocene. Archer et al. (1995a) reviewed the Tertiary biotic change in Australia and concluded that by the Late Pliocene central Australia was becoming arid, coastal regions were forested and open, and rainforest persisted in northeastern Queensland as refugia. Macphail (1997) showed distinctly drier-adapted flora throughout the Late Pliocene of Australia.

A unique opportunity to access a late Cainozoic terrestrial fossil record from central eastern Queensland has been made possible via a series of open-cut limestone quarries and cavernous systems running along the coast to the north and south of Rockhampton (Fig. 1). Exposures of extensive fossiliferous deposits in stratigraphic context allow for this first account of a faunal succession spanning the Pliocene to Holocene in Queensland, including a distinctive Pliocene-aged rainforest community.

HISTORY OF COLLECTION

Collection of vertebrate remains from cave and fissure deposits in central eastern Queensland (CEQ) occurred sporadically for over 90 years, but few papers have appeared on fossils collected from these sites (Longman 1921, 1924, 1925a, 1925b; Hocknull, 2003).

Central eastern Queensland contains several limestone blocks with known karstification. Of these, Marmor and The Caves are the only two areas where vertebrate fossils have been found prior to 2002.

In 1910 G.E. Blundell collected a tooth from Marmor Quarry, S of Rockhampton, which made its way to the British Museum of Natural History

(BMNH10257) identified as *Macropus brehus*, now identified as *Palorchestes*.

First vertebrate remains acquired by the Queensland Museum QM were from guano mining in caves on Reserve Holding 272, Limestone Ridge, east of Mount Etna (R444), between 1920-1921. A mandible assigned to *Sarcophilus laniarius* was presented to Heber A. Longman in 1921 by P.H. Ebbott of Mount Etna Fertilisers Ltd (Longman, 1921). Shortly thereafter, Samuel Evans, mine manager of Marmor Quarry, presented several small collections of fossils unearthed during quarrying. In 1924, Longman collected the QM's first representative samples from CEQ; from Olsen's Cave, SE of Mt Etna and Marmor Quarry, publishing the combined material collected from Marmor Quarry (Longman, 1924, 1925a & b). Longman's faunal records from Marmor Quarry included; *Diprotodon australis* (herein ?*Zygmaturinae*), *Phascolomys* sp. (herein, *Vombatus urinus mitchellii*), *Thylacoleo carnifex* (herein *Thylacoleo* sp.), *Thylacinus spelaeus* (herein *Thylacinus cynocephalus*), *Sarcophilus laniarius*, *Macropus anak* (herein *Macropus titan*), *Phascogale flavipes* (herein *Antechinus* sp. 2), *Petrogale* sp. cf. *P. inornata* (herein *Petrogale* sp.) and *Megalanina prisca*. Smaller fauna included snake and rodent remains. Fossils collected from Olsen's Cave remained unpublished.

In 1925 Evans presented a second Marmor Quarry collection to Longman. F.W. Whitehouse collected bones from Johannsens Cave on Limestone Ridge in 1926, during the peak of guano mining. A hiatus of nearly 30 years followed. In 1954 and 1957 two collections of bones were presented to the QM from Marmor Quarry, by O. Anderson and J.E. Joyce, respectively. Final collections of large pieces of bone-bearing cave breccia were taken from Marmor Quarry in 1964-5 by Bartholomai and Joyce. This breccia is currently being prepared and contains remains of some very large vertebrates, including *Macropus titan*, as well as many smaller-sized species. No collecting has been possible from Marmor Quarry since 1964.

In 1972, Mike Murray donated small surficial collections from Old Timbers, Lion's Den and Johansen's Cave, Mount Etna area.

A second hiatus from the 1970's to mid 1980's occurred when concerns regarding the conservation of several caves on Mount Etna were at their greatest (Bourke, 1970; Vavryn, 1987). Two cave systems, Speaking Tube Cave

and Elephant Hole Cave, were under threat from quarrying operations on the W flank of Mt Etna. In 1986, Kerry Williamson & Dianne Vavryn removed two sacks of loose bone and sediment from the floor of Elephant Hole Cave before mining operations broke into the cave. The small collection was sent to the QM later that year.

Mining operations continued on the western ridge of Mount Etna until early 2004. During the initial stages of operation, the two known caves were broken into and cave breccias exposed. A deposit was unearthed in 1992 when breaking into Speaking Tube Cave. Then mine manager M. Barton, with assistance from David Kershaw and Don Kime, kindly donated bone-breccia samples to the QM and kept a stockpile of bone breccia material on the eastern side of Mount Etna on a flat bench below Main Cave (QML1313).

The author, Paul Tierney and members of the Central Queensland Speleological Society, mounted expeditions to Mt. Etna in 1998, 2000 and 2001. Several sites were successfully located and collected within the Mt. Etna Caves National Park and Mt. Etna Limestone Mine.

Extensive fossiliferous deposits on Limestone Ridge were found in 1998 which included considerably diverse faunas from several distinct ecologies, including rainforest. Twice in 2000, the QM and University of New South Wales systematically collected material from sites on Limestone Ridge and Mt. Etna.

In 2001 collections were made from the Mt Etna Limestone Mine, with the discovery of, inter alia, faunal assemblages of similar diversity and age to those from Limestone Ridge. Deposits represent a series of cave-fills exposed in cross-section by mining operations. Examination of these units has enabled development of a preliminary chronology of the faunas. Continued fieldwork in 2002 and 2003 increased the number of distinct sites on the mining lease and located a remnant chamber of Speaking Tube Cave. In mid-2002 a limestone at Mount Princhester, 50kms north of Mount Etna, was investigated and small deposits of exposed fossiliferous cave floor sediment collected. Further fieldwork (2003) resulted in discovery of new sites in Olsen's Cave and Karst Glen, SE of the main Mount Etna and Limestone Ridge blocks.

METHODS

FOSSIL SITES (Figs. 1-3). Preliminary site geology, including simplified sedimentological descriptions are provided herein. Cave names

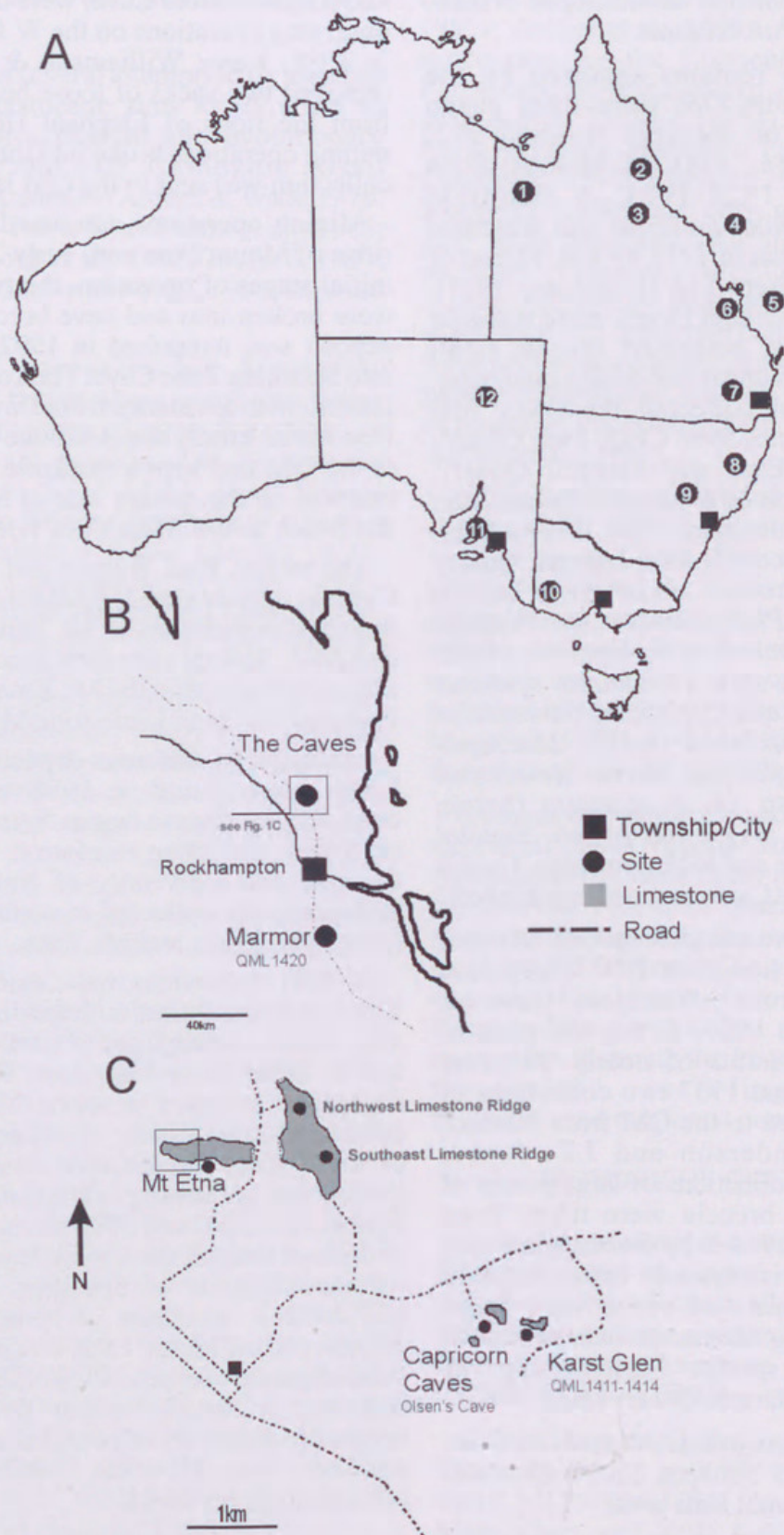


FIG 1. Map of fossil localities. A, Major localities mentioned in text, 1. Riversleigh; 2. Lynch's Crater; 3. Bluff Downs; 4. ODP815, Marion Plateau; 5. Aquarius Well, Capricorn Trough; 6. Mt Etna/Marmor; 7. Chinchilla; 8. Bow; 9. Big Sink, Wellington; 10. Hamilton; 11. Curramulka; 12. Tirari Formation, Lake Eyre. B, 6. expanded. C, The Caves area.

follow (Shannon, 1970b). Fossil sites are given a QML number (Queensland Museum Locality). Superpositional and stratigraphic data was collected from all localities with the exception of Marmor Quarry. Data collected included, stratigraphic context, breccia components, bone preservation, tooth preservation, shell preservation and a facies interpretation. Where possible, sampling bias was reduced by collecting and processing equal amounts of material from each site.

TAXONOMY. A brief systematic account of the taxa found from each site is tabulated (Table 1-3, Appendix 1) with abbreviated systematic descriptions of relevant taxa given below. A selection of the best-preserved specimens was used to provide the identifications that follow. All specimens are held at the Queensland Museum, (prefix QMF). Frog osteological nomenclature and taxonomy follows Tyler (1976) and Cogger (2000) respectively. Squamate nomenclature follows; Hutchinson (1992) for scincids, Hutchinson (1997) for pygopodids and gekkonids, Hecht (1975) for varanids, Hocknull (2002) for agamids, Smith (1976) for elapids and Holman (2000) for typhlopids. Squamate taxonomy follows Cogger (2000); crocodylian nomenclature and taxonomy follows Willis (1995); mammalian nomenclature follows Archer (1984) for tooth morphology and Luckett (1993) for tooth positions. Mammalian taxonomy follows Strahan (1995) and Flannery (1994). Fossil mammal taxonomy follows Long et al. (2002). Avian nomenclature follows Gilbert et al. (1981) and taxonomy Lindsey (1992).

FAUNAL ASSEMBLAGES (LOCAL FAUNA).

Similarities between site faunas were computed using PAUP (Swofford, 2000) and MacClade software (Maddison & Maddison, 2000), where sites defined as 'taxa' and the taxa as 'characters'. 'Characters' were given the states of either being absent (0) or present (1) (Appendix 1).

Small-sized mammals (smaller than and including *Petrogale*) were chosen for the analysis because they were represented in all of the sites and are least affected by taphonomic bias. The dominant accumulating agent for each site was either via a pit-trap and/or owl/bat roosts. This biases the preservation of large-sized vertebrate taxa, thus they are excluded from the analysis.

A mammal list was constructed to define the present day small mammal fauna for Mount Etna. This list was derived from mammal species surveyed directly at Mount Etna (Horsup et al.,

1993; Dwyer, 1970) and those species found in habitat similar to that of present day Mount Etna (semi-evergreen vine thicket), which are also found within the central eastern Queensland region today (Horsup et al., 1993). The present day fauna was fixed in position for the analysis as the 'outgroup'. Present day mammal species not found in the fossil record were excluded from the 'ingroup' analysis because they were simply counted as autapomorphies and uninformative. A dendrogram of relationship was constructed using both PAUP and MacClade parsimony analyses (heuristic search; 1000 replicates).

FAUNAL ASSEMBLAGE AGE. Biocorrelated taxa were used to provide an estimated date for each of the sites. Palaeoecological signals generated from well-constrained palynological records off the coast of central eastern Queensland (Hekel, 1972; Martin & McMinn, 1993) were correlated with palaeoecological signals generated from site faunas. Direct dating of one site, QML1312, was possible via Thermal Ionisation Mass Spectrometry (TIMS) Uranium-series dating. Dating was carried out on a *Petrogale* jaw. The date is considered to be a minimum age based on late-stage uptake of Uranium into bone and dentine (Ayliffe & Veeh, 1988; Shen et al., 2001; Zhao et al., 2002).

GEOLOGICAL SETTINGS

The geological history of the limestone blocks containing cave and fissure deposits of the present study have been subject to debate (Kirkgaard et al., 1970; Shannon, 1970a; Willmott et al., 1986; Barker et al., 1997; Simpson et al., 2001). Sites occur in cavern and fissure systems within Early Devonian limestone blocks (Philip & Pedder, 1967) of the Mount Alma Formation (*sensu* Barker et al., 1997). Limestone blocks are irregular in shape and are scattered randomly throughout the formation. The southern extremity of the limestone blocks occurs in the Marmor-Raglan area 50 kms S of Rockhampton. The northern extension of the limestone outcrops as a series of small limestone bluffs at The Caves township (25km N of Rockhampton) and at Princhester (50km N). Sediments from these sites have yielded an enormous and varied vertebrate fossil record.

Palaeontological and structural evidence suggests the limestones are allochthonous blocks within Late Devonian Mount Alma Formation (Barker et al., 1997).

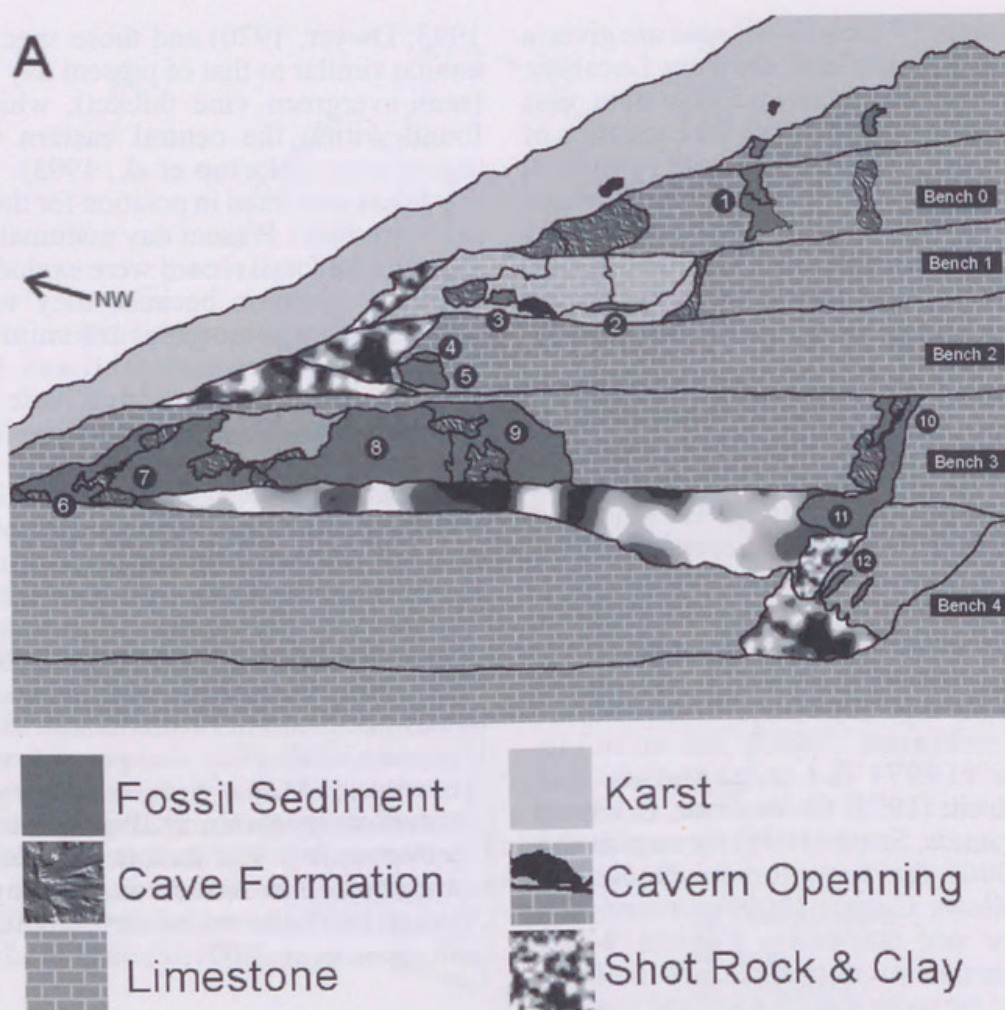


FIG. 2. Fossil localities on the western benches of Mount Etna Limestone Mine. 1. QML1419; 2. QML1313, 3. QML1383, 4. QML1310 Unit 1, 5. QML1310 Unit 2, 6. QML1311 A/B, 7. QML1311 C/D, 8. QML1311 F, 9. QML1311 H, 10. QML1398U, 11. QML1384L, 12. QML1385.

The structural history of these limestone blocks which includes their distance and position from one another, irregular bedding planes, faulting, and complex joint systems, has had a direct influence on the sedimentology of the varying vertebrate fossil deposits found within them (Willmott et al., 1986). Structural history has also influenced the terrestrial communities occupying the limestone (caverns and surrounds) through the past and in the present. Modern ecologies on these limestones strongly reflect this influence because most of the bluffs act as present day refugia for flora and fauna (Horsup et al., 1993).

SITE LIST

Mount Etna Limestone Mine and National Park

Speaking Tube Cave System

Bench 0, QML1419*

Bench 1, QML1313 (=QML1313 & QML1288)**

Bench 1, QML1383*

Bench 2, QML1310 Unit 1

Bench 2, QML1310 Unit 2*

Bench 3, QML1311 Unit A*

Bench 3, QML1311 Unit B*

Bench 3, QML1311 Unit C**

Bench 3, QML1311 Unit D**

Bench 3, QML1311 Unit F*

Bench 3, QML1311 Unit H**

Elephant Hole Cave System

Williamson & Vavryn Collection, QML1312**

Bench 3, QML1384 Upper Unit**

Bench 3, QML1384 Lower Unit**

Bench 4, QML1385**

Northwest Limestone Ridge

Johansen's Cave System

QML1314, Guano deposit**

QML368, Flowstone (False Floor) Unit**

Southeast Limestone Ridge

Mini Cave System

Mini Cave Chamber Deposit, QML1284**

Mini Cave Surface Deposit, QML1284a**

Leo's Lunch Site, QML1382*

Olsen's Cave System**

Karst Glen System

KG3 Surface Deposits, QML1411-1414*

Marmor Quarry

Marmor Bone Breccia collection, QML1420**

* Sites with fauna

** Sites with fauna presented herein

MOUNT ETNA LIMESTONE MINE AND NATIONAL PARK

Approximately 40% of Mount Etna is massive recrystallised limestone with the remainder a combination of faulted sedimentary and volcanogenic units of the Mount Alma Formation (Shannon, 1970a; Barker et al., 1997). Limestone on Mount Etna dips steeply to the SW, with major joints oriented along a NW axis. Joints are predominantly vertical and control cave development (Shannon, 1970b). Phreatic enlargement has occurred along these vertical planes producing deep chambers with sculptured phreatic pendants. Vadose cave development is marked by extensive speleothem formation and cave entrance development. Bone breccias and cemented cave floors are common throughout, occurring within functional cave systems or exposed on weathered and collapsed dolines. Two major cave systems on Mount Etna are the focus of the present study; Speaking Tube and Elephant Hole Cave systems.

Speaking Tube Cave system occupies two major joint controlled rifts running down the mountain in a NW-SE direction. Phreatic chambers developed at depth are linked to the surface by long solution pipes. Elephant Hole Cave system is a third joint-controlled rift to the SE of the Speaking Tube Cave system. It is also linked to the surface by large solution pipes. A geochronological summary of sites found on the western benches of Mount Etna Limestone Mine is provided in Fig. 3.

Speaking Tube Cave System

SPEAKING TUBE CAVE: E7. "This cave has nine entrances at middle to highest levels on the West flank of Mt. Etna. It is a very complicated active inflow cave with three active sumps." (Shannon, 1970b: 25)

It is obvious from the many and varied bone breccias recovered that Speaking Tube Cave system has had a long and complex history. No substantial collections were made from Speaking Tube Cave before it was broken into by mining operations. In 1992, bone breccias were exposed close to surface karst and stockpiled by Pacific Lime Pty Ltd operators. A small sample of these bone breccia blocks was sent to the Queensland Museum marked "Speaking Tube Cave". In 2000 the stockpile was located on the eastern side of

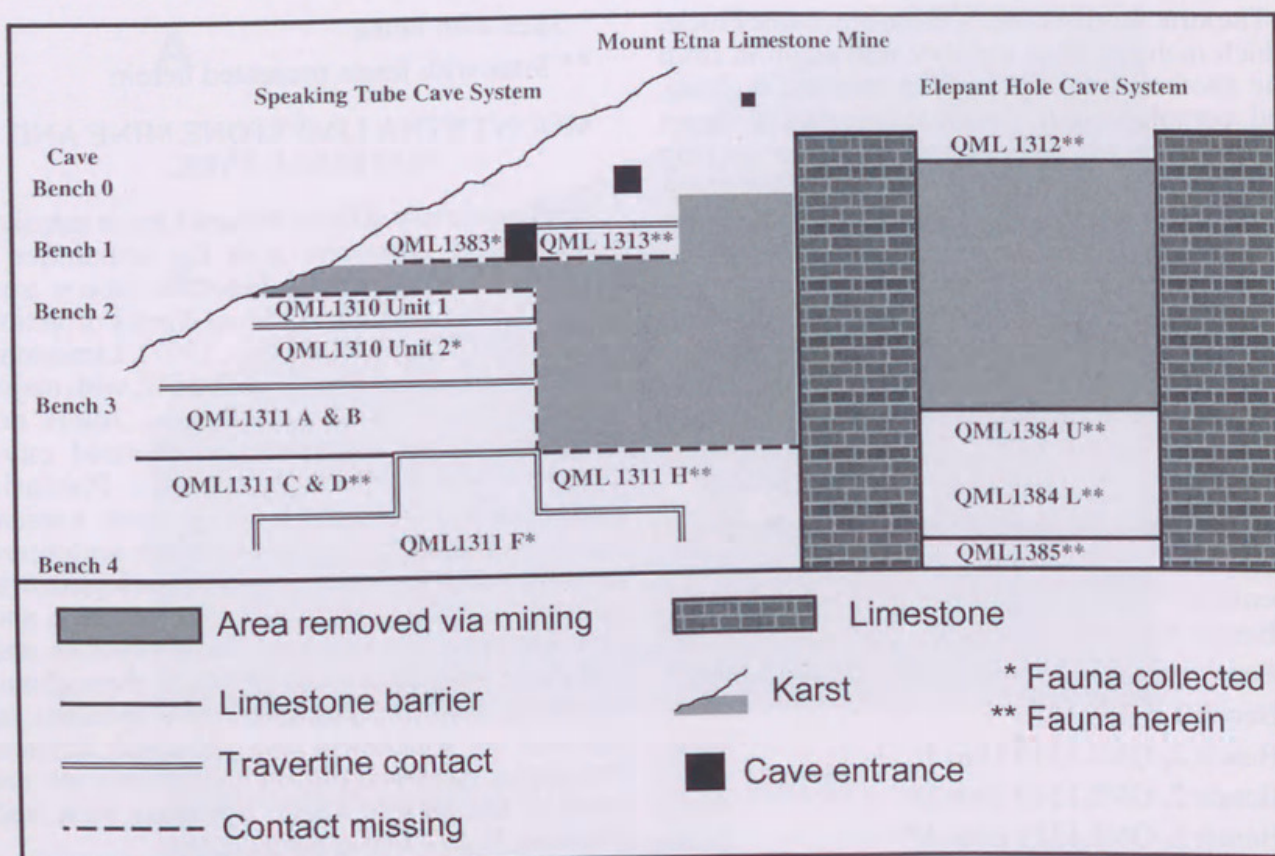


FIG 3. Schematic diagram illustrating the relationships between fossil deposits on the western benches of the Mount Etna Limestone Mine, Mount Etna. * Fauna collected. ** Fauna presented herein.

Mount Etna by the QM and collected, given the site name 'Mat's Menagerie' (QML1313). The original location of the bone breccia was unknown until 2002 when equivalent material was found in situ on Bench 1 of the western benches. Five main benches are considered to preserve portions of the Speaking Tube Cave system, including an entrance to the cave through an exposed chamber on Bench 1.

BENCH 0, QML1419. A thin veneer of limestone covered a solution tube until 2003 when it collapsed and revealed a breccia-filled tube. It was discovered in mid 2003. The solution pipe contains several levels of varying indurated fossiliferous sediment.

BENCH 1, QML1313 (=QML1313 & QML1288). A small amount of bone breccia received from Pacific Lime in 1992 and labeled as 'Speaking Tube Cave' (QML1288) was rediscovered by the Queensland Museum as a stockpile on the eastern face of Mount Etna, subsequently named "Mat's Menagerie Site" (QML1313). The bone breccia originated on the

western benches where its exact locality was unknown. Inspection of the Bench 1 cliff line relocated lithologically identical bone breccia adhering to an exposed cave chamber wall. The material follows a cave wall demarcated by cave formations along the middle length of the bench. The breccia runs in a northwest/southeast axis toward an opened chamber. The chamber constitutes a known chamber within Speaking Tube Cave. Bone breccia received by the museum, stockpiled on the eastern face and adhering to the southeast side of the cave wall on Bench 1, western benches, constitutes the same unit.

Stratigraphic context. There is no preserved contact of this unit with any of the other deposits on the mountain. The area in which a contact may have occurred has been mined. There are no clasts of other bone breccias within the matrix. The only breccia that shows similarities in sedimentology to QML1313 is QML1311 (Unit A) of Bench 3, which indicates that this unit was very extensive and formed deep within the system. It is sedimentologically distinct from the

only other breccia found on Bench 1 (QML1383), which occurs to the northwest of the open chamber.

Breccia components. Distinctly bright yellow to orange coloured, heavily cemented containing large angular clasts of parent limestone, flowstone and smaller clasts of allochthonous rock; abundant bone, teeth and skulls of variable sizes; snails common; large calcite vugs. Small clasts of red to brown clay; pisolites of ironoxide and calcite; bedding chaotic.

Bone preservation. Articulated and semi-associated skeletal elements; well-preserved material with no apparent dominant bone orientation; calcite growth within bone vacuities; bones variable in size, from large limb bones (10-15cm) to grain-sized bone fragments.

Tooth preservation. Teeth usually in jaws.

Shell preservation. Shells complete and isolated.

Facies Interpretation. Abundant large angular clasts, articulated and semi-articulated large-sized bones, large complete shells and no dominant bedding or clasts indicates an entrance facies talus and scree.

BENCH 1, QML1383. Located to the northwest of the open chamber, QML1383 is a large fossiliferous unit.

Stratigraphic context. Sedimentologically this unit is similar to QML1311 (Unit B) of Bench 3 and QML1310 (Unit 2) of Bench 2. QML1310 (Unit 1) of Bench 2 divides the contact between QML1383 and QML1310 (Unit 2) so it is suggested here that QML1383 is stratigraphically younger than both QML1310 and QML1311. The site has an analogous depositional facies.

Breccia components. Dark red to pink clay, heavily cemented with minor clasts of decalcified limestone, allochthonous sediments and pisolites; abundant bones, teeth and shell.

Bone preservation. Bones fragmentary and small; no distinct large bone orientation; smaller bone fragments occur in fine lenses which are horizontally bedded.

Tooth preservation. Usually isolated and well preserved.

Shell preservation. Abundant in small lenses.

Facies Interpretation. Lack of large angular clasts, large bones and the lack of distinct large bone orientation indicates a depositional facies away from an entrance and having not been subject to significant water transport. Abundance

of small fragments of bones and isolated teeth indicates a possible predator accumulation. Thin irregular lenses of material suggest that accumulation occurred from slumping of upper roost deposits, probably *Macroderma*. The deposit seems to occur within an old aven when viewed in sectional profile.

BENCH 2, QML1310. Bench 2 lacks large deposits of breccia, with the two units described here only found on a small pinnacle left from mining operations.

Unit 1; Stratigraphic context. Unit 1 is younger than Unit 2 with a distinct cave floor formation between the two horizons.

Breccia components. Mottled red/grey horizons; lacks bone and teeth; small clasts of allochthonous sediments; heavily cemented.

Bone, tooth and shell preservation. Rare to nil.

Facies Interpretation. Lack of fossil material and major clasts indicates a non-entrance facies. The mottling of the rock indicates the presence of dense rootlets and thus the base of a chamber.

Unit 2; Stratigraphic context. Occurs below and is older than Unit 1. Several thick bands of flowstone occur through the top of this unit, demarcating different levels of formation. Toward the base there is a considerable reduction in flowstone. The base of Unit 2 appears to be very similar in depositional style to QML1311 (Unit B) of Bench 3 and is interpreted as the top of this unit.

Breccia components. Flowstone-dominated light red coloured, heavily cemented bone breccia; flowstones irregular in shape and domed at the middle of the exposure; bones abundant and small; shell abundant in small lenses, associated with flowstones; small, grain-sized clasts of allochthonous sediment.

Bone preservation. Disarticulated, disassociation within the accumulation; large numbers of bones from small animals, usually broken into grain-sized particles.

Tooth preservation. Isolated teeth, well preserved, no rounding.

Shell preservation. Small snail shells, in bands usually associated with flowstone unit.

Facies Interpretation. The mass of banded flowstones at the top of QML1310 Unit 2 indicates a major increase in speleothem genesis over that found in QML1311, Unit B. It is unknown whether this was a rapid phase of precipitation or it was a gradual increase over time. The reason for this is because the contact

between QML1311, Unit B and the base of QML1310 Unit 2 has been removed by mining. The presence of the flowstones and a domed lamination indicates a series of cave floors, probably in the shape of a sediment cone. Absence of large angular clasts and large bones indicates a chamber facies. The sediment cone was probably produced at the base of a bat roost because there are no additional chambers above the deposit that could have acted as a sump.

BENCH 3, QML1311

Unit A; Stratigraphic context. Unit A in contact with Unit B. Unit A formed before Unit B. Unit A is considered lithologically equivalent to QML1313 sediment although found deeper within the system. This is reflected in the breccia components, bone preservation, greater bedding and speleothem genesis of Unit A sediments.

Breccia components. Yellow, grey and pink coloured clay; heavily cemented; massive flowstones and travertine throughout (ranging from 5-20cm thick); cave formations preserved within breccias. Large clasts of allochthonous sediments and semi-rounded parent limestone. Drusy calcite vugs and well preserved bone.

Bone preservation. A semi-articulated, associated accumulation with some patches of sorted large bone; limb bones well preserved with most elements complete; small bones in apparent association; bone vacuities infilled with calcite.

Tooth preservation. Teeth usually found in complete or near complete jaws.

Shell preservation. Snails abundant, isolated, and well preserved.

Facies Interpretation. Unit A is considered a talus accumulation below the entrance facies of QML1313.

Unit B; Stratigraphic context. Unit B occurs in two areas along Bench 3. Unit B contacts Unit A on its north-western extremity and occurs above Unit C/D toward the center of Bench 3. Unit B is divided from Unit C/D by a massive limestone wall, varying from 5-10m thick. Unit B is considered so close in lithology to the sediment at the base of QML1310 Unit 2, Bench 2, that it is considered here to have had a conformable contact between these two units.

Breccia components. Light red heavily cemented clay; numerous clasts of decalcified parent limestone, cave wall travertine and allochthonous sediments, including gravel. Cave formation dominates the clasts, followed by allochthonous sediment and parent limestone.

Bone and tooth fragments abundant; small drusy calcite vugs; isolated iron-oxide pisolites.

Bone preservation. Disarticulated accumulation with some sorting of small bone elements. Sorting is localised and not common; large bones are rare; small bone well preserved with teeth in jaws. Long bones badly preserved, mostly broken at both proximal and distal ends; numerous grain-sized bone particles occur in irregularly graded lenses. Calcite growth within bone vacuities.

Tooth preservation. Well preserved tooth rows.

Shell preservation. Shell abundant and usually associated with bone sorting.

Facies Interpretation. Unit B is considered the base of a talus from a well-developed sediment cone. The base being Unit B and the top being QML1310 Unit 2 Bench 2. The lack of large bone accumulations and the abundance of small bone fragments suggest a similar predator accumulation as to QML1310 Unit 2 Bench 2 within an aven chamber.

Unit C; Stratigraphic context. Unit C grades into Unit D but with less mottling. Unit C and D are considered equivalent in age. Unit C is separated from Unit A & B by a large limestone wall, varying from 5-10m thick. Units C and D unconformably overlies Unit F on a decalcified and eroded travertine surface formed on Unit F and included as clasts in Units C & D. Units C and D are thus considered to be younger than Unit F.

Breccia components. Red/yellow/grey clay, moderately cemented; drusy calcite vugs formed within rootlet vacuities; isolated iron-oxide pisolites; small clasts of decalcified parent limestone and allochthonous sediments. Isolated clasts of broken and transported travertine; large bones, isolated teeth and numerous complete small bones; large bones fractured and exploded by clay matrix; no travertine formation other than calcite formation between Unit C and F. Small clasts of Unit F at the southeast extremity of unit C.

Bone preservation. Disarticulated accumulation with little bone sorting; large long bones missing proximal and distal ends; vertebrae missing processes. Large bones have been transported some distance. Small bones variably preserved; complete elements to grain-sized particles; bone vacuities filled with clay.

Tooth preservation. Large teeth usually preserved within the jaw. Small teeth usually isolated and associated with edentulous jaws.

Shell preservation. Rare to absent.

Facies Interpretation. Unit C is considered to be a deep chamber deposit based on the lack of large angular inclusions and large well-preserved, semi articulated or associated bone. There are no indications that this deposit is a predator accumulation. The lack of sorting of clasts and no distinct bedding planes indicate that stream and channel action was not the main mode of transport and deposition here. The presence of large bones and very few well-preserved snails indicates a deposit where the larger elements have been transported from an entrance facies into a lower chamber probably via extensive slumping, requiring little water transport.

Unit D; Stratigraphic context. Unit D is a mottled breccia very close in lithology to Unit C and is considered equivalent in age. Unit D conformably grades into Unit C without any distinctive demarcation.

Breccia components. Mottled red/yellow/grey clay, loosely cemented; drusy calcite vugs formed within rootlet vacuities. Unit D possesses distinctive mottling due to penetration of the clay load by rootlets. Isolated iron-oxide pisolites; small clasts of decalcified parent limestone and allochthonous sediments; rare large bones and isolated teeth; no travertine formation other than calcite formation between Unit C/D and F.

Bone preservation. Disarticulation accumulation with little bone sorting; large long bones missing proximal and distal ends. Bone vacuities filled with clay.

Tooth preservation. Small teeth usually isolated and associated with edentulous jaws.

Shell preservation. Rare to absent.

Facies Interpretation. As for Unit C but with a greater influence from rootlets altering the general colouration and texture of the sediments.

Unit F; Stratigraphic context. Unit F is located between Units C & D and Unit H. There are contacts between Unit F and Unit C on the northwest flank, and with Unit H on the southeast flank. These contacts are demarcated by cave wall formation in the form of travertine and decalcified, detached flowstones with Units C, D and H. All three Units have been secondarily capped by a more recent travertine. Based on the contact zone, Unit F formed before Units C, D and H.

Breccia components. Bright yellow sandy, clay-rich; cemented; travertine distinct and demarcates contacts with younger sediment;

little internal flowstone formation. Interspersed small, rootlet-shaped drusy calcite vugs; minor clasts (0.5-2cm) of decalcified parent limestone with chalky texture. Small patches of highly fragmented bones and teeth.

Bone preservation. Disarticulated accumulation with no bedding or sorting; bones small and hollow in cross section; no large elements, mostly postcranial.

Tooth preservation. Mostly fragmented rodent incisors.

Shell preservation. Shell absent.

Facies Interpretation. The sediment is unlike any other found in the study area. The paucity of bone, internal speleothem genesis and clasts indicates a possibly dry accumulation. Further investigation of this deposit is needed. The lack of fossil specimens may also indicate a relatively old age for the deposit, before there was major connection of the solution pipes with the surface and well before karstification.

Unit H; Stratigraphic context. Unit H contacts the travertine wall enclosing Unit F and is younger. Unit H has formed at a similar depth to Units C, D and QML1384 Lower Unit, however, their superpositional relationships are unknown, possibly contemporaneous.

Breccia components. Red to dark brown clay, heavily compacted but not heavily cemented; numerous small clasts of altered serpentinite, clasts of decalcified parent limestone and iron-oxide pisolites; large and small bone fragments; isolated teeth and jaws. Minor travertine inclusions from Unit F.

Bone preservation. Dissarticulated accumulation with no distinct bedding or sorting of elements. Tightly packed bone accumulations; large bones are commonly long bones. Long bones usually with broken proximal and distal ends; shafts fractured and exploded by clay matrix; vertebrae usually missing transverse processes and neural spines; metatarsals commonly missing one distal end; small bones include variously fragmented skeletal elements; usually preserving epiphyses. Ranging from complete bone elements to grain-sized bone particles.

Tooth preservation. Mostly edentulous jaws and numerous isolated teeth. Large (e.g. large macropodid) teeth usually remain within the jaw. Teeth variably preserved with tooth roots.

Shell preservation. Nil.

Facies Interpretation. Absence of angular limestone blocks and dipping beds indicates a

non-entrance facies. The lack of cementation indicates a period of saturation of the sediment or the inclusion of humic acids into the cavern, both similarly retarding the precipitation of calcite within the sediment, however, geochemical analyses will be needed to clarify this.

Elephant Hole Cave System

ELEPHANT HOLE CAVE: E8. *"On the West flank of Mt Etna. The cave [Elephant Hole Cave] has three middle level entrances, all containing vertical pitches. An active inflow cave. From the main entrance a talus slope leads to the drop into two large caverns. ...The cave has little decoration, but has some breccia deposits which include bone material."* Shannon (1970b: 25)

Williamson & Vavryn Collection, QML1312; a sample of unconsolidated floor sediment from an earth floor within Elephant Hole Cave in 1986.

Stratigraphic context. Of unknown stratigraphic context. TIMS U-series date based on *Petrogale* dentition (minimum age) $149,000 \pm 611$ ybp. Considered to be young based on the preservation state of the material. Younger than QML1384 and QML1385 deposits.

Breccia components. Sediment and bone that was collected is derived from a loosely compacted cave floor (Vavryn & Williamson pers coms.) which is almost entirely made-up of fine, dark to light brown or red clay. Sediment breaks down easily in water and contains small, angular fragments of cave wall and roof, which show some signs of weathering and decalcification. Bone appears to be subfossil, with minimal bone discolouration, except for black manganese-oxide surface stains.

Bone preservation. Disarticulated, semi associated; bone small to medium-sized (<100mm in length) with portions of larger limb elements; very well preserved with most of the long bones retaining epiphyses and skull bones intact. Bone cavities free of calcite and sediment.

Tooth preservation. Most mandibles and maxillae retain teeth and most molar rows.

Shell preservation. Fragmentary and rare.

Facies Interpretation. Abundance of small bones of mammals, lizards, frogs and passerine birds suggests that a fraction of the deposit be derived from a predator accumulation. Some gnaw marks have been found and identified as rodent gnawings. Present in the deposit are owl (*Tyto* sp.) and ghost bat (*Macroderma gigas*) remains indicating that typical cave dwelling predators were present in Elephant Hole Cave during

deposition. Well-preserved and semi-associated large vertebrate remains attaining a maximum size of the macropodine *Petrogale*, indicate an accumulation close to an entrance.

No orientations of the bones were taken with the collection so it is unclear whether water was involved in the accumulation. No speleothem or cementing has occurred, suggesting the sediment was not water transported. Some sediment clods remained within the deposit and were not broken down during collection, transport or preparation. These compacted sediment clods are thick with bones and teeth with their orientations relatively random. The lack of water transport, compaction and calcite precipitation indicates a very dry accumulation close to an entrance, with input from a predator's roost.

BENCH 3, QML1384 UPPER UNIT. In 2000 whilst collecting on the western benches of Mount Etna Mine, a site (QML 1384U) was discovered with a similar sedimentology to that seen in the material recovered from Elephant Hole Cave by Williamson & Vavryn in 1986 (QML1312). Based on the position of the deposit on the mine site, it would have occupied a deep chamber within the Elephant Hole Cave system.

Stratigraphic context. QML 1384 is considered to be older than QML1312 because it is found much deeper and is more compacted and lightly cemented. There is no distinct reworking of bone material and the bone has a greater degree of alteration than the bone from QML1312.

Breccia components. Cave earth compacted, only lightly cemented, breaking down easily in weak acidic solution. Sediment possesses a strikingly similar colour and texture to QML1312, including an abundance of brown to red clay, angular cave wall and roof inclusions.

Bone preservation. Bones disarticulated; subfossil preservation; similar in preservation to QML1312, especially by the presence of the black manganese oxide staining. The completeness of cranial and postcranial bones also indicates close similarities because no other site at Mt Etna, other than the Elephant Hole Cave collection, has such a high density of perfectly preserved elements. Bones infilled with clay.

Tooth preservation. Complete jaws with tooth rows preserved.

Shell preservation. Rare and fragmentary.

Facies Interpretation. The chambers of Elephant Hole Cave were large and vertical. It is therefore

considered that QML1384U is simply a lower and older extension of the entrance and predator accumulation identified as the QML1312 deposit.

BENCH 3, QML1384 LOWER UNIT.

Stratigraphic Context. QML1384L is lithologically similar to QML1384U. There is no distinct contrast between the upper and lower unit except for a darker colour of the clay in the Lower Unit. The Lower Unit is considered to be continuous with and therefore older than the sediments collected from the upper unit.

Breccia components. Sediment unconsolidated, extremely clay-rich, dark brown in colour. The clay is very greasy in texture; isolated allochthonous cobbles and gravel are dispersed throughout the clay load. Bone rare; little flowstone and few autochthonous clasts are present in the sediment.

Bone preservation. Bone rare and fragmented, where present relatively unaltered, possessing simple manganese staining. Larger bone vacuities free of clay. Similar in preservation to the upper unit, except for greater manganese staining.

Tooth preservation. Rare and isolated.

Facies interpretation. Lower Unit is simply an extension of a large vertically oriented solution pipe which fed into a large chamber housing phreatic pendants. The lack of distinctive vadosely developed flowstones within the sediment suggest that, like QML1311 Units C, D and H, the lower unit was accumulating within a water-saturated chamber, or one with sufficient acidity to prevent carbonate precipitation. This would also explain the lack of carbonate to indurate the clay sediment. The sediment looked to continue deeper within the system and certainly down to the level of Bench 4 (QML1385) deposit. This lower unit may contact QML1385 and be a source for the bone accumulations in it.

BENCH 4, QML 1385. In 2002 a small deposit of bones was discovered further down the mine site benches, in a direct line below QML1384L. The deposit is the lowest found so far on Mount Etna. This deposit is unlike any found on Mount Etna, however, it occurs closest to the base of the QML1384L. It is here considered to be part of the Elephant Hole Cave system, however, it may be independent of all accumulations on the mountain. A large wedge of limestone covers any potential connection between QML1384L and QML 1385 below it.

Stratigraphic context. Although the relationship of the deposit to the Elephant Hole Cave system is unclear, it is considered older than both QML1312 and QML1384 based primarily on the preservation of the bones, cementing of the breccia and great depth on the mountain.

Breccia components. The bone breccia contains deep red coloured clays, well sorted, well rounded pebbles and gravel and abundant fossilised bones and teeth. The breccia is heavily cemented but lacks distinctive speleothem genesis. Clasts of gravels are distinctly allochthonous with few parent limestone fragments.

Bone preservation. Disarticulated, slight reworking and rounding of dark-coloured bones. The majority of the bones are discoloured to some degree with crystallisation occurring within the bone. Long bones are usually found in parallel orientations but are not associated.

Tooth preservation. Variably preserved either within jaws, isolated and complete, or isolated and tumbled with smoothed edges.

Shell preservation. Rare.

Facies Interpretation. QML1385 is a complex mixture of accumulation processes. Bones and teeth are variably preserved and show differing degrees of preservation and alteration. A small portion of the bones and teeth are tumbled and rounded indicating stream or channel deposition. Many bones, especially frog ilia and mammal and bird limb bones show signs of predation, including bite marks (bat) and semi digestion (owl). The site is interpreted as a mixed deposit of material accumulated by reworking and water transportation of a predator accumulation. The material was then washed deep within the mountain to form well-sorted stream gravel deposits. Lack of travertine clasts or travertine development may indicate the deposition into a water-filled pool or a recently opened chamber.

LIMESTONE RIDGE

Limestone Ridge occurs directly to the east and southeast of Mount Etna (Fig 1, C) and may have been connected to Mt. Etna in the past. The ridge is bisected by a large siltstone/mudstone unit of the Mount Alma Formation, therefore, the cave systems presented herein are best described in two sections, northwest Limestone Ridge and southeast Limestone Ridge. The limestone blocks do not dip to the southeast as seen at Mount Etna and overall cave system development is along a horizontal joint axis.

Within a horizontally controlled joint system phreatic enlargement has developed long, 'ballroom' shaped and sized chambers. The presence of massive speleothems illustrates a long vadose history. Some horizontal development of the caves has been due to the influence of intrusive sills of volcanogenic material, such as Ball Room Cave J8 and Lost Paradise Cave J7 (Shannon, 1970a).

NORTHWEST LIMESTONE RIDGE

Johansen's cave system

JOHANSEN'S CAVE J1 AND J2. "This is at present the largest cave in the Mt Etna district" Shannon (1970b: 29).

Johannsens Cave is characterised by its abundance of bat guano. In 1919 guano mining began in Johansen's Cave. A discovery by P.H. Ebbott of a mandible of *Sarcophilus lanarius* (Longman, 1921) from within a guano matrix may be attributed to guano mining in Johansen's or Bee Cave. In 1926 Whitehouse recovered a small surface collection of bones from the guano in Johansen's Cave, all being from modern local species. In 1972 Mike Murray collected kangaroo mandibles, an edentulous *Sarcophilus harrisi* mandible and a crocodilian premaxilla from Lower Johansen's Cave. The mandibles were obviously from guano accumulations as guano still adheres to the bone. A note on the specimen label for the crocodile premaxilla (QMF17071) reads "In flowstone bed, above Tas. Devil level, Lower Johansen's Cave."

In 2002 the author visited Johansen's Cave, in particular Lower Johansen's Cave (J2), to relocate the flowstone bed with a guano unit below it. A distinctive thick (10-30cm) flowstone bed occurs along a small section of the back chamber with a large unit of mined guano below it. Preliminary inspection of the chamber located large vertebrate bones, including macropod metatarsals within the flowstone and similar-sized but differently preserved bone in the guano. The flowstone bed forms a false floor across a small portion of the chamber with a secondary filling of guano.

QML1314, Guano bed below flowstone *Stratigraphic context.* Guano occurs throughout the cave and has an amorphous sedimentological structure. It is considered younger than the flowstone unit because of the false floor nature of the flowstone.

Breccia component. Fine-grained dark brown to black guano, heavily organic; large and small bones of variable size and parent limestone fragments.

Bone preservation. Disarticulated, well preserved bone with long bones preserving epiphyses.

Tooth preservation. Variably preserved jaws with teeth preserved or isolated.

Snail preservation. Abundant, complete snail shells. Colour patterning present.

Facies Interpretation. A guano deposit with minor stream and channel movement within a large chamber.

QML368, FLOWSTONE (FALSE FLOOR) UNIT *Stratigraphic context.* A distinct false floor developed over an older sediment, which has been subsequently eroded leaving the false floor. Guano fills within a vacuity under the false floor. Thus, the flowstone unit is considered to be older than the guano beneath it.

Breccia components. Fine-grained yellow to brown clays with very well preserved, heavily cemented travertine. Numerous large bones and land snails occur within these flowstone bands.

Bone preservation. Disarticulated. Well preserved bones with most epiphyses preserved.

Facies Interpretation. Flowstone false floor.

Surface collection: no stratigraphic context.

SHUFFLE CAVE NO E NO: bone collection QML371

OLDER TIMBERS CAVE J31: surface collection QML372 & 1315

SOUTHEAST LIMESTONE RIDGE

Mini cave system

MINI CAVE J12. "Small horizontal ... active inflow cave. The single entrance leads to a tunnel cavern 60 feet long then a short crawl to an end [second] chamber" (Shannon, 1970b: 32).

At the end of the first chamber is a small shelf of heavily cemented bone breccia. The existing breccia is the remainder of a more substantial deposit that would have filled at least 40% of the first chamber.

QML1284, MINI CAVE CHAMBER BRECCIA, *Stratigraphic context.* The chamber breccia occurs lower on Limestone Ridge than both surface breccias (QML1284a and QML1382), however, they are considered to be

contemporaneous deposits. QML1284a illustrates an entrance facies, which would be expected to occur above the QML1284 section, feeding material into the chamber.

Breccia components. Consists of fine-grained yellow to red coloured clay, bedded travertine, small angular clasts of parent limestone, allochthonous siltstone and serpentinite, small black goethitic and lighter coloured carbonate pisolites. The oxide pisolites are considered to be allochthonous, the carbonate pisolites autochthonous (cave pearls). The sediments are layered with speleothem, producing distinct sections throughout the deposit. These layers are continuous throughout the deposit and are interpreted as a series of sump deposits flowing into permanent rim pools.

Bone preservation. An articulated assemblage of small cave dwelling species such as snakes, frogs and bats. Bones well preserved in a halo of carbonate. Bones vary in size from tiny osteoderms to pockets of larger bone up to 100mm in size. All skeletal elements are well preserved, even the minute osteoderms from skinks. Little evidence of bone gnawing or digestion from predators.

Tooth preservation. Teeth usually in jaws and well preserved tooth rows, mostly molar rows and isolated incisors. Majority of teeth are from small taxa, however, isolated teeth from large-sized taxa occur randomly in the lenses.

Shell preservation. Snail shells well preserved, usually complete shells of varying sizes.

Facies Interpretation. Presence of distinct rim pool formations (basin-shaped travertine, abundant carbonate pisolites, and sorting of sediment matrix) indicates the deposit was at the base of a chamber being fed from above. The entrance is thought to have been higher than the current Mini Cave entrance and QML1284a is in a suitable position to be this entrance facies. The abundance of articulated or associated specimens indicates that many vertebrates including frogs, bats, rodents and snakes inhabited the chamber.

QML1284A, ABOVE MINI CAVE. Located above and to the northwest of the Mini Cave entrance is a heavily weathered bone breccia, which is interpreted as the upper level of the Mini Cave System, and an old cave chamber collapse.

Stratigraphic context. QML1284a deposit sits above QML1284 sediments but is considered to be relatively contemporaneous as it is believed that QML1284a is the entrance facies for the

same series of accumulations making up the deeper rip pool deposits of QML1284. QML1382 is a lateral extension of the QML1284a entrance facies, therefore, is of similar age also.

Breccia components. Pink-grey coloured clay, heavily cemented with thinly bedded travertine throughout. Irregular bedding within breccia blocks. Large clasts of parent limestone, with smaller clasts of oxide and carbonate pisolites, allochthonous gravels and large calcite vugs.

Bone preservation. Well preserved, complete bones and associated specimens. Bones showing predation and partial digestion. Snail shells complete and associated with travertine.

Tooth preservation. Teeth usually in jaws and well preserved.

Shell preservation. Well preserved, complete.

Facies Interpretation. Large angular limestone clasts and irregular bedding suggests a facies close to an entrance. The presence of a distinct predator accumulation and a small contribution of larger vertebrate remains suggests a chamber was close to an entrance, which was big enough to support a bat or owl's roost.

QML1382, LEO'S LUNCH SITE. Located to the north of QML1284a, QML1382 is interpreted as a lateral extension of the QML1284a collapse line.

Breccia components. A grey-pink, heavily cemented bone breccia with large clasts of parent limestone, smaller clasts of flowstone, pisolites and allochthonous sediment.

Bone preservation. Small grain-sized fragments, isolated limbs and vertebrae within flowstones.

Tooth preservation. Isolated teeth.

Shell preservation. Snail shells associated with flowstone.

Facies Interpretation. A lateral extension of the entrance facies of QML1284a, with greater flowstone development and irregular bone accumulations.

Surface collections: no stratigraphic context.

LOST PARADISE CAVE J7: bone collection, stream channel first chamber.

BALL ROOM CAVE J8: bone collection, stream channel southern end of main chamber.

OLSEN'S CAVE SYSTEM

Olsen's cave.

"Essentially only one cave system of sixteen interconnected caverns, usually joint-controlled

and of varying dimensions..." Shannon (1970b: 36).

Stratigraphic context. Unknown, however, bone preservation suggests relatively young deposit.

Breccia components. Dark brown coloured clay sediment. Loosely consolidated and cemented cave floor sediment. No major clasts present.

Bone preservation. A mass of disarticulated, unsorted, tightly compacted fragmentary bone.

Tooth preservation. Jaws with teeth and most molar rows. Exclusively small vertebrates.

Shell preservation. Nil.

Facies Interpretation. Tightly compacted bone accumulation of predominantly small vertebrate remains suggests a typical predator accumulation such as an owl's roost accumulation. Some incorporation of isolated macropod teeth.

KARST GLEN SYSTEM

To the southwest of Olsen's Cave is another isolated outcrop of limestone known as Karst Glen. Several small to medium sized caves occur in this limestone block and possess associated fossil deposits. Tall karst towers on the northern aspect of the limestone outcrop demarcate a collapsed cliff line following an intersecting vertically jointed system. These collapses have exposed a series of bone breccias and cemented cave floor sediments. Amongst the karst scree, several in situ fossil deposits can be found, generally near to, or beneath, a present cave entrance. Within the chambers, deep sequences of breccia are associated with extensive speleothems. Collections were not made within the caves of these breccias, however, outcrops of surface breccia were located and collected.

QM1411-1414, KG3 surface breccia

QML1411, KG3 BRECCIA UPPER BRECCIA SITE. Located as an exposed fissure deposit near the top of the karst limestone at Karst Glen, QML1411 connects with the sediment found deeper within the limestone caverns. Lithologically it is unique amongst the cave deposits for central eastern Queensland being a markedly pisolitic conglomerate rather than a breccia.

Stratigraphic context. QML1411 occurs high on the open karst as a fissure deposit dipping at approximately 45° and running the length of a NW joint. It is stratigraphically higher than any of the other units currently at Karst Glen and is considered to be a very old fissure fill system.

The age of the sites in relation to the other sites on Karst Glen is unknown.

Breccia components. The rock unit at QML1411 is best considered a pisolitic conglomerate. The majority of the unit contains large and small, well rounded conglomerate of black oxide pisolites. The rock is heavily cemented with the matrix a grey-coloured carbonate clay. Small clasts of parent limestone occur throughout the conglomerate.

Bone preservation. Very well rounded and reworked medium-sized bones that are heavily oxidised and shiny black in colour and lustre.

Tooth preservation. Nil.

Shell preservation. Nil.

Facies Interpretation. A heavily reworked channel fill occurring within the confines of a limestone fissure.

QML1412 & QML1413, KG3 B ENTRANCE BRECCIA.

QML1412 and QML1413 occurs beneath and to the southeast of "B" entrance within the KG3 Cave complex at Karst Glen. The unit follows a collapsed joint running NE-SW. The breccia is the remnant sediment fill within the vertical joint that has collapsed. Several of the blocks are *in situ*, forming the source for a large breccia scree found working its way downslope throughout the thick vegetation. Large patches of flowstone exposed on the surface can also be found closer to the present cliff line.

Stratigraphic context. QML1412 and QML1413 are of unknown stratigraphic context to other sites on KG3 and within the Cave systems. As the deposits are all joint controlled, each joint may contain contemporaneous sediment without stratigraphic contact.

Breccia components. A fine grained, red coloured matrix that is heavily cemented. Very small allocthonous gravel and pisolite clasts. Sediment is clay dominant. Weathered flowstone found in patches throughout the site.

Bone preservation. Bone mostly small and well sorted into fine lenses forming the main irregular bedding planes. Finest portion of bone material, small and sand grain-sized. Bone well preserved, however, most elements are fragmentary with epiphyses missing.

Tooth preservation. Teeth usually associated with jaws. Almost entirely comprised of small jaws of rodents, possums, bats and dasyurids. Very few larger vertebrates present.

Shell preservation. Very little shell present. Some well preserved isolated large snails.

Facies Interpretation. The lack of large angular limestone clasts, patchy travertine and abundant clay load indicates a non-entrance facies. The fine lenses of grain-sized bones and massive accumulation of small vertebrates indicates a possible predator accumulation.

MARMOR QUARRY

QML1420.

Bone breccia collected by Bartholomai in 1964

Stratigraphic context. Unknown. QML1420 has been treated as a single fauna because none of the fossils are in stratigraphic context. Two factors suggest that the fossils have been derived from similarly aged sediment, probably the same breccia: 1. The lithology of the matrix adhering to all of the material collected is very similar. When known sites of different age are compared at Mount Etna, the matrix differs dramatically in sediment colour, cementation and bone preservation (e.g. QML1312 versus QML1311). Therefore, it seems likely that the material from Marmor Quarry is derived from the same unit. 2. Two collections have been used for this analysis: One by Longman in the 1920's and one by Bartholomai in the 1960's. Both collections used the mine manager of-the-day as a source of historical knowledge for site location, plus they both collected similar fauna, such as *Macropus titan*, *M. agilis siva*, and *Sarcophilus lanarius*.

Both collections contain similar species of rodents and bandicoots, with the small mammals derived from Bartholomai's collection via acid etching of bone breccia. This breccia also contained megafauna such as *Macropus titan*.

Breccia components. Grey to brown clay, lightly cemented; clasts of limestone only.

Bone preservation. Bone preserved as grain-sized fragments, isolated large long bone elements and occasional large vertebrate remains.

Tooth preservation. Small-sized vertebrates are generally preserved as isolated teeth without jaws. Large-sized vertebrates present as isolated mandibles and maxillae with preserved teeth.

Shell preservation. Isolated large snails.

Facies Interpretation. The sediment type and bone preservation is very similar to the guano found in Lower Johansen's Cave, the major difference being the degree of cementation. Marmor Quarry sediment is considerably more cemented than the guano found at Lower

Johansen's Cave. It is therefore considered that the breccia recovered by Bartholomai in 1964 comes from a cemented guano deposit.

FAUNAS

Many of the sites individually represent diverse faunas and their constituent taxa are tabulated (Tables 1-3, Appendix 1). Higher level taxa which are represented by few or one elements but are noteworthy are listed below. In addition the murids are listed below but will be described in another work.

UNDESCRIBED TAXA

Teleost indet. QMF51442, vertebra, QML368.

Microchiropterans; QMF48001-48108; QMF48160-QMF48165; All localities (except QML1420).

Bats are found in all faunal assemblages except QML1420 and range in size from very small species of *Miniopterus*, to the very large *Macroderma gigas* (Fig. 29A-E.). Identification of the numerous small species of bats was outside the scope of the present study.

Murids: Rodents are a conspicuous element of all sites and faunal assemblages. At least ten genera have been identified (Author and H. Godthelp). The taxa range in size from the large arboreal *Melomys/Uromys* and aquatic *Hydromys*, to the very small arboreal *Pogonomys* and terrestrial *Leggadina*. Specific identifications will be determined in a full review of the rodents. A preliminary list is provided below with identified specimens.

Conilurus sp. Fig. 30A: QMF52052; QML1312.

Hydromys sp. QMF52056; QML1420.

Leggadina sp. Fig. 30B: QMF52040-QMF52042, QML1312; Olsen's Cave; QML1314.

Uromys/Melomys sp. Fig. 30C-D: QMF52014-QMF52021; QML1284; QML1284a; QML1313; QML1420; QML1311; QML1384L.

Mesembriomys spp. QMF52028-QMF52032, QML1284; QML1384L; QML1385; QML1313; QML1311.

Notomys spp. Fig. 30I: QMF52036-52039; QML1312.

Pogonomys sp. nov. Fig. 30G QMF52022-QMF52027; QML1313; QML1284; QML1284a; QML1384U; QML1384L; QML1385; QML1311.

Pseudomys spp. Fig. 30E-F: QMF52043-QMF52051; All Localities.

Rattus spp. Fig. 30J; QMF52033- QMF52035; QML1312; QML1384U; Olsen's Cave; QML1420.

Zyzomys spp. Fig. 30H; QMF52053- QMF52055; QML1284; QML1284a; QML1312.

SYSTEMATIC PALAEOLOGY

Order ANURA Rafinesque, 1815
Family HYLIDAE Rafinesque, 1815

Cyclorana Steindachner, 1867

Cyclorana sp.
(Fig. 4G)

MATERIAL. QMF51443 & QMF51444; Olsen's Cave.

Two ilia represent this genus. Both ilia possess very large acetabular fossae with thin acetabular rims; distinct but small dorsal acetabular expansion; small and rounded ventral acetabular expansion; narrow preacetabular zone; slight curvature of the ilium; distinct dorsal prominence; anteroventrally and laterally orientated dorsal protuberance. Dorsal prominence almost entirely anterior of the acetabular rim. Superior acetabular rim margin above the level of the ventral margin of the ilial shaft. Lateral rim and medial groove absent. Iliac crest absent.

Identified as *Cyclorana* on comparison with Tyler's description of the genus (Tyler, 1976; Tyler et al., 1994). Identified as being close to *Cyclorana cultripes* by the presence of the large acetabular fossa, distinct dorsal prominence and protuberance and laterally projecting protuberance. Comparative specimens of the many species of *Cyclorana* were not available for this study, therefore, no specific assignment is warranted.

Litoria/Nyctimystes

Menzies et al. (2002) illustrated the problems associated with identifying fossil hylids from their pelvic elements, especially differentiating species of *Litoria* and *Nyctimystes*. Using the diagnostic features described by Tyler (1976) and Menzies et al. (2002) for *Litoria* and *Nyctimystes*, it was clear that both these taxa are present within the faunal assemblages. Identification to species level was not possible, except for those fossil specimens closely allying taxa with available comparative specimens such as *Litoria caerulea*.

Specimens assigned to *Litoria* were so based on the presence of the following distinctive

features; 1. Ovoid dorsal protuberance, 2. Dorsal ilial crest absent, 3. Large acetabular fossa. Specimens assigned to *Nyctimystes* were so based on the presence of the following additional features to those seen in *Litoria*; 1. Ventral acetabular expansion rounded. 2. Very broad preacetabular zone.

Litoria Tschudi, 1838

Litoria sp. 1
(Fig. 4D)

MATERIAL. QMF51445; QML1385.

Small *Litoria* with: 1. acetabular fossa large and shallow with distinct peripheral rim. 2. dorsal prominence anterior to acetabular rim. 3. dorsal protuberance a distinct ovoid, laterally developed, knob. 4. small fossa posterior of the protuberance and at the base of prominence. 5. ridge runs anteriorly from base of protuberance to medial side of ilial shaft. 6. Ilial shaft slightly curved. 7. dorsal acetabular expansion and ventral acetabular expansion reduced. 8. narrow preacetabular zone. 9. broad ilial shaft.

Differs from all other *Litoria* within the assemblages by possessing an anterior ridge of the dorsal prominence running from the base of the dorsal protuberance to the medial side of the ilial shaft. Differs from *Litoria* sp. 2 by possessing a narrow preacetabular zone and a shorter dorsal acetabular expansion. Differs from *Litoria* sp. 3 by being smaller and possessing a smaller dorsal protuberance and a narrower preacetabular zone. Differs from *Litoria* sp. 4 by being smaller and having a more ovoid, and better-developed dorsal protuberance.

Litoria sp. 2
(Fig. 4E)

MATERIAL. QMF51446; QML1385.

Medium-sized *Litoria* with the following: 1. broad, oval, and shallow acetabular fossa. 2. distinct acetabular rim. 3. Narrow preacetabular zone. 4. Elongate dorsal acetabular expansion. 5. Well developed and rounded ventral acetabular expansion. 6. Low dorsal prominence. 7. Dorsal protuberance ovoid and laterally developed. 8. Ilial shaft straight.

Differs from *Litoria* sp. 3 by being larger, having a smaller dorsal protuberance and an elongate dorsal acetabular expansion, which extends superiorly of the line of the dorsal protuberance. Differs from *Litoria* sp. 4 by being

larger, possessing a well-developed dorsal protuberance and broad preacetabular zone.

***Litoria* sp. 3**
(Fig. 4B)

MATERIAL: QMF51447-51449; QML1385.

A medium-sized *Litoria* possessing the following features: 1. Large, half-moon shaped acetabular fossa. 2. Reduced dorsal acetabular expansion. 3. Ventral acetabular expansion well developed and rounded. 4. Narrow preacetabular zone. 5. Dorsal prominence reduced. 6. Dorsal protuberance as a massive ovoid knob with a distinct ventral groove.

Differs from *Litoria* sp. 4 by being larger and possessing an enormous ovoid dorsal protuberance with a ventral groove.

***Litoria* sp. 4**
(Fig. 4C)

MATERIAL. QMF51450-51456; QMF51463-51464, QML1385; QML1284.

A small-sized *Litoria* possessing the following features; 1. Reduced, triangular-ovoid acetabular fossa. 2. Dorsal acetabular expansion and ventral acetabular expansion reduced. 3. Dorsal prominence reduced. 4. Dorsal protuberance conical-shaped and laterally produced. 5. Iliac shaft straight.

Differs from *Litoria conicula* by possessing a larger conical protuberance, smaller acetabular fossa, less developed ventral acetabular expansion and a narrow preacetabular zone.

***Litoria caerulea* (White, 1790)**

MATERIAL. QMF51457-51462; QML1314.

A large-sized *Litoria*, possessing the following features: 1. Medial and lateral groove absent. 2. Dorsal acetabular expansion reduced. 3. Ventral acetabular expansion gently curved. 4. Dorsal prominence and protuberance low on the iliac shaft. 5. Dorsal protuberance elongate-ovoid and slightly produced laterally.

Closely resembles comparative material available for *L. caerulea* from Queensland, especially the distinctly low dorsal prominence and ovoid protuberance.

Two smaller morphs of *Litoria* are present in subfossil accumulations from QML1314. It is uncertain whether these represent different taxa or a highly variable *Litoria caerulea*.

***Nyctimystes* Stejneger, 1916**

***Nyctimystes* sp. 1**
(Fig. 4F)

MATERIAL. QMF51465; QML1385.

A large *Nyctimystes* possessing the following features of the ilium; 1. Moderately large triangular acetabular fossa. 2. Reduced dorsal acetabular expansion. 3. Ventral acetabular expansion gently rounded and expanded, spatulate-shaped. 4. Preacetabular zone broad. 5. Dorsal prominence low with small indistinct ovoid protuberance. 6. Posterior ridge of dorsal prominence tapers to anterior base of dorsal acetabular expansion. 7. Iliac shaft straight, medio-laterally compressed and broad.

TABLE 1. Faunal lists for fish and amphibians

	QML368	QML1284	QML1284a	QML1312	QML1314	QML1384U	QML1385	Olsen's Cave
Teleostei indet	x							
<i>Cyclorana</i> sp.								x
<i>Litoria</i> sp. 1							x	
<i>Litoria</i> sp. 2							x	
<i>Litoria</i> sp. 3							x	
<i>Litoria</i> sp. 4		x					x	
<i>Litoria caerulea</i>					x			
<i>Nyctimystes</i> sp. 1							x	
<i>Nyctimystes</i> sp. 2		x	x					
<i>Etmabatrachus maximus</i>		x					x	
<i>Crinia</i> sp.							x	
<i>Kyarranus</i> sp.		x	x			x	x	
<i>Limnodynastes</i> sp. 1							x	
<i>Limnodynastes</i> sp. 2		x		x			x	
<i>Limnodynastes</i> sp. 3			x					
<i>L. tasmaniensis</i> sp. grp.							x	
<i>L. spenceri</i> sp. grp.							x	
<i>L. sp. cf. L. peronii</i>		x		x				
<i>Lechriodus</i> sp.		x						
<i>Neobatrachus</i> sp.							x	
microhylid sp. 1		x	x					
microhylid sp. 2		x	x					
microhylid sp. 3		x						

Differs from *Nyctimystes* sp. 2 by lacking a well-developed dorsal prominence and laterally developed dorsal protuberance. Further differs by lacking a distinctive groove ventral of the dorsal protuberance.

***Nyctimystes* sp. 2**

MATERIAL. QMF51466-51468; QMF51469-51471, QML1284; QML1284a.

A large *Nyctimystes* possessing the following features of the ilium; 1. Large ovoid acetabular fossa. 2. Reduced and pointed dorsal acetabular expansion. 3. Ventral acetabular expansion rounded and very broad. 4. Preacetabular zone broad and gently curved to the base of the ilial shaft. 5. Dorsal prominence and protuberance low on the ilial shaft. 6. Dorsal protuberance distinct and laterally developed into an elongate-ovoid knob. 7. Beneath the dorsal protuberance runs a distinct lateral groove. 8. Dorsal protuberance above anterior-most margin of acetabular rim.

Nyctimystes sp. 2 most closely resembles *N. disrupta* and *N. zweifeli* from illustrations and descriptions available from Tyler (1976) and Menzies et al. (2002).

***Etnabatrachus* Hocknull, 2003**

***Etnabatrachus maximus* Hocknull, 2003
(Fig. 6B)**

MATERIAL. QMF44207, QMF44208; QML1385, QML1284.

A giant frog probably from the Hylidae, based on the large rounded dorsal protuberances. Previously described by Hocknull (2003) and currently endemic to the Plio-Pleistocene of Mount Etna and Limestone Ridge.

Family LEPTODACTYLIDAE Werner, 1896

***Crinia* Tschudi, 1838**

***Crinia* sp.
(Fig. 4A)**

MATERIAL. QMF51472, QML1385.

A small leptodactylid. Only the rim of acetabular fossa preserved, indicating a large rounded and shallow fossa. Other features include: 1. Dorsal acetabular expansion short and pointed. 2. Ventral acetabular expansion broken and insignificant. 3. Preacetabular zone narrow. 4. Dorsal prominence low and long, running halfway anterior of the acetabular rim. 5. Dorsal protuberance inconspicuous. 6. Long thin

median groove running the length of the ilial shaft. 7. Ilial shaft curved and slender.

Crinia sp. is identified as *Crinia* based on its small-size, reduced dorsal prominence and protuberance, slender curved ilial shaft, large acetabular fossa and longitudinal medial groove.

***Kyarranus* Moore, 1958**

***Kyarranus* sp.
(Fig. 5F)**

MATERIAL. QMF51488, QMF51489, QMF51490, QMF51491; QML1284a; QML1284, QML1385, QML1384U.

Large sub-triangular acetabular fossa. Acetabular rim distinct and high. Dorsal acetabular expansion expressed as a triangular point at an equivalent height to the dorsal prominence and protuberance. Ventral acetabular expansion narrow and anteriorly projecting. Preacetabular zone narrow. Dorsal prominence high and anterior of acetabular rim. Dorsal protuberance is an elongate antero-dorsally projecting process from dorsal prominence. Small fossa at the posterior base of the dorsal prominence. Ilial shaft long, slender and curved.

Kyarranus is a distinctive leptodactylid, possessing an elaborate dorsal prominence and anteriorly projecting protuberance. The combination of this feature with a long, curved ilial shaft and a high acetabular rim identify *Kyarranus* here. Specific placement will be considered in later works.

***Limnodynastes* Fitzinger, 1843**

Tyler et al. (1998) describes all species of *Limnodynastes* as possessing an extremely large dorsal prominence and protuberance, and a high and steep dorsal acetabular expansion of the ilium. Within the genus there is considerable variation of these features, with the development of an ilial crest in some taxa (Tyler 1976). Specimens possessing these features are here assigned to *Limnodynastes*.

***Limnodynastes* sp. 1**

MATERIAL. QMF51473-51474; QML1385.

Acetabular fossa large and high, with a distinct acetabular rim. Dorsal acetabular expansion rises steeply from the shaft to an acute point. Ventral acetabular expansion is gracile and rounded. Preacetabular zone narrow and runs beneath the rim of the acetabulum. Dorsal prominence rises high above ilial shaft and positioned anterior of the acetabular margin. Dorsal prominence antero-dorsally oriented and distinct. A short

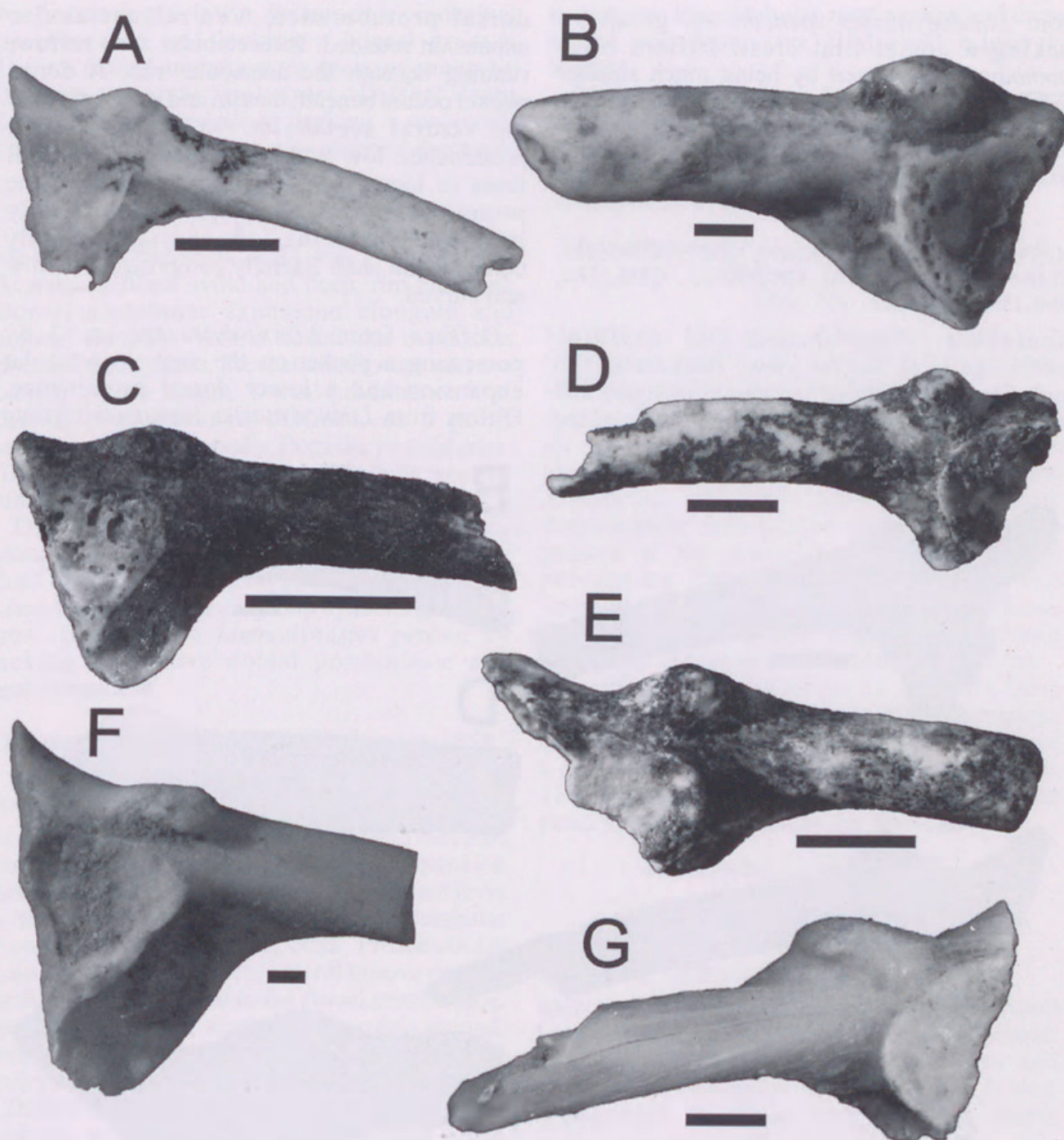


FIG. 4. A, *Crinia* sp.; QMF51472, right ilium. B, *Litoria* sp. 3; QMF51447, left ilium. C, *Litoria* sp. 4; QMF51450, right ilium. D, *Litoria* sp. 1; QMF51445, left ilium. E, *Litoria* sp. 2; QMF51446, left ilium. F, *Nyctimystes* sp. 1; QMF51465, left ilium. G, *Cyclorana* sp.; QMF51443, left ilium. Scale bar = 1mm.

lateral groove runs 1/3 the length of the ilial shaft, originating just anterior to the base of the dorsal prominence. A long median groove runs the length of the ilial shaft. Iliac shaft slightly curved.

Differs from *Limnodynastes* sp. 2 by possessing a median groove, a larger dorsal prominence and protuberance and missing a

pocket on the ventral acetabular expansion, situated beneath the acetabular rim. Differs from *Limnodynastes* sp. 3 by lacking a lateral groove ventral to the dorsal prominence and possessing a better-developed dorsal protuberance. Differs from *Limnodynastes tasmaniensis* sp. group by possessing a median groove on the ilium. Differs

from *Limnodynastes spenceri* sp. group by lacking a dorsal ilial crest. Differs from *Limnodynastes peronii* by being much smaller and lacking the massive development of the dorsal prominence and protuberance.

***Limnodynastes* sp. 2**
(Fig. 5E)

MATERIAL. QMF51476-51477, QMF51478-51481, QMF41864, QMF41856, QMF33383; QML1284, QML1385, QML1312.

Acetabular fossa broad and shallow, subtriangular in lateral view. Acetabular rim high. Dorsal acetabular expansion elongate and pointed reaching much higher than the tip of the

dorsal protuberance. Ventral acetabular expansion rounded. Preacetabular zone narrow, running beneath the acetabular rim. A dorsal pocket occurs beneath the rim and at the origin of the ventral acetabular expansion. Dorsal prominence low and inconspicuous. A small fossa is located at the posterior base of the prominence. Dorsal protuberance equally inconspicuous being low and only slightly conical. Iliac shaft laterally compressed, narrow and curved.

Differs from *Limnodynastes* sp. 3 by possessing a pocket on the ventral acetabular expansion and a lower dorsal prominence. Differs from *Limnodynastes tasmanicus* group



FIG. 5. A, *Limnodynastes* sp. 3; QMF51486, right ilium. B, *Limnodynastes* sp. cf. *L. peronii*; QMF41793, left ilium. C, *Limnodynastes* sp. 1; QMF51473, right ilium. D, *Limnodynastes spenceri*; QMF51484, left ilium. E, *Limnodynastes* sp. 2; QMF51476, right ilium. F, *Kyarranus* sp.; QMF51489, right ilium. Scale bar = 1mm.

by possessing a lower prominence, indistinct protuberance and lacking a lateral groove. Differs from *Limnodynastes spenceri* group by lacking a dorsal ilial crest. Differs from *Limnodynastes peronii* by lacking a massively developed dorsal prominence and protuberance.

***Limnodynastes* sp. 3**
(Fig. 5A)

MATERIAL. QMF51486; QML1284a.

Acetabular fossa ovoid and deep, rim elevated. Dorsal acetabular expansion elongate and pointed dorsally. Ventral acetabular expansion rounded and gracile. Preacetabular zone narrow. Lateral groove absent. Dorsal prominence low. Dorsal protuberance distinct, as a point projecting antero-dorsally from the prominence. Ilial shaft slightly curved. Median groove running the length of the ilial shaft.

Differs from *Limnodynastes tasmaniensis* group by possessing a median groove along the shaft and lacking a lateral groove. Differs from *Limnodynastes spenceri* group by lacking an ilial crest. Differs from *Limnodynastes peronii* by lacking a massive dorsal prominence and protuberance.

***Limnodynastes tasmaniensis* Günther, 1858**
sp. group.

MATERIAL. QMF51482-51483; QML1385.

Acetabular fossa distinctly rounded and elevated from the shaft. Dorsal acetabular expansion elongate, tapering to a point at an equivalent level to the dorsal protuberance. Ventral acetabular expansion narrow and tapered. Preacetabular zone narrow and concave. Lateral groove present on the shaft just ventral to the dorsal prominence. Dorsal prominence distinct, triangular shaped. Dorsal protuberance elongate, ovoid and projecting antero-dorsally. Ilial shaft curved.

Differs from *Limnodynastes spenceri* group by lacking a dorsal ilial crest. Differs from *Limnodynastes peronii* by lacking the massive dorsal prominence distinctive of *L. peronii*.

***Limnodynastes spenceri* Parker, 1940 sp.**
group.
(Fig. 5D)

MATERIAL. QMF51484-51485; QML1385.

Small ilium possessing a distinct dorsal ilial crest and prominent antero-dorsally oriented dorsal protuberance. Acetabular fossa small and rounded. Acetabular rim distinct. Dorsal acetabular expansion unknown in the specimens. Ventral acetabular expansion unknown in

specimens. Preacetabular zone narrow and close to the acetabular rim. Ilial shaft relatively straight.

Differs from all other *Limnodynastes* species by possessing an ilial crest. Differs from the only other taxa with ilial crests, *Rana*, *Mixophyes* and *Lechriodus*, by lacking the extreme dorsal development of the crests.

***Limnodynastes* sp. cf. *L. peronii* Duméril & Bibron, 1841**
(Fig. 5B)

MATERIAL. QMF41793, QMF41801, QMF41812, QMF41821, QMF41827, QMF33380, QMF41863, QMF41865-41866; QML1284; QML1312.

Acetabular fossa large and rounded. Rim elevated and thick. Dorsal acetabular expansion elongate and tapered, steeply pointed. Ventral acetabular expansion rounded and broad. Preacetabular zone narrow and concave. Fossa present at the posterior base of the dorsal prominence. Dorsal prominence distinct and anterior of acetabular rim. Dorsal protuberance large and well developed. Protuberance anterior projecting. Ilial shaft broad and slightly curved.

Specimens assigned to *L. peronii* from QML1284 differ from conspecific specimens from QML1312 in possessing a distinct fossa and a more anteriorly projecting dorsal prominence. This variation is considered to be within the possible range of variation for this taxon.

***Lechriodus* Boulenger, 1882**

***Lechriodus* sp.**
(Fig. 6A)

MATERIAL. QMF51492; QML1284.

Ilial crest present. Dorsal protuberance ovoid and level with the acetabular rim. Dorsal acetabular and ventral acetabular expansions narrow and short. Preacetabular zone narrow. Broad semicircular acetabular fossa. Shallow lateral groove runs the length of the ilial crest.

***Neobatrachus* Peters, 1863**

***Neobatrachus* sp.**
(Fig. 6C)

MATERIAL. QMF51487; QML1385.

Acetabular fossa very small and rounded. Acetabular rim low and distinct from preacetabular zone. Dorsal acetabular expansion very broad and high, coalescing with the posterior margin of the dorsal prominence. Ventral acetabular expansion narrow and pointed. Preacetabular zone narrow and close to

acetabular rim. Dorsal prominence is large with a tiny point making up the dorsal protuberance. Iliac shaft nearly straight and laterally compressed.

Neobatrachus possesses distinct iliac characteristics not found in other leptodactylids, including the elaboration of the dorsal acetabular expansion and its coalescence with the dorsal prominence, small acetabular fossa and reduced ventral acetabular expansion. Specific assignment is not justified at this stage due to the lack of comparative specimens.

Family MICROHYLIDAE Günther, 1858

Microhylids have been identified from some of the faunal assemblages based on their small size, very large acetabular fossa, curved shaft and diminutive posteriorly placed dorsal prominence and protuberance.

microhylid sp. 1 (Fig. 6C)

MATERIAL. QMF51493-51494, QMF51495; QML1284, QML1284a.

Large rounded acetabular fossa which is distinct from the shaft and possesses a distinct acetabular rim. Dorsal acetabular expansion short and pointed. Ventral acetabular expansion short and rounded. Preacetabular zone narrow and constricted toward the acetabular rim. Dorsal prominence low with a conical protuberance posterior of acetabular rim. Iliac shaft recurved without dorsal crest.

Differs from microhylid 2 by possessing a curved shaft and less ridged dorsal protuberance. Differs from microhylid 3 by lacking a dorsal crest.

microhylid sp. 2 (Fig. 6F)

MATERIAL. QMF51496, QMF51497; QML1284, QML1284a.

Acetabular fossa large and rounded. Distinct acetabular rim. Dorsal acetabular expansion and ventral acetabular expansion unknown, however, inferred to be reduced. Preacetabular zone narrow. Dorsal prominence low, dorsal protuberance small and ridged. Iliac shaft slightly curved and slender. Differs from microhylid 3 by lacking a dorsal crest.

microhylid sp. 3 cf. *Hylophorbus* Macleay, 1878 (Fig. 6D-E)

MATERIAL. QMF51498; QML1284.

Large rounded acetabular fossa. Distinct acetabular rim, set high above iliac shaft. Dorsal acetabular expansion elongated to a sharp dorsal point. Ventral acetabular expansion anteriorly deflected and rounded. Preacetabular zone narrow. Dorsal prominence inconspicuous, forming the posterior margin of a dorsal crest. Dorsal protuberance elongate and antero-dorsally projecting. Iliac shaft curved. Dorsal crest laterally compressed, angled medially, running almost the entire length of the iliac shaft.

The form of the ilium, distinct iliac crest, and curvature of the shaft ally this taxon very closely to *Hylophorbus* from Papua New Guinea as described and figured in Menzies et al. (2002). More specimens and access to comparative *Hylophorbus* will be needed to clarify its taxonomic placement within the Microhylidae.

Order TESTUDINES Linnaeus, 1758

Family CHELIDAE Gray, 1825a

chelid indet. (Fig. 7G-H)

MATERIAL. QMF52061, QMF52062, QMF52063; QML1311(H); QML1384L; QML1311(C/D).

Several pieces of carapace and plastron represent remains of freshwater turtles. The portions of carapace are thick, with distinct suture lines. A single posterior portion of a plastron is very thin and preserves pelvic sutures from the left side.

Order NEOSUCHIA Benton & Clark, 1988 Family CROCODYLIDAE Cuvier, 1807

Mekosuchinae indet. (Fig. 7A-F)

MATERIAL. QMF51499-51505, QMF52064-52065, QMF17071; QML1311 (H), QML1384L, QML368, QML1313.

Fragmentary remains, including a serrated ziphodont tooth, a portion of an edentulous premaxilla, two partial vertebrae, three scutes, the proximal end of a femur and an ungual represent crocodylians. The tooth has a distinctly serrate carinae and is ziphodont in form. A wear facet can be seen on the mesial margin of the tooth. The premaxilla is rounded with three alveoli, linked to one another by thick ridges on the lateral premaxillary margin. The vertebrae are antero-posteriorly compressed and squat, preserving both the condyle and cotyle. Scutes, small and thin, with a flat ventral surface and a keeled dorsal surface. Rows of pits occur on the dorsal surface of the scutes.



FIG 6. A, *Lechriodus* sp.; QMF51492, right ilium. B, *Etnabatrachus maximus*; QMF44208, left ilium. C, *Neobatrachus* sp.; QMF51487, right ilium. D-E, microhylid sp. 3; QMF51498, left ilium in mesial and lateral view. F, microhylid sp. 2; QMF51496, left ilium. G, microhylid sp. 1; QMF51493, right ilium. Scale bar = 1mm.

The overall shape and size of the premaxillary bone, tooth and femur are similar to that of *Baru huberi* (QMF31061) but differs by having a deep reception pit for the first dentary tooth, that breaks the dorsal surface of the premaxilla.

Order SQUAMATA Oppel, 1811
Family AGAMIDAE Hardwicke & Gray, 1827

Amphibolurus Wagler, 1830

Amphibolurus sp.
(Fig. 8D)

MATERIAL. QMF43893; QML1312.

Right maxilla bearing two pleurodont tooth loci, both broken at the base. Nine acrodont tooth loci. The dorsal maxillary process is broken dorsal to the narial basin.

QMF43893 is placed within *Amphibolurus* on the basis of the following combined features: 1. Possessing a significantly reduced, near absent, naris ridge. 2. Dorsal maxillary process constricted superiorly and broad inferiorly. 3. Two pleurodont teeth with P^1 approximately three quarters the size of P^2 . 4. Less than fifteen acrodont teeth. 5. Angular dorsal maxillary process. 6. Hooked anterior profile.

Diporiphora Gray, 1842

Diporiphora group 2 (*sensu* Hocknull, 2002)
(Fig. 8)

MATERIAL. QMF51507; Olsen's Cave.

A left maxilla bearing one large pleurodont and six acrodont teeth. Maxilla broken posterior to A^6 . Pleurodont tooth large, recurved and orientated labially. Angulate dorsal maxillary process.

Identified as a species within *Diporiphora* group 2 *sensu* Hocknull (2002) on the basis of the following combined features: 1. Naris ridge absent. 2. Broad dorsal maxillary process, narrowed superiorly. 3. One large caniniform maxillary pleurodont tooth.

Hypsilurus Peters, 1867

Hypsilurus sp.

MATERIAL. QMF51506; QML1313.

Half of a badly preserved right dentary (Length: 12.13+mm) bearing 11 acrodont and one tiny pleurodont tooth represents a medium-sized agamid. The dentary is broken posteriorly of A_{11} and is gracile, tapering anteriorly with little curvature. Four visible foramina are present on the labial side of the dentary, with the last

occurring below A_{11} . The dental sulcus is narrow along its length and tapers markedly anteriorly. The dentary symphysis is small and ovoid. Acrodont dentition is badly weathered, however, there are distinct mesoconids and small antero and posterconids. Tooth size changes markedly between tooth position A_5 and A_6 .

Agamid dentaries are difficult to identify, however, only five Australian agamid genera possess such distinctively diminutive pleurodont dentition of the dentary; *Chelosania*, *Hypsilurus*, *Physignathus*, *Moloch* and *Pogona* (Hocknull, 2002). The fossil is most similar to *Hypsilurus* by sharing one very tiny pleurodont tooth (*Hypsilurus* possesses one or two) and a very gracile, tapered dentary outline. The fossil dentary differs from all of the other four genera by possessing a much more gracile dentary and narrowly tapered dental sulcus. The fossil specimen differs further from *Chelosania* by being larger and possessing less tricuspid acrodont dentition. The fossil differs further from *Physignathus* by being smaller and possessing one versus three pleurodont dentary teeth. The fossil differs further from *Pogona* by possessing less rounded acrodont dentition and relatively shallower posterior and anterior margins.

Pogona Storr, 1982

Pogona sp. (small morphotype)
(Fig. 8C)

MATERIAL. QMF41969; QML1312.

Left maxilla with the anterior and posterior margins broken. Twelve acrodont teeth present.

Pogona has been identified from QML1312 by the presence of the following feature of the maxilla: 1. Posterior region deep. 2. Rounded acrodont teeth with large mesocones. Based on its size, the specimen allies the smaller *Pogona* species, such as *P. mitchelli* and *P. minor*.

Tympanocryptis Peters, 1863

Tympanocryptis sp. cf. *T. cephalus* Günther,
1867
(Fig. 8A)

MATERIAL. QMF41963; QML1312.

A nearly complete right maxilla, which is broken posteriorly to A_{12} . Twelve acrodont and two pleurodont teeth preserved. Dorsal maxillary process broken at the dorsal margin.

Specimens referred here to a species of *Tympanocryptis* have been identified based on the following combined features; 1. Naris ridge present. 2. Naris ridge borders narial basin. 3.

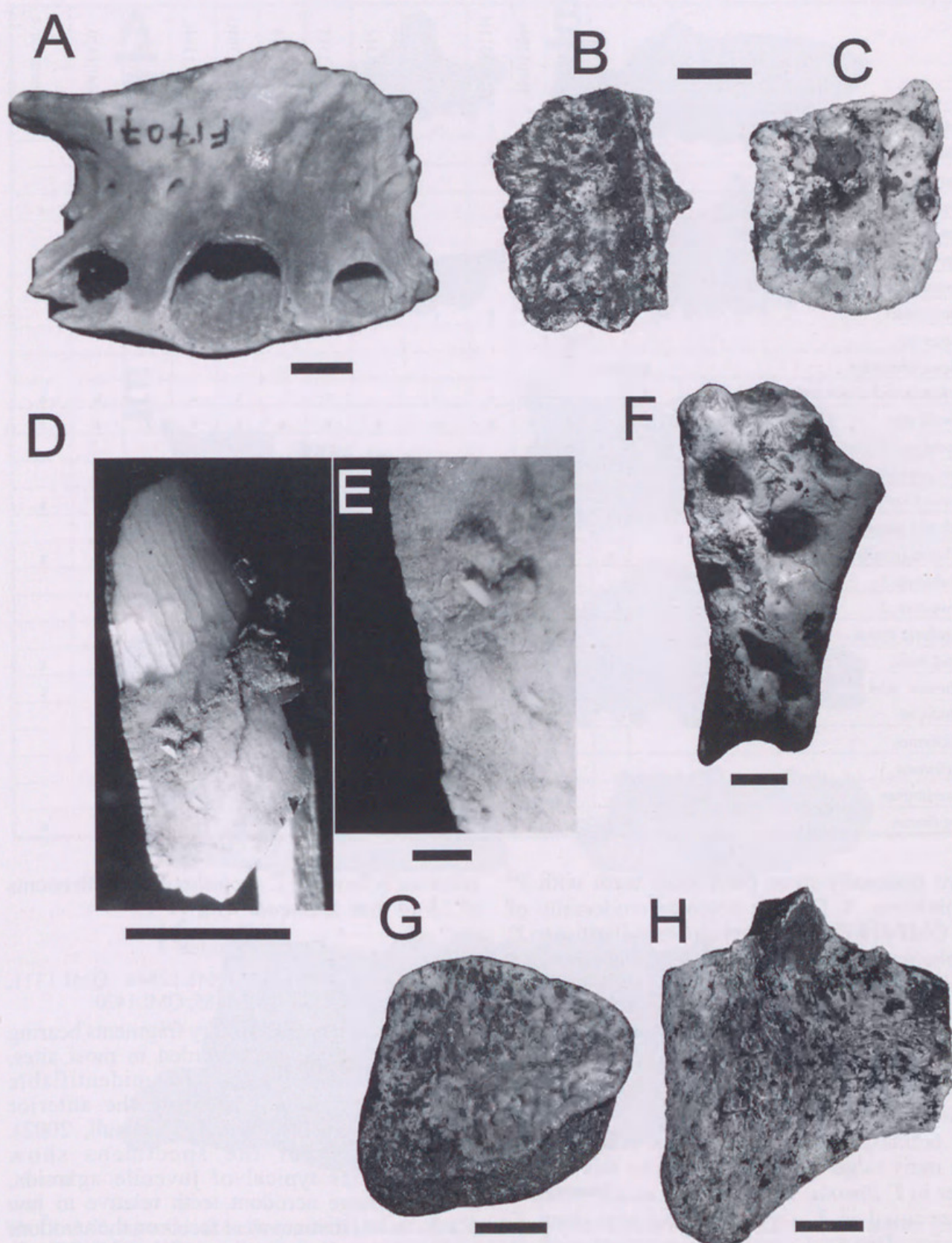


FIG. 7. A-F, Mekosuchinae; A, QMF17071, premaxillary. B, QMF52064, scute. C, QMF52065, scute. D, QMF51503, ziphodont tooth. Scale bar = 5mm. E, QMF51593 closeup of carinae (Scale bar = 1mm). F, QMF51505, scute. G-H, Chelidae; G, QMF52061, carapace. H, QMF52062, plastron.

TABLE 2. Faunal lists for reptiles and birds.

	QML368	QML1284	QML1284a	QML1311H	QML1311CD	QML1312	QML1313	QML1314	QML1384U	QML1384L	QML1385	QML1420	Olsens Cave
chelid indet.				x	x					x			
mekosuchine indet.	x			x			x			x			
<i>Amphibolurus</i> sp.						x							
<i>Diporiphora</i> sp.													x
<i>Hypsilurus</i> sp.							x						
<i>Pogona</i> sp.						x							
<i>Tympanocryptis</i> sp. cf. <i>T. cephalus</i>						x							
agamid indet	x	x	x	x	x	x	x		x	x	x	x	
<i>Tiliqua</i> sp.		x											
<i>Tiliqua scincoides</i>							x	x					
<i>Cyclodomorphus gerrardii</i>		x	x	x	x		x		x	x	x	x	x
<i>Egernia</i> spp.	x	x	x	x	x	x	x	x	x	x	x	x	x
<i>Eugongylus</i> Group		x	x										
<i>Sphenomorphus</i> Group (gracile)		x	x			x	x				x		
<i>Sphenomorphus</i> Group (robust)						x							x
gekkonid (large)		x	x				x						
gekkonid (small)	x	x	x	x	x	x	x	x	x	x	x	x	x
<i>Varanus</i> sp. 1				x		x							
<i>Varanus</i> sp. 2				x	x	x	x						
<i>Megalania prisca</i>												x	
elapid indet.	x	x	x	x	x	x	x	x	x	x	x	x	x
pythonine indet.	x	x	x	x	x	x	x	x	x	x	x	x	x
typholopid		x	x										
Galliformes						x							
Gruiformes						x							
Passeriformes		x				x							
Strigiformes	x	x	x	x	x	x	x	x	x	x	x		x

Two unequally-sized pleurodont teeth with P² caniniform. 4. Distinct notch anterodorsally of P¹. QMF41963 shares very close similarities to *T. cephalus*. P¹ and P² are parallel to one another, which is not found in *T. tetraporophora* and *T. intima*. Also, *T. intima* is considerably larger than the specimen and comparative *T. cephalus*. The posterior "molar" acrodont teeth do not show the marked size change typical of *T. lineata* and *T. intima* (Hocknull, 2002). The lateral margin of the premaxillary/maxillary suture is higher and the naris ridge contributes more to this than it does in *T. lineata*. The P¹ is very small, which is more usual in *T. cephalus* specimens, than *T. lineata*. The total number of acrodont teeth is unknown in this specimen, however, judging from the amount of missing maxilla, the number of teeth would be thirteen or more. Thirteen or more acrodont teeth in the maxilla is more

commonly found in *T. cephalus* with tooth counts of 13-14 than *T. lineata* with 11-13.

agamid indet.

MATERIAL: QML1284, QML1284a, QML1311, QML1313, QML1384, QML1385; QML1420

Several maxillary and dentary fragments bearing acrodont dentition are recorded in most sites, however, most of these are unidentifiable because they do not preserve the anterior diagnostic elements needed (Hocknull, 2002). The majority of the specimens show characteristics typical of juvenile agamids, including large acrodont teeth relative to jaw depth, lack of distinct wear facets on the acrodont teeth and dental bone, and overall bone fragility.

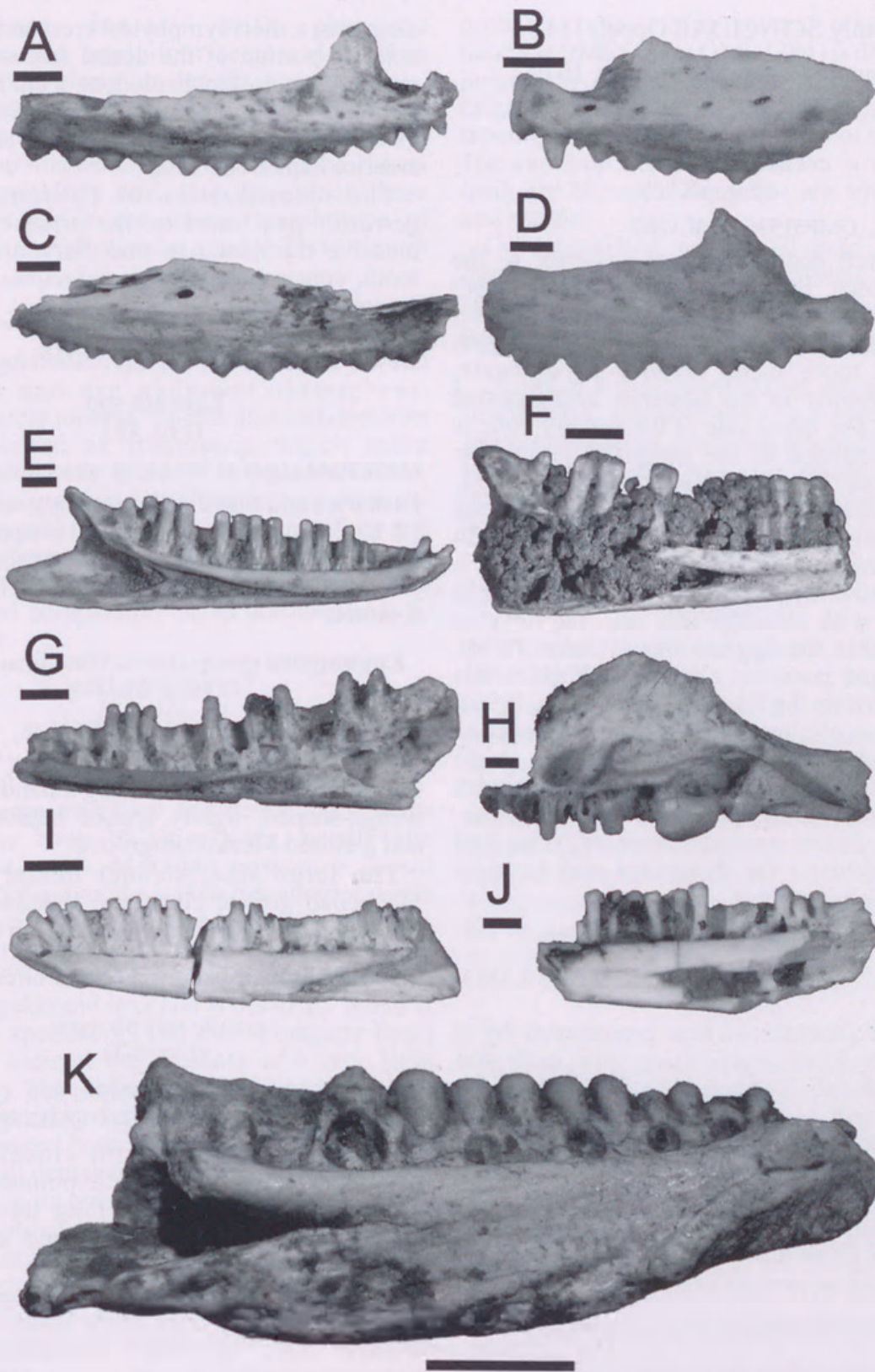


FIG. 8. A-D, Agamidae; A, *Tympanocryptis* sp. cf. *T. cephalus*; QMF41963, right maxilla. B, *Diporiphora* group 2; QMF51507, left maxilla. C, *Pogona* sp.; QMF41969, left maxilla. D, *Amphibolurus* sp.; QMF43893, right maxilla. E-K, Scincidae; E, *Sphenomorphus* group (robust morph); QMF51543, left dentary. F, *Egernia* sp.; QMF51529, left dentary. G, *Sphenomorphus* group (gracile morph); QMF51537, right dentary. H, *Cyclodomorphus gerrardii*; QMF51519, right maxilla. I-J, *Eugongylus* group; QMF51535 & QMF51536, right dentaries. K, *Tiliqua* sp.; QMF51516, left dentary. Scale bar = 5mm.

Family SCINCIDAE Oppel, 1811

Egernia Group *sensu* Greer, 1979

Tiliqua Gray, 1825

Tiliqua sp. nov.
(Fig. 8K)

MATERIAL. QMF51516; QML1284.

A robust left dentary, broken posterior to the splenial notch. Eleven conical, haplodont teeth are preserved with four addition tooth loci. Symphyseal crest extends to below the eighth haplodont tooth locus. Symphysis elongate, tapering sharply to the posterior and rounded anteriorly. The labial side of the dentary bone is distinctly inflated to the posterior, giving the dentary a very robust appearance in lateral view. Teeth gradually increase in width toward the posterior, all retaining their conical grooved tooth crowns. Dental shelf deep along its length.

The closed Meckelian groove places this specimen with the *Egernia* and *Eugongylus* groups within the Lygosominae (Greer, 1979). The enlarged posterior conical teeth place this specimen within the *Tiliqua* lineage (Shea, 1990). The presence of a long symphyseal crest, bunched haplodont dentition and the absence of a single massive posterior durophagous tooth excludes this specimen from being *Cyclodomorphus*. *Tiliqua* sp. differs markedly from all living and fossil *Tiliqua* so far described and is most probably a new species.

Tiliqua scincoides (White, 1790)

MATERIAL. QMF51517; QMF51518; QML1313, QML1314.

Tiliqua scincoides is best represented by a single right dentary possessing nine teeth and twelve tooth loci. The largest tooth is toward the posterior and is characterised by having a rounded durophagous tooth crown. The elongate symphyseal crest places this specimen within *Tiliqua*, its size and tooth morphology place it firmly within *Tiliqua scincoides* by being much smaller and more gracile than both *T. gigas* and the large *Tiliqua* species from Mini Cave.

Cyclodomorphus (Fitzinger, 1843)

Cyclodomorphus gerrardii (Gray, 1845)
(Fig. 8H)

MATERIAL. QMF51519-QMF51527; Olsen's Cave, QML1284, QML1284a, QML1311(H), QML1311(C/D), QML1384 U, QML1313, QML1385, QML1420.

Several isolated maxillae and dentaries possess a massively rounded posterior tooth in both jaw

elements, a short symphyseal crest and a concave anterior portion of the dental sulcus. Maxillae preserve up to ten haplodont teeth in varying degrees of replacement. Dentaries usually exhibit some form of abrasion on the smaller anterior haplodont teeth.

The identification of *Cyclodomorphus gerrardii* was based on the presence a single massive durophagous maxillary and dentary tooth, concave anterior dental sulcus and short symphyseal crest.

Egernia Gray, 1838

Egernia spp.
(Fig. 8F)

MATERIAL. QMF51529-51534; all localities.

Dentaries and maxillae large, possessing at least 12 haplodont teeth with chisel-shaped crowns. Meckelian groove closed. Posterior portion of the jaw robust and deep. Large inferior mental foramen.

Eugongylus group (*sensu* Hutchinson, 1992)
(Fig. 8I-J)

MATERIAL. QMF51535-QMF51536; QML1284, QML1284a.

Large-sized scincid possessing a slender dentary, wedge-shaped, tightly spaced haplodont teeth and a closed Meckelian groove.

The large size, slender dentary, closed Meckelian groove ally these specimens to the *Eugongylus* Group *sensu* Hutchinson (1992).

Sphenomorphus Group (*sensu* Greer, 1979)

gracile morphotype
(Fig. 8G)

MATERIAL. QMF51537-QMF51541; QML1284a; QML1284, QML1312, QML1313, QML1385.

Small-sized dentary with closely-spaced haplodont teeth. Teeth with pointed crowns. Meckelian groove open along its length to symphysis. Dentary shallow and symphysis small.

The small gracile form of the dentary and the open Meckelian groove place these specimens within the gracile morphotype of *Sphenomorphus* Group *sensu* Hutchinson (1992).

robust morphotype
(Fig. 8E)

MATERIAL. QMF51543, QMF51544; QML1312, Olsen's Cave.

Large-sized dentary with elongate blunt-crowned haplodont teeth. Meckelian groove open along its length to symphysis. Dentary deep at posterior, tapering markedly to ovoid symphysis.

The open Meckelian groove, large size, robust tooth morphology and deep jaw place these specimens within the robust morphotype of *Sphenomorphus* Group sensu Hutchinson (1992).

Family GEKKONIDAE Oppel, 1811

Fossil gekkonids have been found in several deposits and are abundant throughout. Unfortunately most of the maxillae and dentaries are preserved as fragments, which make identification very difficult. In addition to this, there is no premise for identification of fossil Australian gekkonid taxa based on maxillary and dentary characteristics, therefore, gekkonid specimens described here were only compared to the limited comparative collection available to the author.

gekkonid (large) (Fig. 9A-C)

MATERIAL. QMF51508, QMF51509, QMF51510; QML1284, QML1284a, QML1313.

Several large maxillary and dentary fragments preserving rows of closely-set, needle-like homodont teeth. Maxillae possess a dorsal process of the maxilla, which lies anterior to the orbit and contacts the nasal bones. The process borders the posterior margin of the narial opening. The morphology of this margin varies between gekkonid taxa and is distinctly broad in the fossil specimens. The most complete fossil dentaries indicate the presence of a very large gekkonid. The dentaries are characterised by being long and curved mesially, possessing many closely-spaced homodont teeth, a splenial notch and a small dental symphysis.

Based on its overall very large size, the fossil taxon must have reached a snout-to-vent length of 16 cm or more, making it similar in size to the largest extant Australian gekkonids (*Phyllurus*, *Cryptodactylus*). The maxillae and dentaries of all three genera show similarities with the fossil taxon.

gekkonid (small) (Fig. 9B)

MATERIAL. QMF51511-51515; All localities.

Several small fragmentary dentaries and maxillae are preserved throughout the deposits,

probably representing several taxa. A small maxilla (QMF51511; QML1284) is distinctive in possessing a relatively narrow dorsal process originating posterior of the narial opening and tapering markedly to the posterior of the maxilla. The dentition is simple, however several of the teeth are bicuspid. Dentaries are small, curved and slender.

On comparison with small-sized gekkonids, most of the gekkonid specimens cannot be adequately identified.

Family VARANIDAE Hardwicke & Gray, 1827

Varanids are a conspicuous member of the lizard fauna. Varanids have been identified from isolated, recurved small and large-sized serrated teeth, an isolated parietal, quadrate, femur, dentary fragments and several isolated cervical, dorsal and caudal vertebrae.

Varanus Merrem, 1820

Varanus sp. 1

MATERIAL. QMF51546, QMF51547; QML1312, QML1311(H).

A medium-sized species of *Varanus* is represented by a parietal, two dentary fragments, an isolated dorsal and several caudal vertebrae. The fossils compare favourably with a similarly sized *Varanus varius*, particularly in the broad flat parietal with narrow, slender temporal ridges; small-sized teeth and a dorsal vertebrae that falls within measurements provided by Smith (1976) for *Varanus*. The dorsal vertebrae compare in size to either *V. varius* or *V. gouldi*.

Varanus sp. 2 (Fig. 9D-E, G-H)

MATERIAL. QMF51548-QMF51550, QMF52066; QML1312, QML1311(H), QML1311(C/D), QML1313.

A very large varanid is represented by an isolated right quadrate, a cervical and several dorsal and caudal vertebrae. On prezygopophysis to postzygopophysis length alone, these specimens fall within the range of dorsal vertebral measurements provided by Smith (1976) for *V. giganteus* and below the range provided for a small species of *Megalania* from Chinchilla provided by Hutchinson & Mackness (2002). The dorsal vertebrae are most similar in length to *V. giganteus*, however, differ remarkably in the ratio defined by Smith (1976) as prezygopophysis- prezygopophysis (Pr-Pr) width over prezygopophysis- postzygopophysis (Pr-Po) length. In particular, when comparing this ratio to modern and fossil varanids the dorsal

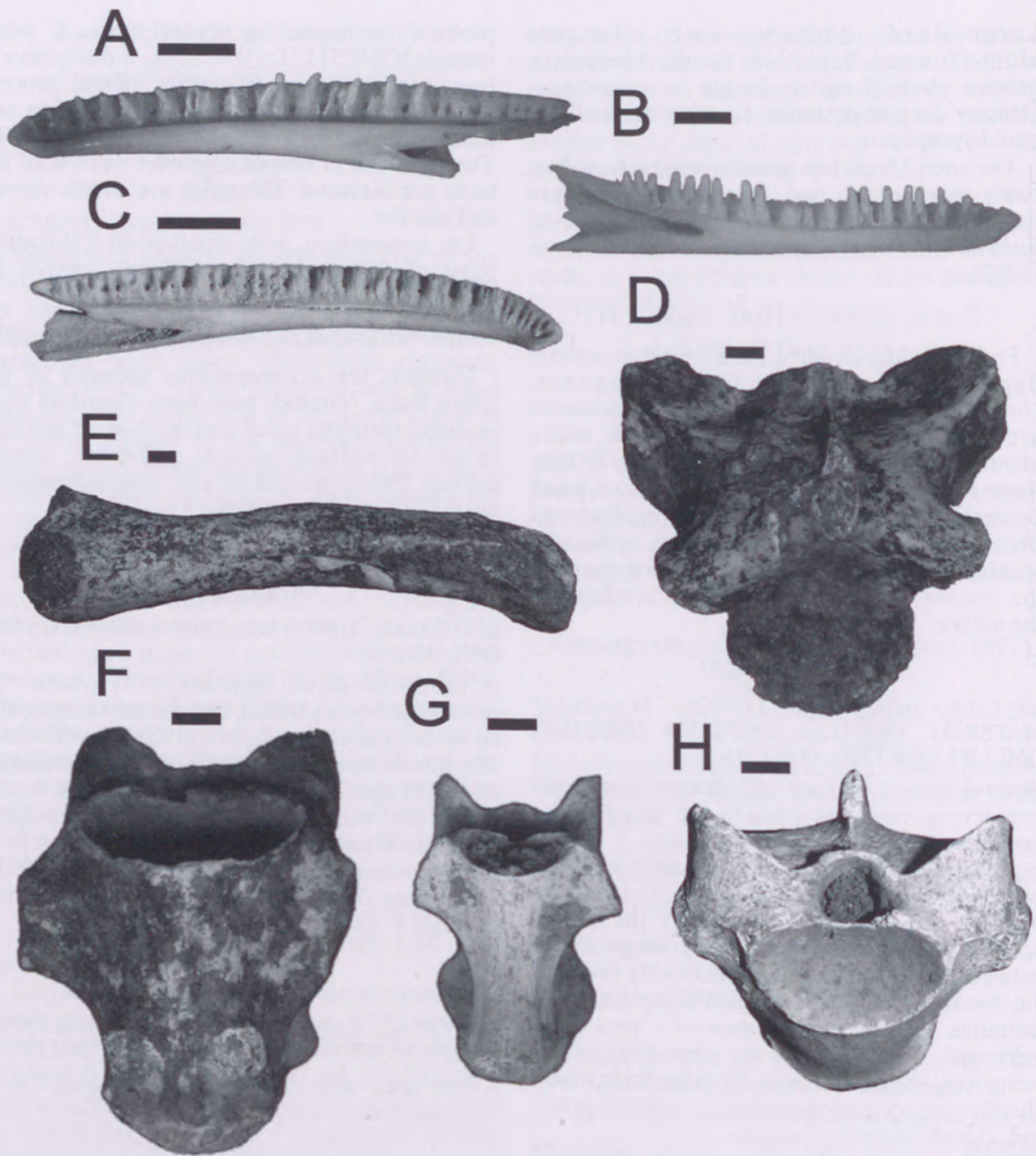


FIG 9. A-C, Gekkonidae; A&C, gekkonid (large morph); QMF51508, right dentary, QMF51510, left dentary. B, gekkonid (small morph); QMF51511, left dentary. Scale bar = 1mm. D-H, Varanidae; D-E, *Varanus* sp. 2; D, QMF51548, dorsal vertebra. E, QMF51549, femur. F, *Megalanina prisca*; QMF1418, caudal vertebra. G-H, *Varanus* sp. 2; G, QMF51550, cervical vertebra. H, QMF52066, dorsal vertebra. Scale bar = 5mm.

vertebrae measured here attain a ratio of between 1.07 and 1.22. This indicates that the Pr-Pr width of the vertebrae are generally wider than the Pr-Po length. Interestingly, the measurements provided by Smith (1976) show that dorsal vertebrae of extant *Varanus* are mostly longer

than broad with some being nearly equally as long as broad. Very few measured slightly broader than long.

Specimens referable to *Megalanina* from both Chinchilla, Bluff Downs (Mackness &

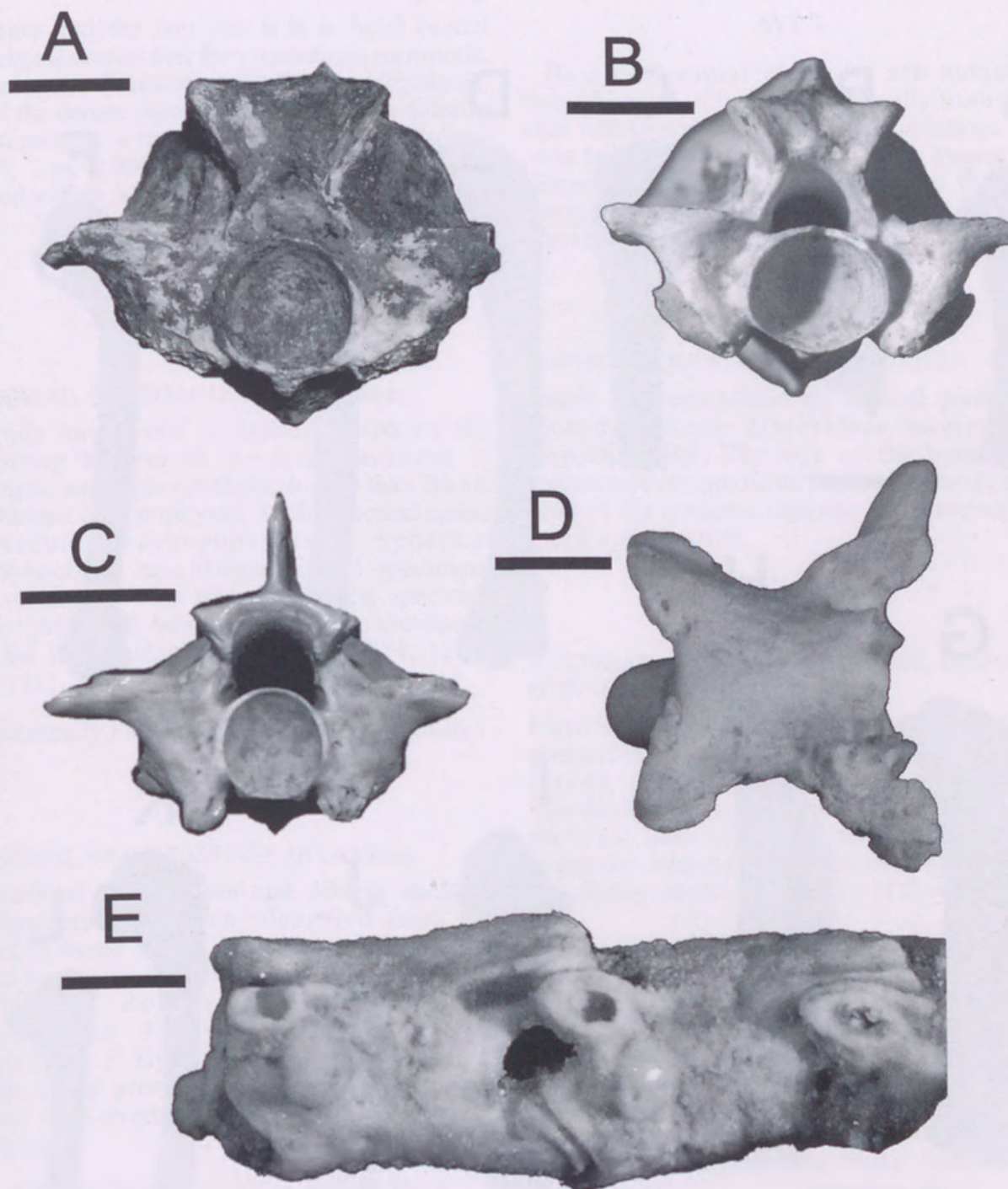


FIG 10. A-B, Pythoninae; A, QMF51560, dorsal vertebra. B, QMF51561, dorsal vertebra. C, Elapidae; QMF51551, dorsal vertebra. Scale bar = 5mm. D-E, Typhlopidae; D, QMF51578, dorsal vertebra. E, QMF51579, three articulated dorsal vertebrae. Scale bar = 1mm.

Hutchinson, 2000; Hutchinson & Mackness, 2002) and the Darling Downs (Hecht 1975; pers. obs.) possess dramatically broader than long dorsal vertebrae. This feature is easily seen in the largest *Megalania prisca* dorsal vertebrae. Further comparisons of *Varanus* spp larger than *V. giganteus*, such as *V. komodoensis*, will be needed to verify the validity of these differences.

Megalania (Owen, 1860)

Megalania prisca (Owen, 1860) (Fig. 9F)

MATERIAL. QMF1418; QML1420.

Megalania prisca is represented by a single varanid distal caudal vertebra, cotyle-condyle length: 28.80mm. The massive size of the



FIG 11. A-C, Galliformes; QMF51607-51609 (left to right), humeri. D-H, Gruiformes; D-F, QMF51610-51612 (left to right), humeri. G-H, QMF33458 & QMF33460 (left to right), carpometacarpi. I-L, Passeriformes; QMF51601-51604 (left to right), humeri. Scale bar = 5mm.

vertebra and the fact that it is a distal caudal vertebra indicates that the varanid was enormous, attaining the dimensions only seen in *Megalania*. Until the debate surrounding the generic validity of *Megalania* is resolved (Hecht, 1975; Molnar, 1990; Lee, 1996), this giant varanid will be placed within *Megalania*.

Family ELAPIDAE Boie, 1827

elapid indet.

Fig. 10C

MATERIAL. QMF51551-51559; All Localities.

Elapids have been identified based on the following features of the trunk vertebrae: 1. Elongate and high vertebrae, longer than broad. 2. Distinct hypopophyses. 3. High neural spine. 4. Accute prezygopophyses. 5. Spherical condyle-cotyle articulation. Elapid specimens are variable in size with the largest specimen from QML1312, being at least twice the size of the the largest elapids from QML1284, 1284a and 1311.

Subfamily PYTHONINAE Fitzinger, 1826

pythonine indet.
(Fig. 10A-B)

MATERIAL. QMF51560-51569; All Localities.

In addition to maxillary and dentary remains, pythonines have been identified from the deposits based on the following features of the trunk vertebrae: 1. Short, stout vertebrae, as wide as long. 2. Robust zygantrum. 3. Thick zygosphen. 4. Ovoid condylar-cotylar articulation. 5. Hypopophysis tiny or absent. 6. Large ovoid prezygopophyses. 7. High neural spines with overhanging anterior and posterior margins.

Family TYPHOLOPIDAE Gray, 1825

typholopid indet.
(Fig. 10D-E)

MATERIAL. QMF51578-51582, QMF51583-51587; QML1284, QML1284a.

Typholopids have been identified on the basis of the following features of the trunk vertebrae: 1. Neural spine absent. 2. Neural arch low and thin. 3. Zygantrum narrow and deep. 4. Accute prezygopophyses. 5. Hypopophysis absent. 6. Hemal keel abent or only slight. 7. Neural canal very large relative to vertebral size.

AVES

Bird postcranial elements are numerous throughout all of the sites, especially from those sites interpreted as predator accumulations with owls as the major accumulator. The largest bird elements are currently attributed to the owls (Strigiformes), the smallest from the song birds (Passeriformes).

Galliformes
(Fig. 11A-C)

MATERIAL. QMF51607-51609; QML1312.

Quails are represented by several postcrania, including very distinctive humeri and carpometacarpi. The size of the humeri and presence of two proximal pneumatic fossae in the head of the humerus suggests the presence of a species of *Coturnix*.

Gruiformes
(Fig. 11D-H)

MATERIAL. QMF33458, QMF33460, QMF51610-QMF51612; QML1312.

Buttonquails are represented by several postcrania, including humeri, carpometacarpi, femora, tarsometatarsi and sternal fragments. The distinctive larger pneumatic fossa in at the proximal head of the humerus and the large triangular intermetacarpal tuberosity ally these specimens closest to a species of *Turnix*.

Passeriformes
(Fig. 11I-L)

MATERIAL. QMF51601, QMF51602-51606; QML1284 QML1312.

Passeriformes were identified from humeri possessing a distinct entepicondylar prominence, ectepicondyle distinct and distal to internal condyle, and a shallow pneumatic fossae.

Strigiformes
(Fig. 12 A-K)

MATERIAL. QMF51578-51587; All localities except QML1420.

Owls were identified from numerous postcranial specimens including humeri, ulnae, carpometacarpi, phalanges, claws, femora and tarsometatarsi. Owls possess a distinct first phalange of the pes digits, with four tuberosities in each corner of the phalange. The phalange tends to be short and squat with a deep facet on the dorsal and distal margin.

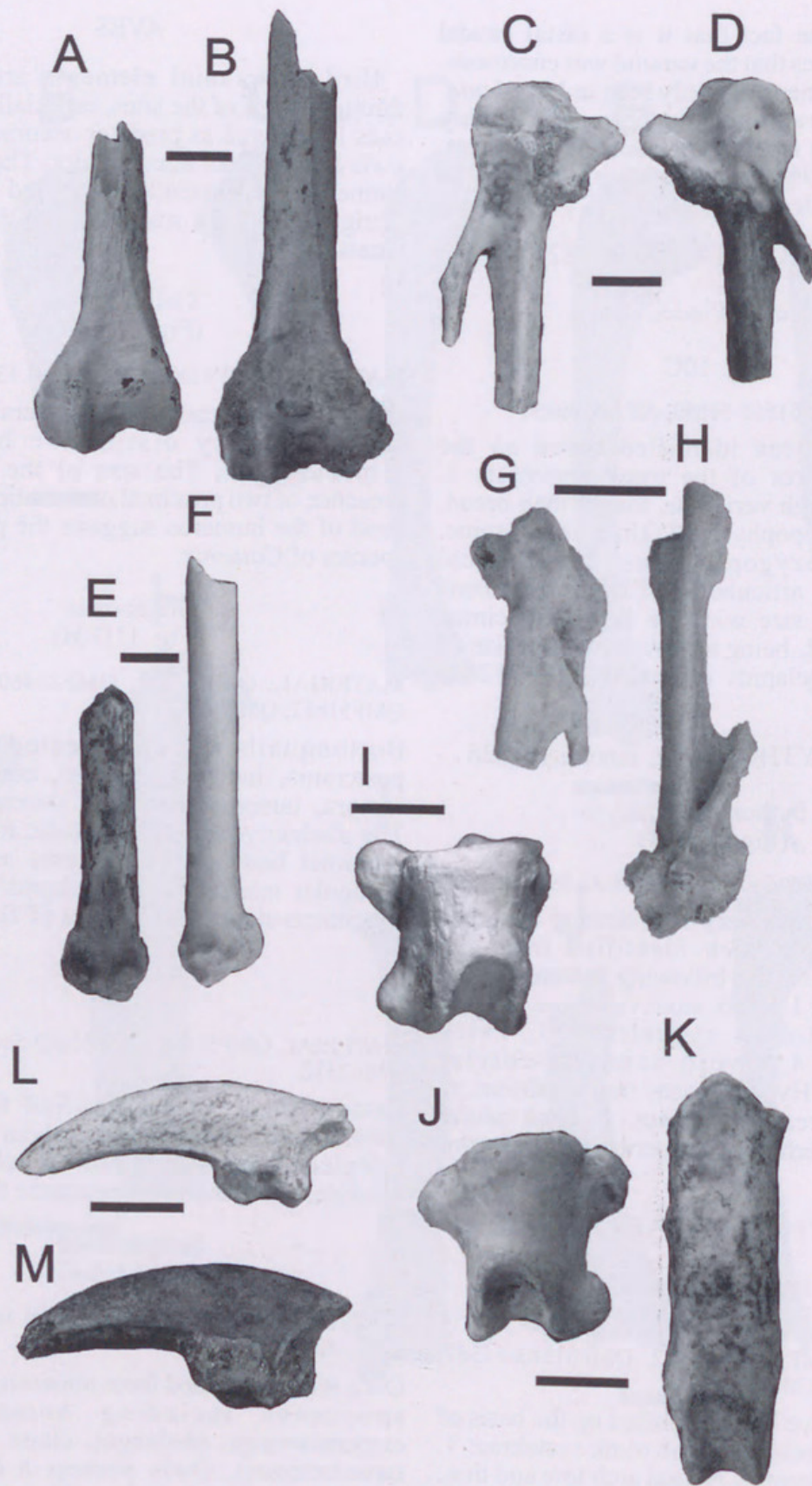


FIG. 12. A-K, Strigiformes; A-B, QMF51578 & 51579, femora. C-D, QMF51580 & 51581, carpometacarpi. E-F, QMF51582 & 51583, ulnae. G-H, QMF51584 & 51585, carpometacarpi. I-K, QMF51586, 51581, 33361, phalanges. L-M, QMF33863 & 33864, claws. Scale bar = 5mm.

MAMMALIA

Family PERAMELIDAE Gray, 1825b

Perameles Geoffroy, 1803*Perameles* sp. 1
(Fig. 13A)

MATERIAL. QMF51613-QMF51620; QML1284, QML1284a, QML1311(H), QML1313, QML1384U, QML1385, QML1420, QML1311(C/D).

A species of *Perameles* on the basis of the following combination of features; 1. Presence of fully developed anterior and posterior cingulae on M^{1-3} . 2. Triangular tooth crown with the para and metastylar corners outside the margin of the tooth crown. 3. Equidistant protoconid-metaconid, protoconid-paraconid distances on M_{1-4} . 4. Absence of the anterior cingulid on M_1 .

When compared to the modern species of *Perameles* the fossils differ as follows:

Perameles sp. 1 is larger than *P. bougainville* and has a more buccally developed posterior cingulum on M^{1-3} . The posthypocristid runs to the hypoconulid on M_{1-3} whereas the posthypocristid only runs to the hypoconulid in M_{1-2} of *P. bougainville*.

Perameles sp. 1 is smaller than *P. nasuta*. The meta- and parastylar corners in unworn molars of the fossil taxon are bicuspid whereas *P. nasuta* possess single conical meta- and parastyle.

Perameles sp. 1. is smaller than *P. gunnii* and possesses a more buccally developed posterior cingulum on M^{1-4} . The posthypocristid runs to the hypoconulid on all lower molars in the fossil *Perameles*, whereas it only runs to the hypoconulid in M_{2-3} of *P. gunnii*.

Perameles sp. 1. differs from *P. bowensis* by being larger, possessing larger hypoconulids, and a posthypocristid that runs to the hypoconulid on M_3 . *Perameles* sp. 1. differs from *P. allinghamensis*, which is only known by an isolated upper molar, by being much smaller and possessing a posterior cingulum that terminates below and buccal to the metacone. *Perameles* sp. 1. differs from *P. sobbei*, which is only known from lower dentition, by possessing larger hypoconulids on M_{1-3} , a posthypocristid that runs to the hypoconulid on M_{1-3} , and by being smaller.

Perameles sp. 2
(Fig. 13B)

MATERIAL: QMF51621-QMF51626; QML1284, QML1284a, QML1311(H), QML1313, QML1384U, QML1385.

A second medium-sized species of *Perameles* possesses the following features: 1. Anterior cingulid of M_1 absent. 2. Hypoconulid reduced on M_{1-3} . 3. Posthypocristid contacts the base of the entoconid M_{1-3} . 4. Trigonid cusps approximated. 5. Entoconid conical with a small preentocristid crest. *Perameles* sp. 2 differs from *Perameles* sp. 1 by being larger, possessing a posthypocristid that contacts the entoconid and a preentocristid crest. *Perameles* sp. 2 differs from *P. nasuta*, *P. bougainville*, *P. eremiana*, *P. bowensis* by possessing an M_1 with a posthypocristid that contacts the entoconid instead of the hypoconulid. *Perameles* sp. 2 differs from *P. gunnii* by being markedly smaller, possessing a more mesially terminating cristid obliqua and not possessing a simple conical entoconid. *Perameles* sp. 2 differs from *P. sobbei* by its smaller size, larger hypoconulid on M_1 , narrower protoconid-metaconid distance and smaller paraconid.

Perameles bougainville Quoy & Gaimard,
1824
(Fig. 12C-E)

MATERIAL. QMF51627-51630, QMF51631; QML1312; Olsen's Cave.

A small species of *Perameles* is present in the fauna recovered from QML1312 and a single specimen in Olsen's Cave. The fossils are identified as *Perameles* on the basis of the following combined features: 1. Para- and metastylar corners angular, occurring outside the peripheral margin of the tooth crown base. 2. The presence of a variably complete posterior cingulum. 3. Anterior cingulum on M_{2-4} that originates well below the apex of the paraconid. 4. Gently curved ascending ramus. 5. Reduced metaconule.

When compared to the three available species of modern *Perameles* (*P. nasuta*, *P. gunnii* and *P. bougainville*) this fossil species was closest to *P. bougainville* in size. The fossils referred to here as *P. bougainville* differ from both *P. nasuta* and *P. gunnii* by; being considerably smaller; possessing small, isolated parastyles on M^1 instead of large, curved parastyles that are connected to the main tooth crown by a distinct preparacrista; possessing distinct protocones and metaconules on M^{1-3} ; acute angle made by the postprotocrista and premetaconule crista; possessing a lower angle of the postmetacrista to the longitudinal axis of the tooth crown; more lingually oriented stylar cusp B & D. They differ from *P. allinghamensis* by being much smaller

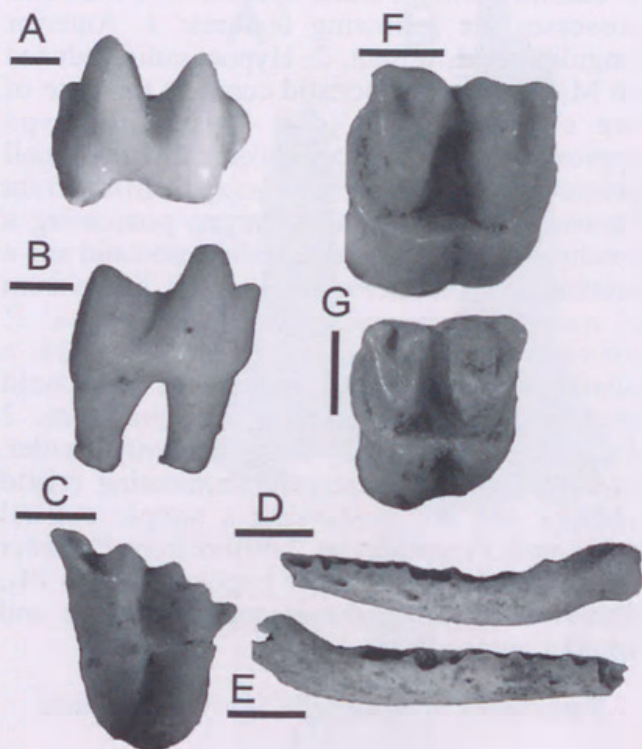


FIG. 13. A-G, Peramelidae; A, *Perameles* sp. 1; QMF51613, LM₁. B, *Perameles* sp. 2; QMF51621, RM₁. C-E, *Perameles bougainville*; QMF51627, RM₁. Scale bar = 1mm. D, QMF51628, left mandible. E, QMF51529, right mandible. Scale bar = 5mm. F, *Isoodon obesulus*; QMF51632, RM₂. G, *Isoodon* sp.; QMF51635, RM₂. Scale bar = 1mm.

and possessing a more triangular outline in occlusal view. They differ from *P. bowensis* by being larger and better developed posterior cingulum on M³.

The fossils compare favourably with *P. bougainville* on the basis of: 1. Small size, though they are slightly larger than the samples measured by Freedman & Joffe (1966). 2. Form of the parastyle on M¹, being small, isolated and not connected to the preprotocrista. 3. Higher angle of the postmetacrista to the longitudinal axis of the tooth crown. 4. Lingually oriented styler cusps B & D. 5. Incomplete posterior cingulum on M¹⁻² with a short posterior cingulum on M³.

The identification presented here is made with some caution due to the absence of *P. eremiana* from comparative collections available. However, Muirhead (1994) provides characteristics to split these two species. These features included the development of the

posterior cingulum (complete on M¹ in *P. eremiana* and incomplete on M¹ of *P. bougainville*) and the hypoconulid. Features characteristic of *P. bougainville* are shared with the fossil over *P. eremiana*. It is unlikely that the fossil taxon represents an extinct species based on the closeness in morphology to *P. bougainville*. Instead, it may represent a larger-sized eastern population of the arid-adapted *P. bougainville*. This record represents the most easterly and northerly record of the small-sized, arid-adapted members of *Perameles*.

Isoodon Desmarest, 1817

Isoodon obesulus (Shaw, 1797) (Fig. 13F)

MATERIAL. QMF51632-QMF51634; QML1312, QML1384U, QML1420.

Isoodon fossils are abundant in the QML1384U and QML1312 deposits. These specimens are referred to *Isoodon* based on the following combined features: 1. Well developed anterior and posterior cingulae on M¹⁻³; 2. Styler corners well within the tooth crown margins on M²⁻³; 3. Styler cusps B & D oriented lingually; 4. Deep, dumb-bell shaped lingual root on upper molars; 5. Cuspid at the anterobuccal base of the hypoconid, 6. Anterior cingulae on M²⁻⁴ terminates just ventral to the paraconid.

Morphologically, the fossils differ from *I. macrourus* and *I. auratus* in possessing distinct metaconules and protocones on M¹⁻³, where the postprotocrista and premetaconule crista form an acute angle between the two cusps. They also agree in size with modern *I. obesulus*.

Isoodon sp. (Fig. 13G)

MATERIAL. QMF51635-QMF51636; QML1384U, QML1312.

Specimens of a species of *Isoodon* represent a second species. The specimens are smaller than all three extant *Isoodon* species, being closer to *I. obesulus* than *I. macrourus* and *I. auratus*. In morphology the specimens differ from all species of *Isoodon* by possessing an incomplete anterior cingulum on M² and narrower metastyle-styler cusp D and parastyle-styler cusp B distances. The fossil specimens are all smaller than those teeth assigned to *I. obesulus* from the same deposit.

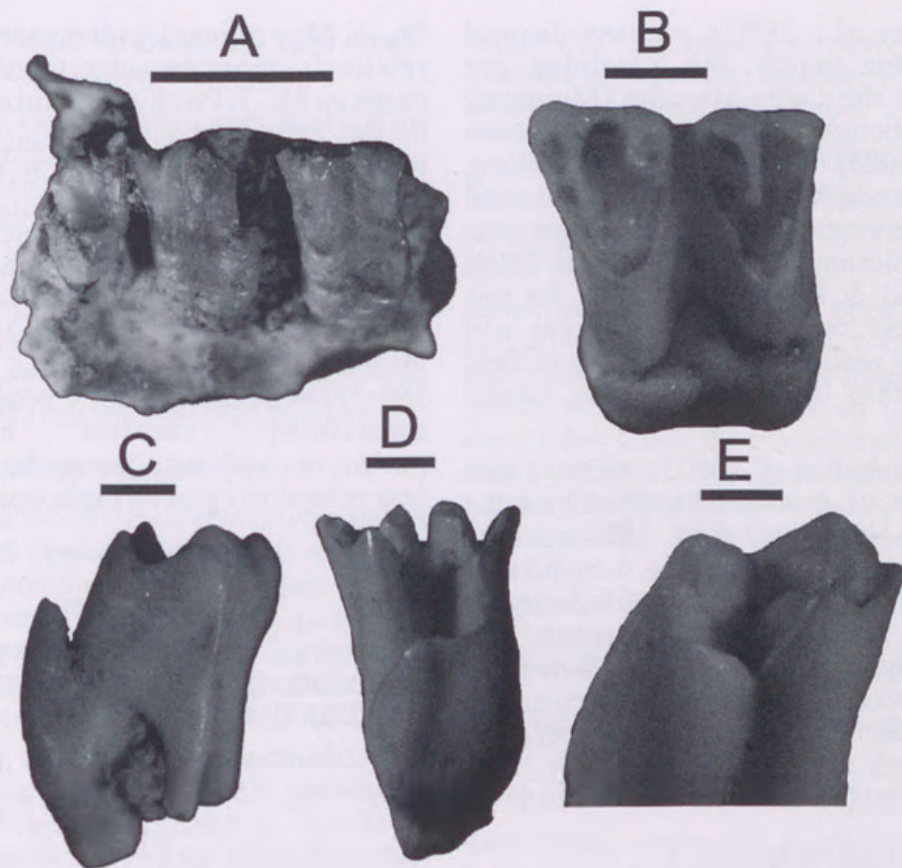


FIG 14. A-D, Peramelidae; A-D, *Chaeropus ecaudatus*; A, QMF51637, RM³⁻⁴. Scale bar = 5mm. B-C, QMF515638, RM², occlusal & anterior views. D, QMF51639, RM³. E, Thylacomyidae; *Macrotis lagotis*; QMF51642, RM¹. Scale bar = 1mm.

Chaeropus Ogilby, 1838

Chaeropus ecaudatus (Ogilby, 1838) (Fig. 14A-D)

MATERIAL. QMF51637-51641; QML1312.

Chaeropus ecaudatus is only known from QML1312 and is the third most abundant bandicoot in that deposit. *C. ecaudatus* has been identified from upper molars using the following combination of characteristics defined by Muirhead and Godthelp (1995): 1. Near parallel preparacristae and postmetacristae to each other and almost perpendicular to the long axis of the tooth crown. 2. Absence of both an anterior and posterior cingulae. 3. Very tall and slender molar crowns. 4. Preprotocristae and postprotocristae terminate at the base of the paracone and metacone respectively. 5. Preparacristae straight with no anterior curvature.

Family THYLACOMYIDAE (Bensley, 1903)

Macrotis Reid, 1837

Macrotis lagotis (Reid, 1837) (Fig. 14E)

MATERIAL. QMF51642-51643; QML1312.

The Greater Bilby is an enigmatic species of bandicoot with a highly specialised and distinctive tooth morphology. Two molars have been recovered from QML1312. Identification of the teeth as *M. lagotis* was based on the following combination of features. 1. Absence of the paraconid, 2. Absence of the metaconule, 3. Rectangular-ovoid molar crowns, 4. Dumbbell-shaped molar roots and 5. Large cuspid on the anterobuccal side of the lower molars (considerably larger than that found in *Isoodon*).

Family INCERTAE SEDIS

Two new bandicoots are present in the fauna with uncertain family-level taxonomic position. Several indications of new bandicoot groups within the Late Tertiary have been made in the literature (Muirhead, 1994, 1999; Dawson et al.,

1999; Long et al., 2002) without formal description. One family, the Yaralidae, are described from the Oligo-Miocene (Muirhead, 2000) and are thought to occur into the Pliocene (Long et al., 2003). Based on dentition alone, family-level taxonomy becomes complicated with several perviously diffinitive features now thought to be plesiomorphies (Muirhead, 1994; 2000; Muirhead & Filan, 1995). It is for this reason that these two distinct bandicoots will remain *incertae sedis* with the possibility of their placement within the plesiomorphic family Yaralidae.

Recently, Turnbull et al., (2003) erected a new bandicoot taxon, cf. *Peroryctes tedfordi* from the Early Pliocene Hamilton Fauna. Although they place the taxon in the Peroryctidae, they did note its plesiomorphic features and similarity to *Yarala*. The taxa identified below are morphologically very similar to cf. *Peroryctes tedfordi*, however, I reserve the placement of these taxa into any perameloid family until a full revision of both the Hamilton and Mt. Etna material is available.

Gen. et sp. nov. 1
(Fig. 15A)

MATERIAL. QMF51644; QML1311 (H).

A large species of perameloid, similar in size to *Echymipera rufescens*, possessing the following features: 1. A distinct anterior cingulum on M_1 . 2. Trigonid extremely compressed with protoconid and metaconid cusps high and approximated. 3. Paraconid small. 4. Bladed entoconid. 5. Hypoconulid heavily reduced on M_{1-2} , less so on

M_3 . 6. M_{2-3} trigonid with protoconid-metaconid relatively more broader than corresponding cusps on M_1 . 7. Posthypocristid contacts the base of the entoconid on M_{1-3} . 8. Cristid obliqua terminates on the posterior trigonid flank, buccally of the tooth midline.

This taxon shares a complete and distinctive anterior cingulum with only one other published bandicoot, *Yarala burchfieldi* from the Oligo-Miocene of Riversleigh, Far North Queensland (Muirhead & Filan 1995). It differs from *Yarala burchfieldi* by possessing a bladed entoconid, smaller hypoconulids, posthypocristid that contacts the entoconid and a less posteriorly placed metaconid.

Gen et sp. nov. 2

(Fig. 15B)

MATERIAL. QMF51645-QMF51650; QML1284, QML1284a, QML1311(H), QML1384U, QML1313, QML1385, QML1311 (C/D).

A medium-sized bandicoot possessing the following dental characteristic: 1. M_1 with anterior cingulid present as distinct antero-dorsally projecting cuspule. 2. A small buccal cuspule between metaconid and hypoconid. 3. Compressed trigonid with all three main cusps closely approximated. 4. Bladed entoconid on M_1 . 5. Posthypocristid runs to the base of the entoconid on M_{1-3} . 6. Hypoconulid reduction on M_1 , further reduction on M_2 and near absent on M_3 . 7. Cristid obliqua runs to the middle of the posteroventral flank of the trigonid. 8. Talonid broadens consecutively along molar row.

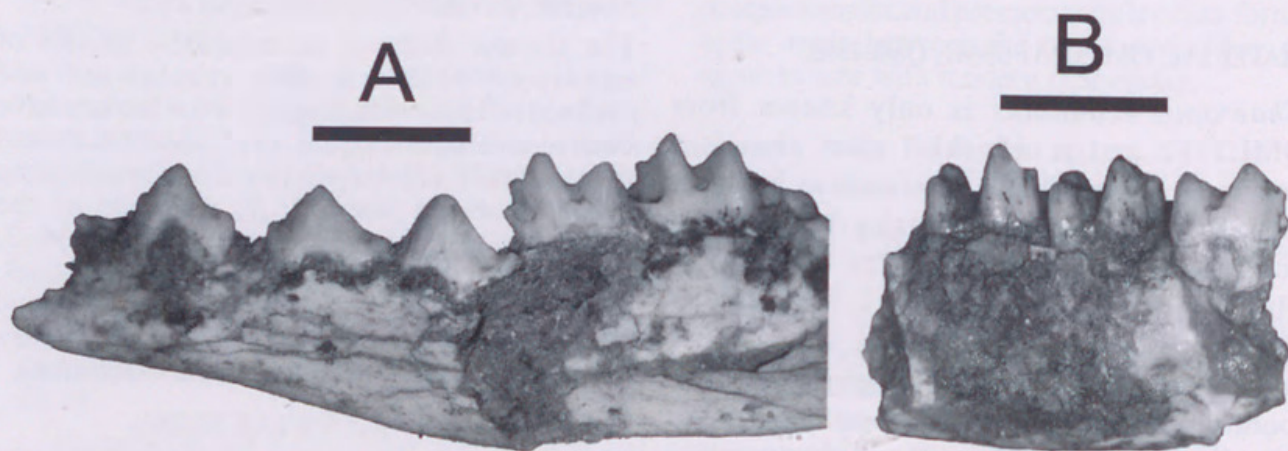


FIG 15. A-B, Family incertae sedis; A, Gen. et sp. nov. 1; QMF51644, LP_1-M_3 . B, Gen. et sp. nov. 2; QMF51645, RM_{1-3} . Scale bar = 5mm

Family DASYURIDAE Goldfuss, 1820 *sensu*
Waterhouse, 1838

Dasyurids are a conspicuous part of all of the faunas, being represented by isolated teeth, nearly complete mandibles and maxillae, or even partial skulls. Identification of dasyurids follows the character states defined by Wroe and Mackness (1998) for *Dasyurus*, Van Dyck (2002) for *Antechinus*, Archer (1981) for *Sminthopsis*, Dawson (1982a) for modern and fossil *Sarcophilus*, Archer (1976) for *Planigale* and Wroe et al. (2000) for other dasyurid genera.

***Antechinus* Macleay, 1841**

Antechinus is a morphologically diverse group as defined by Van Dyck (2002). Specimens were identified as *Antechinus* on the basis of the combined features: 1. Complete posterior cingulum on upper molars. 2. P_3 / P^3 reduced. 3. Meta- and hypocristids not transverse to the longitudinal axis of the jaw. 4. Entoconid variably present.

***Antechinus* sp. 1**
(Fig. 16A)

MATERIAL. QMF51651-51653, QMF51654-51657; QML1313, QML1284a.

Antechinus sp. 1 is allied very closely to *Antechinus adustus* based on maxillary morphology. The fossil maxillae possessed the greatest number of maxillary character-states provided by Van Dyck (2002) for *A. adustus*, which included characters; 18-19, 22, 25-28, 30, 33, 36-37. Mandibles and isolated lower molars conform in size to the maxillary specimens, however, they do not conform in the character-states that are present in *A. adustus*. Instead, the mandibles show a greater similarity to *A. godmani* or *A. minimus* (characters 40-46; 48-54). Due to the very small sample size, these morphological variations may either constitute a single morphologically distinct new taxon or two similarly-sized known species of modern *Antechinus*. The most convincing characteristics seem to be from the maxilla, thus *A. adustus* would be considered the most likely taxon present in the deposits.

***Antechinus* sp. 2**

MATERIAL. QMF51663-51680; QML1284a, QML1385, QML1311(C/D), QML1420, QML1311(H), QML1313, QML1284.

A second species of *Antechinus* is present and differs from *Antechinus* sp. 1 by being larger in overall dimensions and possessing a relatively

larger P_3 . This species of *Antechinus* does not possess any greater similarity to any of the modern species of *Antechinus*.

***Antechinus flavipes* (Waterhouse, 1838)**
(Fig. 16B)

MATERIAL. QMF51681-51685; QML1312, QML1384U.

Antechinus flavipes has been identified by numerous fragmentary and complete maxillae and mandibles. The most complete specimens, which are also the easiest to identify, are the mandibles. Using the characteristics provided by Van Dyck (1982, 2002) and Smith (1972), which included: 1. Tiny and crowded P_3 . 2. Transversely orientated P_3 . 3. Small entoconids. 4. Small paraconid. 5. Size (7.54-7.66mm M_{1-4} Length), I am able to differentiate this species from a second species present in the same deposit, *Antechinus swainsoni*.

***Antechinus swainsoni* (Waterhouse, 1840)**
(Fig. 16C)

MATERIAL. QMF51686-51688; QML1312.

Antechinus swainsoni is also represented by numerous maxillae and mandibles. Using features in Van Dyck (1982) that differentiate *A. flavipes* from *A. swainsoni*, this smaller species was able to be distinguished. The premolar row is not crowded as in *A. flavipes*, the mandible is gracile and M_{1-4} length reaches 7.30-7.34mm.

***Dasyurus* Geoffroy, 1796**

Dasyurus was identified by the absence of P^3 or P_3 (except *Dasyurus dunmalli*) and its moderately large-sized molars and total mandibular dimensions (larger than *Phascogale*, smaller than *Sarcophilus* and *Glaucodon*).

***Dasyurus hallucatus* Gould, 1842**

MATERIAL. QMF51689, QML1312.

A small-sized *Dasyurus*, differing from other modern and extinct *Dasyurus* by possessing a relatively shorter metacrista length on M^3 than M^2 , and a metacone on M^1 perpendicular to stylar cusp D.

***Dasyurus viverrinus* (Shaw, 1800)**
(Fig. 16K)

MATERIAL. QMF51690-51695; QML1312; QML1384U.

A medium-sized *Dasyurus*, differing from other modern and extinct *Dasyurus* by possessing a longer metacrista on M^3 than on M^2 ; metacone anterior to stylar cusp D; reduced paracones; not

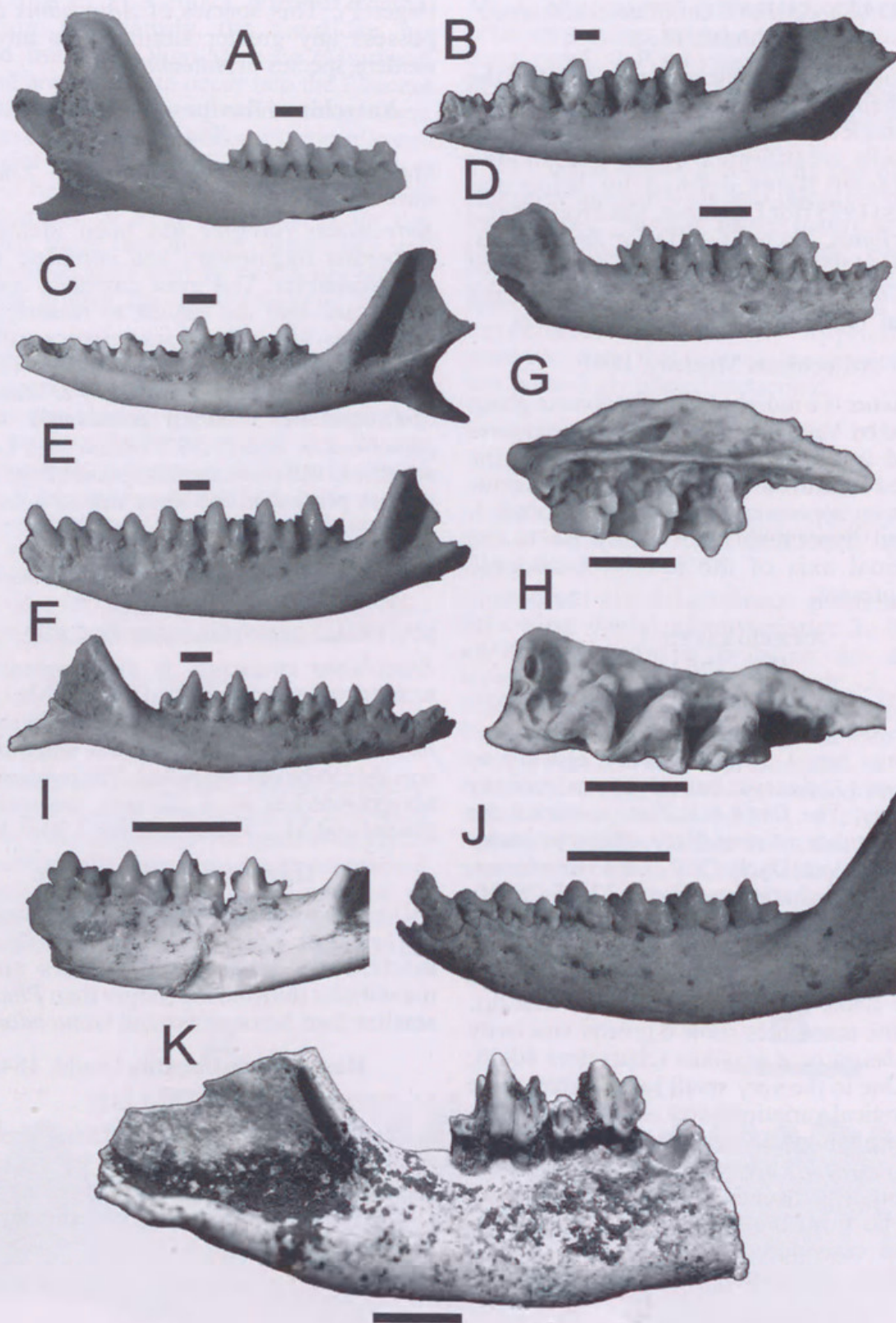


FIG 16. A-K, Dasyuridae; A-C, *Antechinus*; A, *Antechinus* sp. 1; QMF51651, RM₁₋₄. B, *Antechinus flavipes*; QMF51681, LP₃-M₄. C, *Antechinus swainsoni*; QMF51686, LM₂₋₄. D, *Planigale maculate*; QMF51707, RM₁₋₄. E-F, *Sminthopsis*; E, *Sminthopsis macroura*; QMF51715, LC₁-M₄. F, *Sminthopsis murina*, QMF51724, RP₂-M₄. G-H, Gen et sp. nov.; QMF51743, lingual and occlusal views. Scale bar = 1mm. I-J, *Phascogale*; I, *Phascogale* sp.; QMF51704, LM₁₋₄. J, *Phascogale topoatafa*; QMF51699, LC₁-M₄. K. *Dasyurus viverrinus*; QMF51690, RM₃₋₄. Scale bar = 5mm.

bulbous (as in *D. maculatus*); reduced metaconid. Differs specifically from *D. geoffroyi*, a species most similar to *D. viverrinus*, by having relatively longer metacristae. Fossil specimens show similarities to *D. maculatus*, including a small entoconid and a reduced posterior cingulid on M_{1-3} . These features are intriguing and with more specimens may constitute further review, however, at the present time there are significantly more morphological features shared with *D. viverrinus*.

***Dasyurus* sp.**

MATERIAL. QMF51696-51698; QML1313.

A medium-sized species of *Dasyurus* is represented by an isolated M_2 , M^{2+3} . There are not enough features available on the specimen to warrant specific placement at the present time.

***Phascogale* Temminck, 1824**

Species of *Phascogale* are distinguished from other similar dasyurids by the P_3 being higher than P_2 and by being considerably larger than the only other dasyurid exhibiting the former trait, *Sminthopsis*.

***Phascogale topoatafa* (Meyer, 1793) (Fig. 16J)**

MATERIAL. QMF51699-51703; QML1312.

Phascogale topoatafa is distinguished from *Phascogale calura* by being larger, possessing a small posterior cusp on P^3 and possessing a smaller protocone on M^{1-3} .

***Phascogale* sp. (Fig. 16I)**

MATERIAL. QMF51704-51706; QML1420, QML1313.

A small, possibly undescribed, species of *Phascogale* is tentatively identified here based on the great number of similarities (as defined by Van Dyck (2002)) shared with both *P. topoatafa* and *P. calura*. Its smaller size seems to differentiate it from the two extant species of *Phascogale*, however, further analysis of *P. calura* is needed to determine whether the fossil specimens are within the variation for this species.

***Planigale* Troughton, 1928**

***Planigale maculata* (Gould, 1851) (Fig. 16D)**

MATERIAL. QMF51707-QMF51711, QML1312; Olsens Cave.

A species of *Planigale* was identified based on its diminutive size, reduced single-rooted P_3 , absent entoconid, present posterior cingulum and reduced styler cusps, especially styler cusp D on M^{2-3} . *P. maculata* was distinguished by its size, being smaller than *P. novaeguineae*, larger than *P. ingrani* and *P. tenuostris*, and by possessing P_3 (versus *P. gilesi*, which does not).

***Sarcophilus* Cuvier, 1837**

Species of *Sarcophilus* were determined by using criteria described by Dawson (1982a) for *Sarcophilus lanarius* and *Sarcophilus harrisii*. No site has yet been found where both taxa can be said to occur sympatrically, however, a fragment of a mandible which is referred to here as

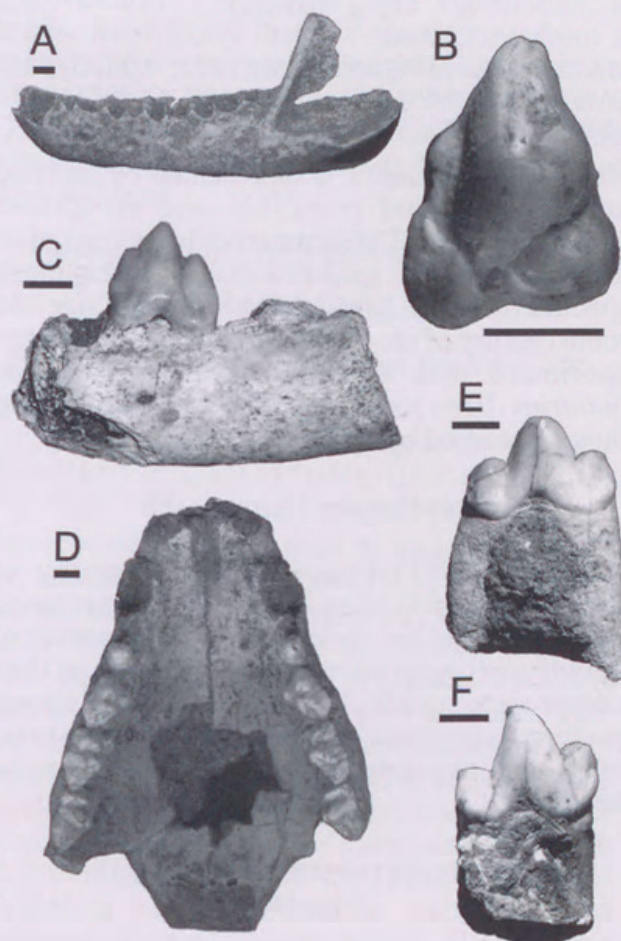


FIG 17. A-D, Dasyuridae; *Sarcophilus*; A, *Sarcophilus harrisii*; QMF51712, left mandible. B-D, *Sarcophilus lanarius*; B, QMF41997, LM^1 . C, QMF51713, LM^1 . D, QMF1872, partial skull. E-F, Thylacinidae; *Thylacinus cynocephalus*; E, QMF1737, RM_2 . F, QMF51755, RM^1 . Scale bar = 5mm.

Sarcophilus laniarius may have been derived from sediments from within Lower Johansen's Cave, a site containing the only representative of *Sarcophilus harrisii*.

***Sarcophilus harrisii* (Boitard, 1841)**
(Fig. 17A)

MATERIAL. QMF51712; QML1314.

Sarcophilus harrisii is represented by an edentulous left mandible (M_{1-4} alveoli length: 39.50mm). The specimen differs markedly from *Sarcophilus laniarius* known from the Darling Downs and specimens from Marmor Quarry by being much smaller in size and having a more gracile lateral profile.

***Sarcophilus laniarius* (Owen, 1838)**
(Fig. 17B-D)

MATERIAL. QMF693, QMF1872, QMF51713-QMF51714, QMF41997; QML1420, QML1311(H), QML1312, QML1384U, QML1384L.

Sarcophilus laniarius is represented by isolated molars, a partial mandible and an almost complete palate. The distinctive large triangular dasyurid molars unquestionably place these specimens within *Sarcophilus*. The large size and robust nature of the palate and molars allies these specimens with those of typical *Sarcophilus laniarius* from the eastern Darling Downs and those measured by Dawson (1982a).

***Sminthopsis* Thomas, 1887**

Archer (1981) reviewed the taxonomy of *Sminthopsis*, providing keys to the species using either external or skeletal features. Species of *Sminthopsis* were identified on the basis of their compressed upper and lower molars; absent posterior cingulum on upper molars; transverse meta- and hypocristids; and subequal premolar heights.

***Sminthopsis macroura* (Gould, 1845)**
(Fig. 16E)

MATERIAL. QMF51715-QMF51723; QML1312, QML1384, QML1314.

Sminthopsis macroura was identified by possessing the following features: large and distinct entoconid; hypocristid that does not contact the entoconid; C_1 not enlarged; premolars longer than broad; medium-sized species ($M_{1-4}L = 5.8\text{mm}$).

***Sminthopsis murina* (Waterhouse, 1838)**
(Fig. 16F)

MATERIAL. QMF51724-51739; QML1312, QML1313, QML1420, QML1284, QML1284a, QML1385, Olsen's Cave.

Difficulty was experienced in identifying a second species of *Sminthopsis*, distinguished by the absence of the entoconid. Very few features were available from Archer (1981) to distinguish species of this group based simply on mandibular or maxillary features. Three species were possible candidates; *S. butleri*, *S. leucopus* and *S. murina*. *S. butleri* was excluded because it apparently shows signs of tiny entoconids on M_{1-3} , the fossil specimens do not. *S. leucopus* was excluded because the fossil specimens show premolars that do slightly contact each other, a feature generally not seen in *S. leucopus*, however, this is a relatively variable trait. *S. murina* is preferred until further analysis is possible.

Gen. et sp. nov.
(Fig. 16G-H)

MATERIAL. QMF51743-51754; QML1311(H), QML1385, QML1284, QML1284a, QML1313, QML1384U.

A tiny dasyurid, similar in size to *Planigale* and *Ningaui*, possesses heavily reduced upper dentition, including a significantly reduced protocone on M^{1-3} ; an extremely reduced paracone on M^1 ; absent styler cusps D and B on all molars; and a distinct ectoloph indentation. There are only four roots found between the canine root and M^1 suggesting the loss of P^3 as in *Planigale gilesi*. The possession of these distinctly derived traits (*sensu* Wroe et al., 2000) suggests the possible need to erect a new genus of dasyurid to accommodate this highly distinctive taxon. More complete material will soon be available and a more formal description and analysis is underway.

Family THYLACINIDAE Bonaparte, 1838

***Thylacinus* Temminck, 1824**

***Thylacinus cynocephalus* (Harris, 1808)**
(Fig. 17E-F)

MATERIAL. QMF1737, QMF51755-QMF51757; QML1420, QML1313, QML1311(H), QML1311 (C/D), QML1312.

Several isolated molars and an almost complete skull and mandibles represent the marsupial carnivore, *Thylacinus cynocephalus*. They compare favourably with modern and fossil

TABLE 3. Faunal lists for large-sized mammal species

	QML1284	QML1284a	QML1311H	QML1311CD	QML1312	QML1313	QML1384U	QML1384L	QML1420
<i>Thylacinus cynocephalus</i>			x	x	x	x			x
<i>Vombatus ursinus mitchellii</i>				x					x
?zygomaturine									x
<i>Palorchestes</i> sp. cf. <i>P. parvus</i>			x	x					x
?diprotodontid indet			x						
<i>Bohra</i> sp.				x					
<i>Kurrabi</i> sp.			x	x					
<i>Protemnodon</i> sp. cf. <i>P. devisi</i>	x		x	x					
macropodine indet.	x	x	x				x	x	x
<i>Macropus</i> sp. 1					x				x
<i>Macropus</i> sp. cf. <i>M. agilis siva</i>			x						x
<i>Macropus titan</i>									x
<i>Thylacoleo</i> sp.								x	x
<i>Thylacoleo hilli</i>			x						

specimens assigned to *T. cynocephalus*, falling within the variation provided by Dawson (1982b).

Family VOMBATIDAE Burnett, 1830

Vombatus Geoffroy, 1803

Vombatus ursinus mitchellii (*sensu* Dawson, 1983) (Fig. 18A)

MATERIAL. QMF51758, QMF1420; QML1311 C/D, QML1420.

The only large marsupial with hypsodont molars, wombats are easily identified from any deposit. *Vombatus* is represented from QML1420, Marmor Quarry, by an incomplete left mandibular ramus with molars and insisor root preserved, and a partial right maxilla. A single tooth, within a partial maxilla has also been recovered from QML1311 Unit C/D. Based on size comparisons, the three specimens are much smaller than *Phascolonus* and slightly smaller than *Phascolomys medius*, falling within the size range of the Late Pleistocene *Vombatus ursinus mitchellii* (*sensu* Dawson 1983; Murray 1998) from the eastern Darling Downs.

Family DIPROTODONTIDAE Gill, 1872

?zygomaturine (Fig. 18B)

MATERIAL. QMF1419, QML1420.

Tooth fragments of a diprotodontid from Marmor Quarry which were initially identified by Longman (1925a) as *Diprotodon australis* are revised to ?zygomaturine. Two of the three tooth fragments come from the same molar. The fragments consist of a protolophid which possesses a narrow anterior cingulum. The third tooth fragment may come from the same molar and represents the posterior lingual side of the molar, preserving the lingual edge of the hypolophid. The tooth is low crowned and the lophes are relatively straight and narrow. Based on this, and comparing the molars to specimens of *Zygomaturus*, *Euryzygoma* and *Diprotodon*, it seems most likely that the tooth came from a species *Zygomaturus*. Phalanges and fragments of vertebrae have also come from Marmor Quarry, however, these do not aid in the identification of this relatively large form of diprotodontid.

Family PALORCHESTIDAE (Tate, 1948)

Palorchestes Owen, 1873

Palorchestes sp. cf. *P. parvus* De Vis, 1895 (Fig. 18C-D)

MATERIAL. QMF51759-51760, QMF42635 (cast) / BMNH10257; QML1311(H); QML1311 (C/D), QML1420.

Palorchestes is represented by an isolated M₂, a left maxillary fragment preserving the posterior portion of M¹ and a complete M², and a left I¹⁻². Left I¹ large, curved and broad distally. LI² broad with tapering root. LM¹ preserves a double midlink and a posterior-lingual fossette. LM² ovo-rectangular in occlusal view, lophes relatively narrow with the metaloph slightly narrower than paraloph. Single mid- and forelink. Anterior cingulum deep and completely running the length of the molar, bisected by forelink. Buccal cingulum present between paracone and metacone. Postero-lingual pocket. No posterior cingulum. M₂ rectangular in occlusal view, lophids high and narrow, distinct fore- and midlink, posterior cingulid absent.

These specimens cannot be assigned to a species of *Palorchestes* because they lack diagnostic features of the M¹ (Black, 1997). Based simply on size, the specimens are from a small species of *Palorchestes*, much smaller than

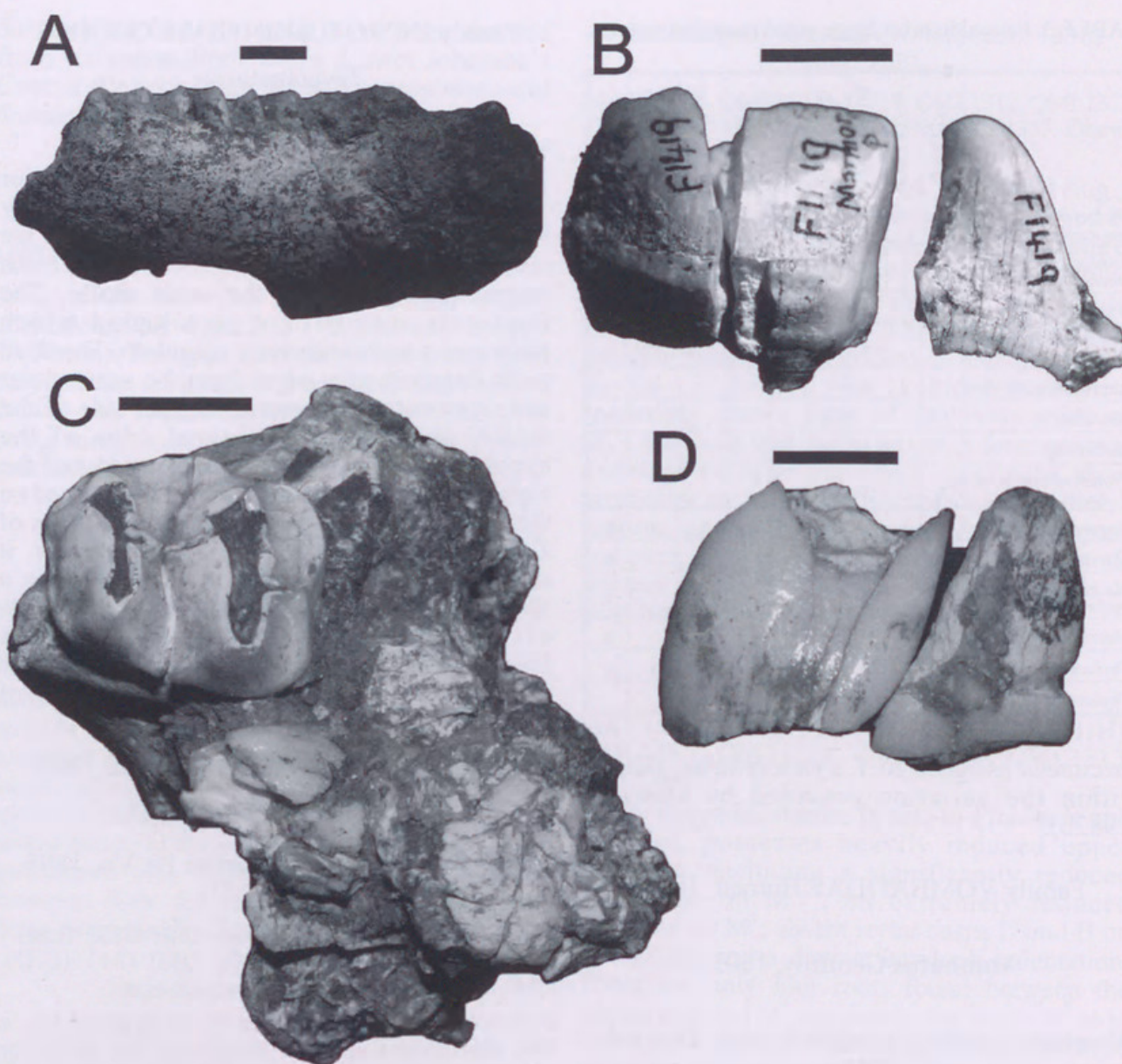


FIG 18. A, Vombatidae; *Vombatus ursinus mitchelli*; QMF1420, LM₁₋₄. B, ?Zygomaturine; QMF1419, fragmentary molar. C-D, Palorchestidae; *Palorchestes* sp. cf. *P. parvus*; C, QMF51759, RM² (partial M¹). D, QMF51760, LI¹⁻². Scale bar = 10mm.

P. azael and very similar in size to *P. parvus*. The M₂ is larger than the species recovered from the Hamilton LF, which was considered by Turnbull & Lundelius (1970) to be *Palorchestes painei*. This identification has been challenged by Rich (1991) who considers it to represent a new taxon, illustrating the taxonomic uncertainty surrounding the smaller members of the Palorchestidae.

?diprotodontid indet.

MATERIAL. QMF51761; QML1311H.

Approximately a quarter of a lower molar possibly represents a small diprotodontid. The tooth is low crowned, lophodont and bears thick slightly crenulated enamel distinctive in several diprotodontian groups. The molar is distinctly not macropod based on the thickness of the enamel and the crenulations are not as distinct as those found in the Sthenurinae. The lophids are lower than those found in palorchestids.

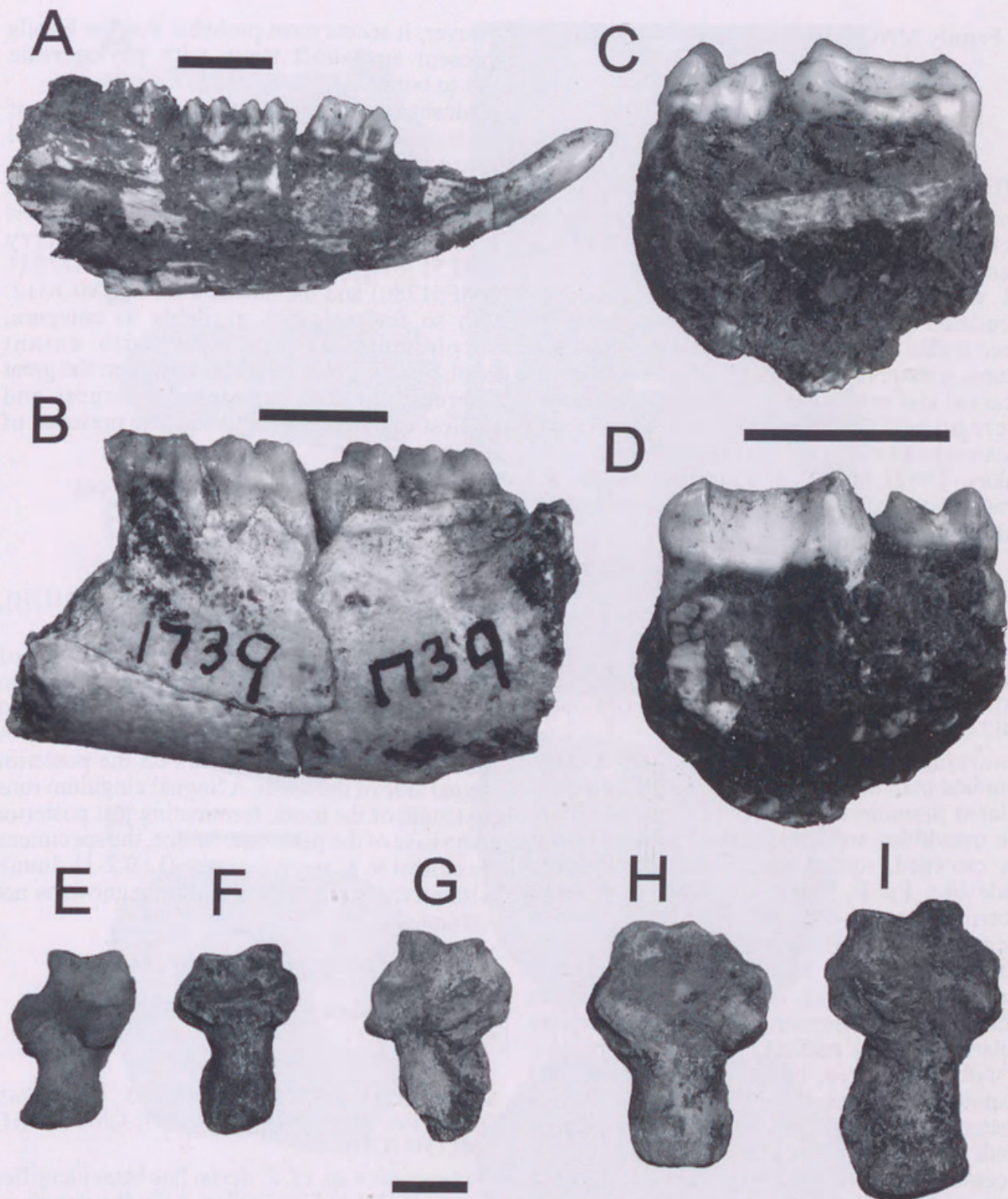


FIG19. A-I, Macropodidae. A-H, *Dendrolagus* sp.; A, QMF51770, RI₁-M₄. B, QMF1739, LM₁₋₄. C-D, QMF51771, RP₃-M₁ in lingual and buccal view (showing postero-buccal cuspule on P₃). E-H, Calcanea; QMF51772-51775 (left to right). I. *Bohra* sp.; QMF51783, calcaneum. Scale bar = 5mm.

Family MACROPODIDAE Gray, 1821

Bohra Flannery & Szakay, 1982**Bohra** sp.
(Fig. 19I)

MATERIAL. QMF51762; QML1311C/D.

Bohra sp. is represented by a complete right calcaneum (Calcaneal Length: 46.79mm; Calcaneal-Cuboid articulation height 12.43mm and width 18.96; Astragalar-calcaneal articulation length 23.01mm). The calcaneum is placed within *Bohra* on the basis of the following features it shares with *Bohra paulae*: 1. Massive calcaneal size relative to all other dendrolagine macropods. 2. Height to width of calcaneal-cuboid articulation (Flannery & Szakay, 1982) (0.65). 3. Calcaneal length to astragalar-calcaneal articular length (Flannery & Szakay, 1982) (0.49).

Dendrolagus Muller & Schkegel, 1839**Dendrolagus** sp.
(Fig. 19A-H)

MATERIAL. QMF51770-QMF51783; QML1284, QML1311(H), QML1311(C/D), QML1312, QML1385, QML1420.

Dendrolagus is represented by two nearly complete mandibles, three maxillary fragments, isolated premolars, molars and three calcanea. The mandibles are characterised by possessing low crowned, square molars and an elongate, blade-like P_3 . P_3 blade bounded by a large anterior cusp and posterior cusp. A single intermediate cuspule is situated a third the way along the crest. The upper dentition is characterised by an ovo-rectangular P^3 in occlusal view, possessing low-crowned square molars with weak midlinks and absent forelinks. P^3 with both postero-buccal and postero-lingual cuspules. Paracone linked to metacone via a crested blade. A single vertical ridge runs to a small cuspule near the centre of the blade. A tiny accessory cuspule is present posterior to the main cuspule. Lingual cingulum runs the length of the tooth, terminating below the paracone. When compared to extant species of *Dendrolagus* the fossil taxon shares closest lower dentition morphology with *D. matschiei*, whereas the upper dentition most closely resembles *D. ursinus*. At present there are no morphological or morphometric features that suggest that the mandibles represent one taxon and the maxillae another. Further material will be needed to clarify the specific placement of these specimens,

however, it seems most probable that the fossils represent an extinct taxon with phylogenetic links to both *D. matschiei* and *D. ursinus*.

Calcanea have been identified by possession of a distinctive squat shape, short calcaneal tuberosity, and broad anterior articular facets. Four specimens have been recovered so far and all four are distinctly different in size. The largest is from QML1420 Marmor Quarry (QMF51781), the second largest from QML1311 (QMF51780) and the smallest from QML1312. With so few calcanea available to compare, morphometric comparison with extant populations was not possible, however, the great difference in size between the largest and smallest calcanea may illustrate the presence of several species.

Kurrabi Flannery & Archer, 1984**Kurrabi** sp.
(Fig. 20A-D)

MATERIAL. QMF51767-51769; QML1311(H), QML1311 (C/D).

Three isolated P^3 's represent a species of *Kurrabi*. Each premolar is elongate with two small vertical ridges on the longitudinal crest between the paracone and metacone. A moderate-sized fossette occurs on the posterior lingual side of the tooth. A lingual cingulum runs the length of the tooth, terminating just posterior of the base of the paracone. In size, the specimens are closest to *K. merriwaensis* (L: 9.2-11.5mm). Without more material specific diagnosis is not warranted.

Protemnodon Owen, 1874**Protemnodon** sp. cf. *P. devisi* Bartholomai,
1973
(Fig. 20E-H)

MATERIAL: QMF41737, QMF41953, QMF51763-QMF51766, QMF52068; QML1284, QML1311(H), QML1311 (C/D).

Protemnodon sp. cf. *P. devisi* has been identified from an isolated premolar; a badly preserved palate with portions of RP^2 , RdP^3 , RM^{1-3} and LdP^3 , RM^{1-2} preserved; a left mandible with M_{2+3} ; left mandible preserving P_3 ; isolated RM^1 , LM^3 , LM^4 , LdP_3 , LM_2 , LM_3 and an isolated I_1 . Dimensions of the premolar and molars are within the range given for *P. devisi* by Bartholomai (1973). However, the specimens here differ from *P. devisi* from Chinchilla, but are similar to those of *P. sp. cf. P. devisi* described by Dawson et al. (1999) from Big Sink, in the

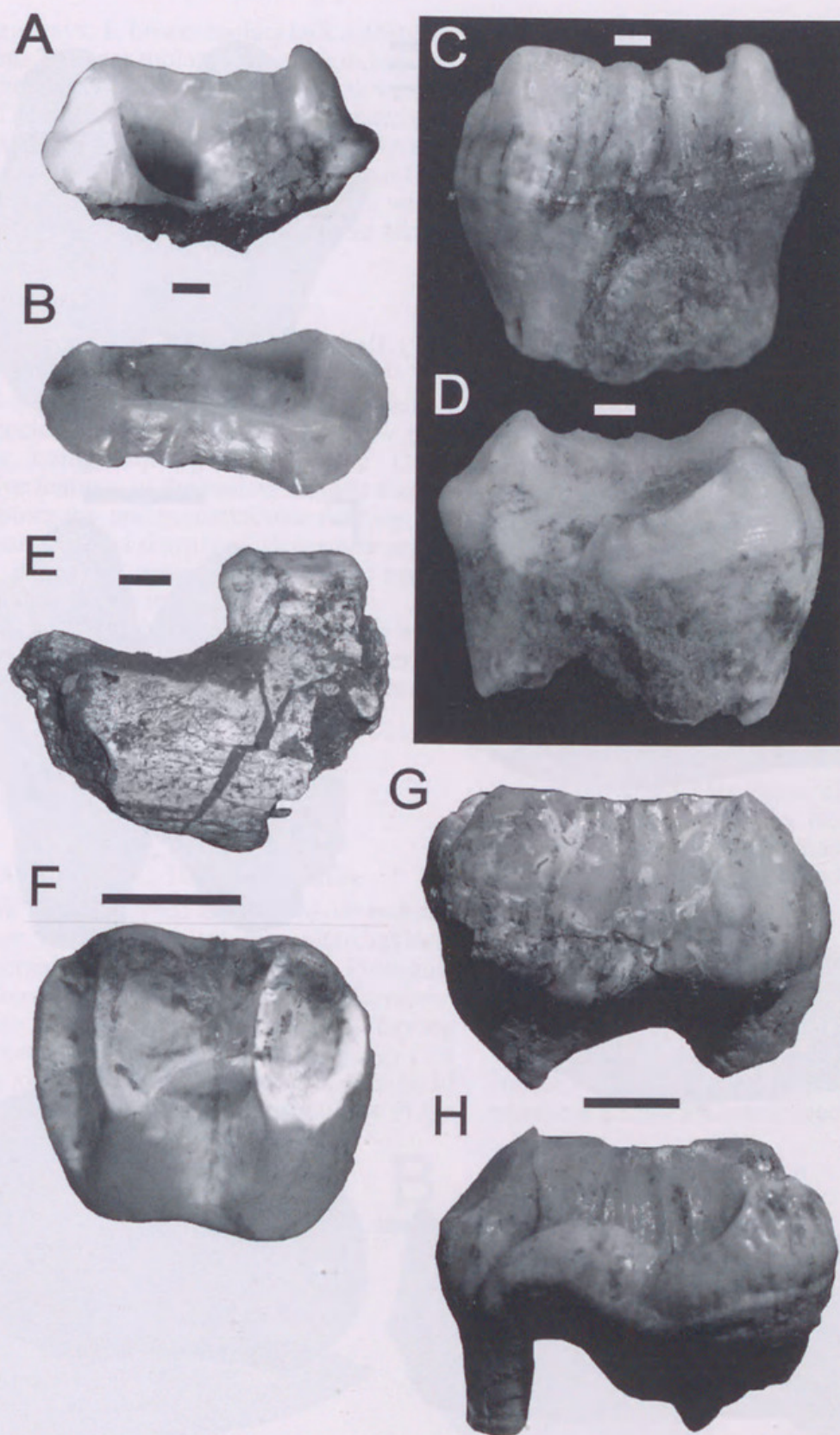


FIG 20. A-H, Macropodidae. A-D, *Kurrabi* sp.; A-B, QMF51767; RP³ in lingual & occlusal views. C, QMF51768, LP³. D, QMF51769, LP³. Scale bar = 1mm. E-H, *Protomnodon* sp. cf. *P. devisi*; E, QMF41737, LP₃. F, QMF41953, LM³. G-H, QMF51763; LP³ in buccal & lingual views. Scale bar = 5mm.

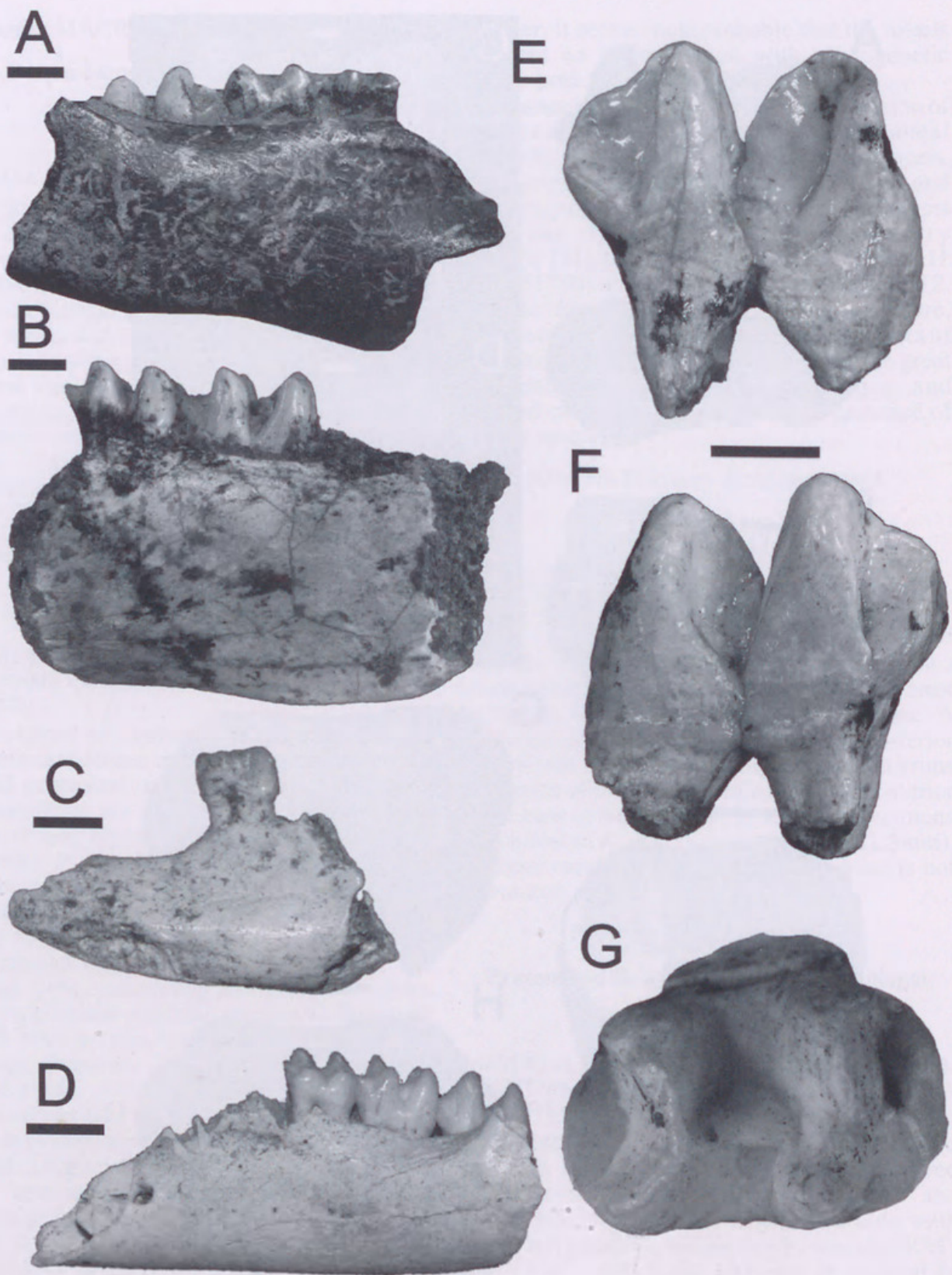


FIG 21. A-G, Macropodidae; A-B, *Macropus* sp. cf. *M. agilis siva*; A, QMF51829, RM₁₋₃. B, QMF51830, LM₁₋₂. C-D, *Petrogale* sp.; C, QMF51812, RP₃. D, QMF51813, LM₂₋₄. E-G, *Macropus titan*; QMF1697 in lingual (E), buccal (F) & occlusal (G) views. Scale bar = 5mm.

following ways: 1. Lower molars lack a posterior cingulum. 2. Upper molars lack a secondary link across the median valley. 3. P^3 has weak vertical ridges. The specimens do possess premetacristae, which the Big Sink specimens do not. The overall variation seen in the specimens of *P. devisi* from Chinchilla, Big Sink and Mount Etna is within that seen for similar cosmopolitan species such as *P. anak*.

macropodine sp. indet

MATERIAL. QMF51802-51811; QML1284, QML1284a, QML1420, QML1384, QML1311(H).

Several isolated molars appear to represent a large species similar to species of *Thylogale*, however, being much greater in size. Other distinctive features of the molars include sharply crested postpara- and premetacrista running into the median valley; a sharply crested preparacrista linking onto the anterior cingulum, and a well-developed forelink.

The molar is high crowned, and similar in shape to some species of *Macropus*, however, the midlink is weakly developed and the cristae are sharp and elaborated unlike *Macropus*.

Petrogale Gray, 1837

Petrogale sp.
(Fig. 21C-D)

MATERIAL. QMF51812-51824; All localities.

Petrogale is represented by dozens of isolated mandibles, maxillae, molars, premolars, insisors and postcrania. The only taxa close to *Petrogale* are *Thylogale* and small members of *Macropus*. *Petrogale* differs from *Thylogale* in having lower-crowned molars, in the I^3 morphology (not having a longitudinal groove along the length of the I^3 crown) and the anterior morphology of the

P^3 (not having a well-developed lingual cingulum with an anterior-lingual pocket). *Petrogale* differs from small-sized *Macropus* by being generally smaller, having a relatively longer P^3 and smaller I^3 . The taxonomic diversity of modern species of *Petrogale* is not reflected in dental morphology, thus species placement is not warranted on the basis of available material.

Macropus Shaw, 1790

Isolated molars and partial jaws represent species of *Macropus*. BarBtholomai (1975), Archer (1978) and Dawson & Flannery (1985) illustrate the difficulty in identifying species of *Macropus* on the basis of isolated molars or jaws without premolars and insisors. Distinction of different species of *Macropus* requires almost complete mandibles or maxillae. When dealing with isolated teeth, absolute size comparisons are the only features available for comparison to available data such as Bartholomai (1975). More complete specimens are required before specific allocations can be made.

Macropus sp. 1

MATERIAL. QMF51825-51828; QML1312, QML1420.

A medium-sized *Macropus*, close to *Macropus dorsalis*, is represented by isolated molars that are larger in absolute size than those species of *Petrogale* but smaller than modern species of the size of *Macropus agilis*.

Macropus sp. cf. *M. agilis siva* (De Vis, 1895)
(Fig. 21A-B)

MATERIAL. QMF51829-51834; QML1420, QML1311(H).

Isolated molars and a partial right mandible represent a medium-sized species of *Macropus*.

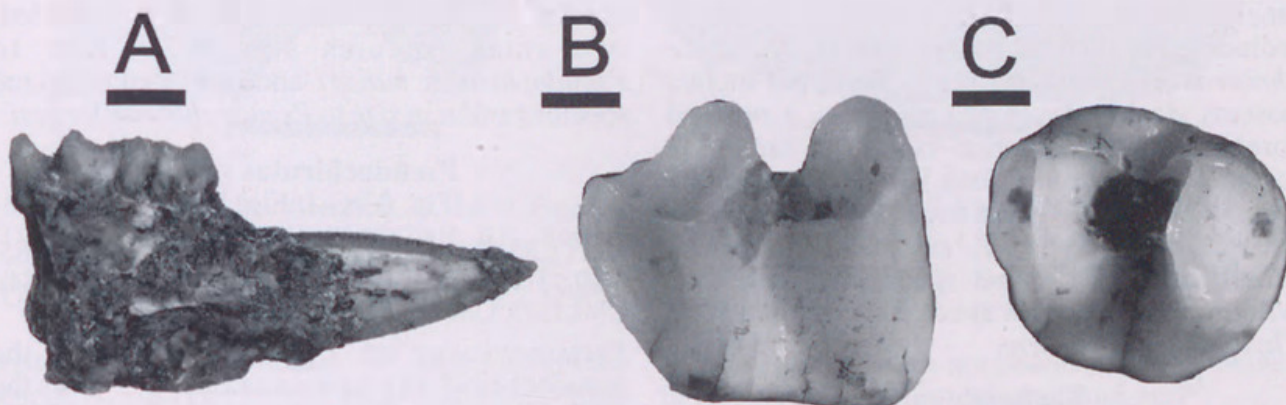


FIG 22. A-C, Macropodidae; *Thylogale* sp.; A, QMF51784, LI_1 - M_2 . Scale bar = 5mm. B, QMF51785, LM_2 . C, QMF51786, LM_2 . Scale bar = 1mm.

Macropus agilis agilis is closest in overall size to the fossil specimens from Marmor Quarry, however, there is overlap with *Macropus agilis siva* when comparing the mandible from Lost Paradise Cave (J7) and the maxilla and mandible from QML1311. All dental measurements fall within the range for *Macropus agilis siva* defined by Bartholomai (1975).

Macropus titan (Owen, 1838)
(Fig. 21 E-G)

MATERIAL. QMF1697, QMF51835-51837; QML1420. *Macropus titan* is a large macropod easily distinguished by its large high crowned molars, distinct mid- and fore-links and posterior hypolophid groove. Specimens referred to here are placed within *M. titan* based on these features and their similar size to samples taken from the Darling Downs (Bartholomai, 1975).

Thylogale Gray, 1837

Two species of *Thylogale* have been identified based on the presence of high-crowned (relative to *Dendrolagus*), rectangular molars, poorly developed midlinks, an anterior cingulum that does not extend across the entire width of the upper molars, and an I³ that has a complete longitudinal groove on the occlusal face. They have been differentiated from *Petrogale* by having weaker midlinks, an incomplete anterior cingulum on upper molars, smaller-sized molars, and better-developed cristae on dP3s and upper molars.

Thylogale sp. 1
(Fig. 22A-C)

MATERIAL. QMF51784-51797; QML1284, QML1284a, QML1385, QML1384U.

A very small-sized new species of *Thylogale*, smaller than any extant or extinct species, including the smallest known species, *Thylogale christenseni* from Irian Jaya. The upper molars possess weakly developed midlinks, a reduced forelink and an anterior cingulum that only extends slightly more than half way across the front of the molar. These features are shared to a greater extent with *T. christenseni* and *T. billardierii*. With further specimens, this taxon will probably be a new species closely related to *Thylogale christenseni*.

Thylogale sp. 2

MATERIAL. QMF51798-51801; QML1312, QML1420. On the basis of molar size and morphology, differentiation of *Thylogale thetis* and *Thylogale*

stigmatica is extremely difficult. The fossil specimens are within the range of both taxa and are very similar in overall morphology.

Family PSEUDOCHEIRIDAE (Winge, 1893)

Pseudocheirids are represented by hundreds of isolated premolars and molars, molar rows and jaw fragments. The apparent morphological diversity in the collection is corroborated by the diversity in sizes, ranging from very small ringtails of similar size to *Pseudochirulus mayeri*; medium-sized similar to *Pseudochirulus forbesi*; large-sized *Pseudocheirops* and giant *Pseudokoala*. On reviewing the morphology of modern and Tertiary pseudocheirid taxa it became obvious that the most useful features for identification are found in the P3 and M1 of the upper and lower dentition. Based on characters from these key teeth, several groups emerged. More specific formal taxonomy will be provided in a future analysis as more complete material becomes available.

Pseudochirulus Matschie, 1915

Pseudochirulus has been identified based on the following combined features: P³ morphology; elongate-ovoid, preparacrista variably linked to paraconule by blade or valley, only two cusps, posterolingual cingulum variably expressed. M¹ morphology; molar profile elongate-rectangular, preprotoconule crista variably expressed, lingual cingulum absent. P₃ morphology; metaconid blade-like or absent, paraconid distinct and not linked to protoconid by blade, cristid obliqua distinct running from the hypoconid to protoconid. M₁ morphology; distinct paraconid; preprotocristid kindred buccally to paraconid, metaconid variably expressed, entostylid absent. Three species of *Pseudochirulus* have been identified, two small species similar in size to *Pseudochirulus mayeri* and one medium-sized species similar in size to *Pseudochirulus forbesi*.

Pseudochirulus sp. 1
(Fig. 23 G-I, Fig. 24 E)

MATERIAL. QMF51838-51870; QML1385, QML1311(H), QML1311(C/D), QML1284, QML1284a, QML1313, QML1385L.

Pseudochirulus sp. 1 is the smallest of the pseudocheirid taxa represented and possesses the following distinctive features that distinguish it and differentiate this species from *Pseudochirulus* sp. 2 and 3: 1. Simple preprotoconule that does not connect to any other

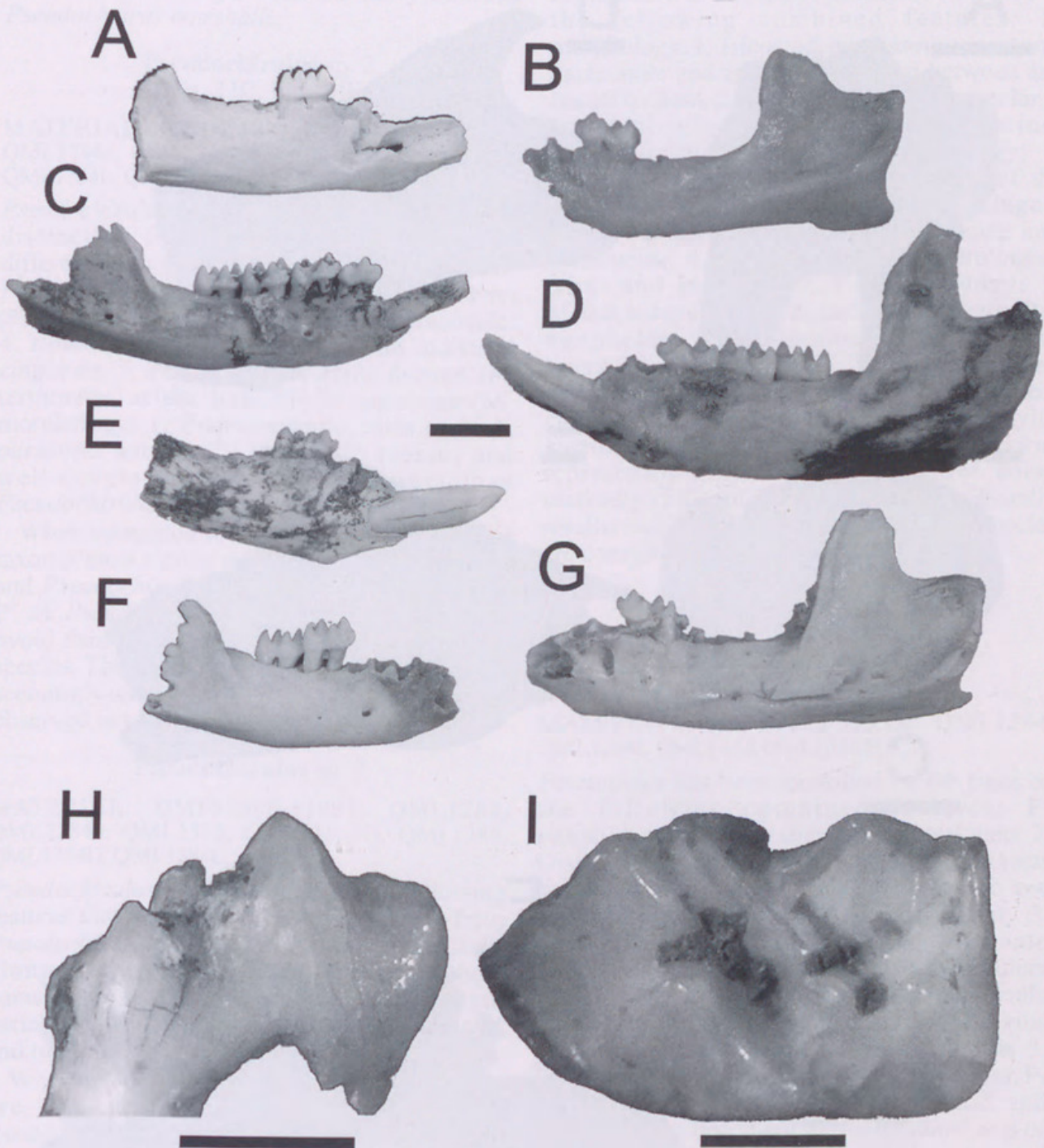


FIG 23. A-I, *Pseudocheiridae*. A, B, D, E & H, *Pseudocheirus* spp.; A, QMF51898, RM₁. B, QMF51899, RI₁-M₃. D, QMF51900, RM₂₋₃. E, QMF51901, RP₃. Scale bar = 5mm. H, QMF51840, LM₁. (Scale bar = 1mm). C, *Pseudochirulus* sp. 2; QMF51871, RI₁ & M₁. F, G & I, *Pseudochirulus* sp. 1; F, QMF51838, LM₁. G, QMF51839, LI₁ & M₁₋₃. Scale bar = 5mm. I, QMF51841. Scale bar = 1mm.

cristae. 2. Protostyle absent. 3. Lingual cingulum absent. 4. Anteriorlingual para- and metacristae absent. 5. Posterolingual para- and metacristae absent. 6. P³ elongate-ovoid in occlusal view. 7.

P³ preparacrista does not connect to paraconule. 8. Distinct posterolingual cingulum on P³.

Pseudochirulus sp. 1 is closest in morphology to the living *Pseudochirulus canescens* and

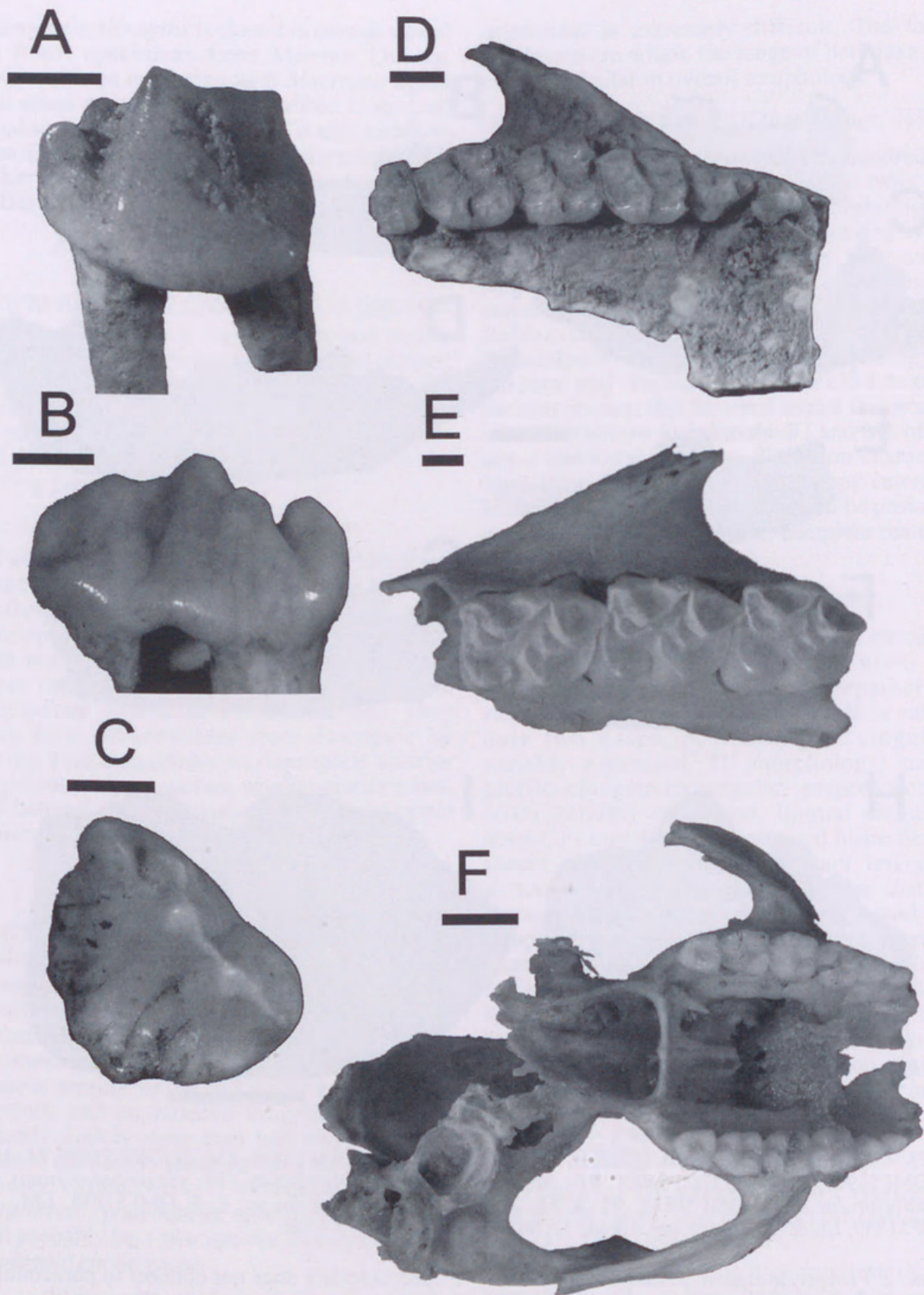


FIG 24. A-F, Pseudocheiridae; A-D, *Pseudocheirus* sp.; A, QMF51920, LP³. B-C, QMF51921, LP³ in buccal & occlusal views. E, *Pseudochirulus* sp. 1; QMF51870, RP³-M³ (broken). Scale bar = 1mm. F, *Pseudochirulus* sp. 2; QMF51887, partial skull. Scale bar = 5mm.

Pseudochirulus mayeri and the Early Pliocene
Pseudocheirus marshalli.

***Pseudochirulus* sp. 2**
(Fig. 23C, Fig. 24F)

MATERIAL. QMF51871-51887; QML1284, QML1284a, QML1313, QML1311(H), QML1384U, QML1384L, QML1385.

Pseudochirulus sp. 2 possesses the following distinctive features, that when combined differentiate it from *Pseudochirulus* sp. 1 and 3: P^3 morphology; 1. P^3 elongate-ovoid. 2. Distinct paraconule. 3. Preparacrista contacts paraconule. 4. Broad posterolingual margin with indistinct cingulum. 5. Postparaconule crista distinct and terminates at the base of the paracone. M^1 morphology; 1. Preprotoconule crista contacts paracone buttress. 2. Protostyle present and well-developed. Overall size larger than *Pseudochirulus* sp. 1.

When compared to modern species the fossil taxon is most similar to *Pseudochirulus cinereus* and *Pseudochirulus forbesi* in overall size. The P^3 of *Pseudochirulus* sp. 2 is distinctly more ovoid than the morphology seen in the modern species. The P^1 has large double roots, a feature seemingly unique to this taxon, having not being observed in any of the modern or fossil taxa.

***Pseudochirulus* sp. 3**

MATERIAL. QMF51888-51897; QML1284, QML1284a, QML1313, QML1311(H), QML1385, QML1384U, QML1384L.

Pseudochirulus sp. 3 possesses the following features that in combination differentiate it from *Pseudochirulus* sp. 1 and 2: P^3 morphology; 1. P^3 elongate-ovoid. 2. Preparacrista contacts paraconule. 3. Distinct posterolingual cingulum, variably cuspidate. 3. Kink in the posterobuccal end of the postparacrista.

When compared to modern species, the fossils are closest in morphology to both *Pseudochirulus mayeri* and *Pseudochirulus herbertensis*. The fossil specimens differ from these species in being larger than *Pseudochirulus mayeri* and smaller than *Pseudochirulus herbertensis*.

***Pseudocheirus* Ogilby, 1837**

***Pseudocheirus* spp.**
(Fig. 23A-B, D-E, H, Fig. 24A-D)

MATERIAL. QMF51898-51922; QML1284, QML1284a, QML1313, QML1311(H), QML1385, QML1384U, QML1384L.

Pseudocheirus has been identified on the basis of the following combined features: P^3 morphology; 1. Tricuspid, possessing a paracone, paraconule and an accessory cusp between and buccal to them. 2. Ovoid shape to the premolar in occlusal view. 3. Shallow, indistinct posterolingual basin. M^1 morphology; 1. Preprotoconule terminating at the base of the parastyle. 2. Protostyle distinct. 3. Lingual cingulum present between protocone and metaconule. 4. Lack postero- and anterolingual para- and metacristae. P_3 morphology; 1. Metaconid present as a distinct and high cusp. M_1 morphology; 1. Preprotocristid blade-like running to tip of paraconid. 2. Paraconid in line with protoconid. 3. Protostylid tall and crested, closely set against protoconid. 4. Entostylid absent. There are three species of *Pseudocheirus* represented from the sites, all three being markedly different in size but all significantly smaller than extant *Pseudocheirus*. Three species are considered to be new extinct species.

***Petauroides* Thomas, 1888**

***Petauroides* spp.**
(Fig. 25A-C)

MATERIAL. QMF51923-51935; QML1284, QML1284a, QML1313, QML1311(H).

Petauroides has been identified on the basis of the following combined features: P^3 morphology; 1. Ovoid shape in occlusal view. 2. Distinctly straight blade made by the crests running between the paraconule, paracone and posterobuccal margin of the premolar. 3. Posterolingual postparacrista running into posterolingual basin. 4. Posterolingual cingulum present. M^1 morphology; 1. Preprotoconule connects to preprotocrista. 2. Posterolingual para- and metacristae well developed as crests. 3. Protostyle absent. 4. Lingual cingulum absent. P_3 morphology; 1. Paraconid, protoconid and metaconid in a line along the longitudinal axis of the tooth crown. 2. Cristids variably expressed and probably constitute several species. 3. Small posterior pocket below the metaconid developed in some specimens.

The morphological diversity seen in specimens referred to here as *Petauroides* indicates a very complex fossil history leading to the modern *Petauroides* and *Hemibelideus*. The only P^3 specimen available is closest in morphology to *Hemibelideus*. P_3 morphology shows great degrees of morphological diversity albeit retaining typical *Petauroides* characteristics.

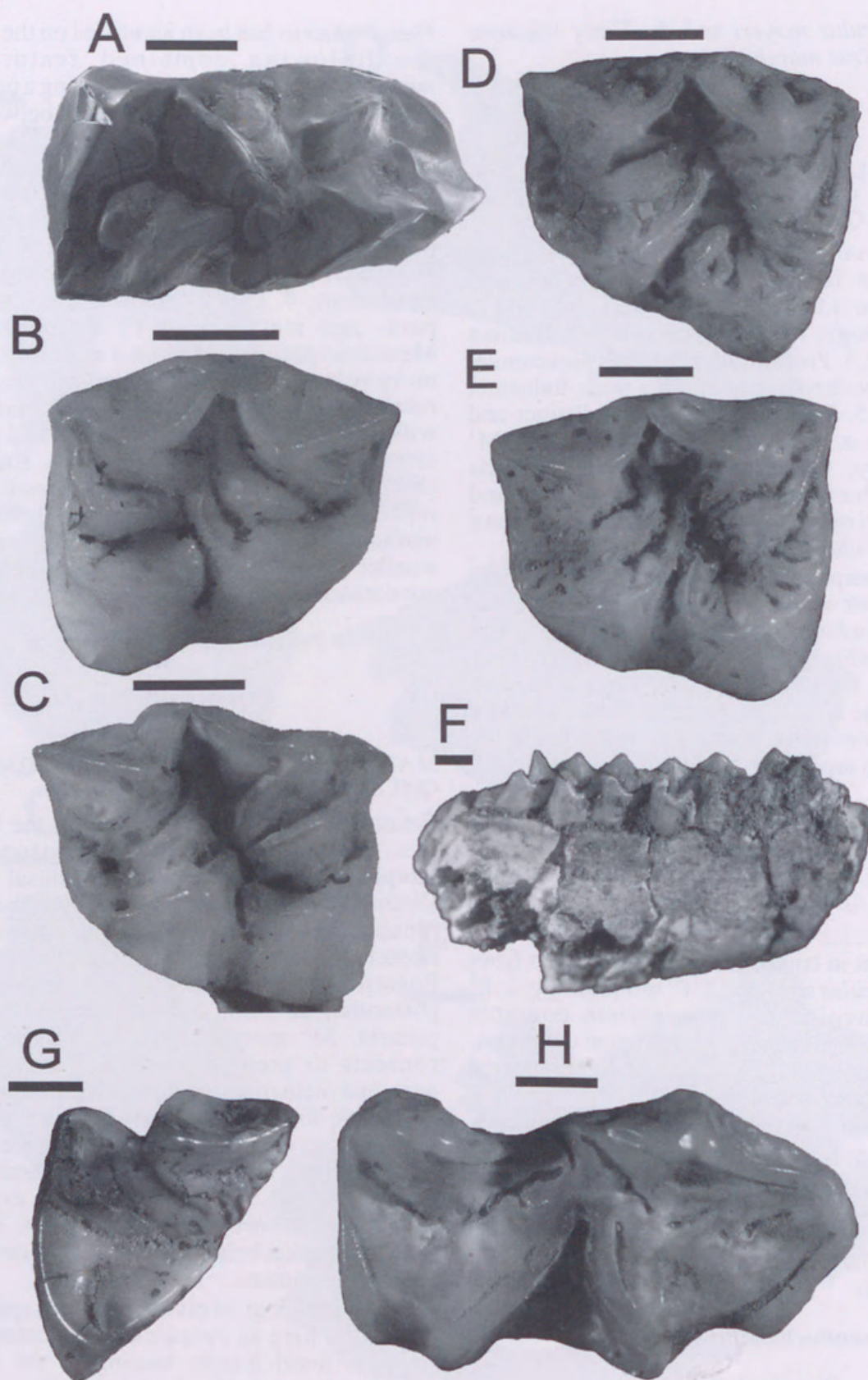


FIG 25. A-H, Pseudocheiridae; A-C, *Petauroides* sp.; A, QMF51923, RM₁. B, QMF51924, LM₂. C, QMF51925, RM₂. D-F, *Pseudocheirops* sp.; D-E, *Pseudocheirops* sp. 1; D, QMF51934, RM₃. E, QMF51935, RM₂. Scale bar = 1mm. F, *Pseudocheirops* sp. 2; QMF51937, RM₂. Scale bar = 5mm. G-H, *Pseudokoala* sp.; G, QMF51934, RM₇. H, QMF51939, RM₂. Scale bar = 1mm.

Five distinct morphologies are present, however, these will be treated as polymorphic until a larger collection is available. Even so, no P_3 clearly represents known species of *Petauroides* or *Hemibelideus*. M_1 morphology shares greater similarities with extinct species of *Petauroides* (*Petauroides stirtoni* and *Petauroides ayamaruensis*, see Long et al., (2002)) than with the modern *Petauroides volans* and *Hemibelideus lemuroides*.

Pseudocheirops Matschie, 1915

Pseudocheirops has been identified on the basis of the following features: 1. Protostylid basin on M_{1-3} . 2. Elaborate crenulations on upper and lower molars. 3. Entostylid present. 4. Posterior bifurcation of protoconule. 5. Protostyle present. 6. Crest present labial to protostyle. Two species of *Pseudocheirops* have been identified so far.

***Pseudocheirops* sp. 1 (Fig. 25D-E)**

MATERIAL. QMF51936, QMF51934-51935; QML1311(H), QML1384L.

Pseudocheirops sp. 1 is a right mandible preserving a partial M_1 , complete M_{2-3} and a partial M_4 . Two upper right molars are also considered to be conspecific. The fossils compare favourably with *Pseudocheirops archeri* both in size, crenulations and development of the protostylid basin.

***Pseudocheirops* sp. 2 (Fig. 25F)**

MATERIAL. QMF51937; QML1284.

The second, much smaller species *Pseudocheirops* sp. 2, is only known from a right M_2 . The crenulations are indistinct with a narrow entostylid and very small protostylid basin. The fossil is much smaller than any of the modern *Pseudocheirops* available to study, yet it is similar in size to the Pliocene *Pseudocheirops winteri* from Bluff Downs. The fossil differs from *Pseudocheirops winteri* by possessing a complete preentocristid-metacristid connection.

***Pseudokoala* Turnbull & Lundelius, 1970**

***Pseudokoala* sp. (Fig. 25G-H)**

MATERIAL. QMF51938-51939; QML1385; QML1311 (C/D).

Pseudokoala has been identified from an isolated M_2 and a fragment of upper molar. It has been placed within *Pseudokoala* based on the

following combined features: 1. Very large size. 2. Crenulations present but forming large buttresses, less crenulated than *Pseudocheirops* spp. 3. Lack of an entostylid. 4. Truncated posthypocristid. 5. Buccally buttressed protoconid.

When compared to the three species of *Pseudokoala*, *Pseudokoala* sp. is closest to *Pseudokoala erlita* in size (M_2L : 6.78mm *Pseudokoala* sp., M_2L : 6.2-7.3mm *Pseudokoala erlita* Turnbull & Lundelius (1970), M_1L : 10.7mm *Pseudokoala curramulkensis*, M_1L : 10.9mm *Pseudokoala cathysantamaria* Archer et al. (1997). The molar crown is simplified as in *Pseudokoala erlita*, however, due to the worn nature of the tooth no more specific comparisons can be made.

pseudocheirid indet.

MATERIAL. QMF51940; Olsen's Cave.

A posterior fragment of an upper molar with distinctly selenodont morphology represents the only material of a pseudocheirid from the Olsen's Cave collection. The lack of crenulations and an anterolingual metacrista allies the specimen to a large member of *Pseudochirulus* or *Pseudocheirus peregrinus*.

Family PETAURIDAE (Gill, 1872)

Petaurids are represented by several nearly complete maxillae, fragmentary mandibles, isolated insisors, premolars, molars and postcrania. Two genera are recorded, *Dactylopsila* and a new undescribed genus.

***Dactylopsila* Gray, 1858**

Dactylopsila has been identified based on the following combined features: 1. Possession of a distinct and large M^1 parastyle. 2. Reduction of the styler margin with a distinct indentation between the paracone and metacone. 3. Reduced metaconule. 4. Procumbent I_1 . 5. Bulbous, rectangular-ovoid lower molars.

***Dactylopsila* sp. 1 (Fig 26E)**

MATERIAL. QMF51943-QMF51946; QML1284; QML1284a; QML1384U; QML1385.

Dactylopsila sp. 1 is 10-12% smaller than the species of *Dactylopsila* available for study, *Dactylopsila trivirigata* and *Dactylopsila palpator*. The fossil species also differs from *D. trivirigata* and *D. palpator* by possessing less rounded and more gracile lower molars, a more buccal placement of the protoconid on M_1 and a

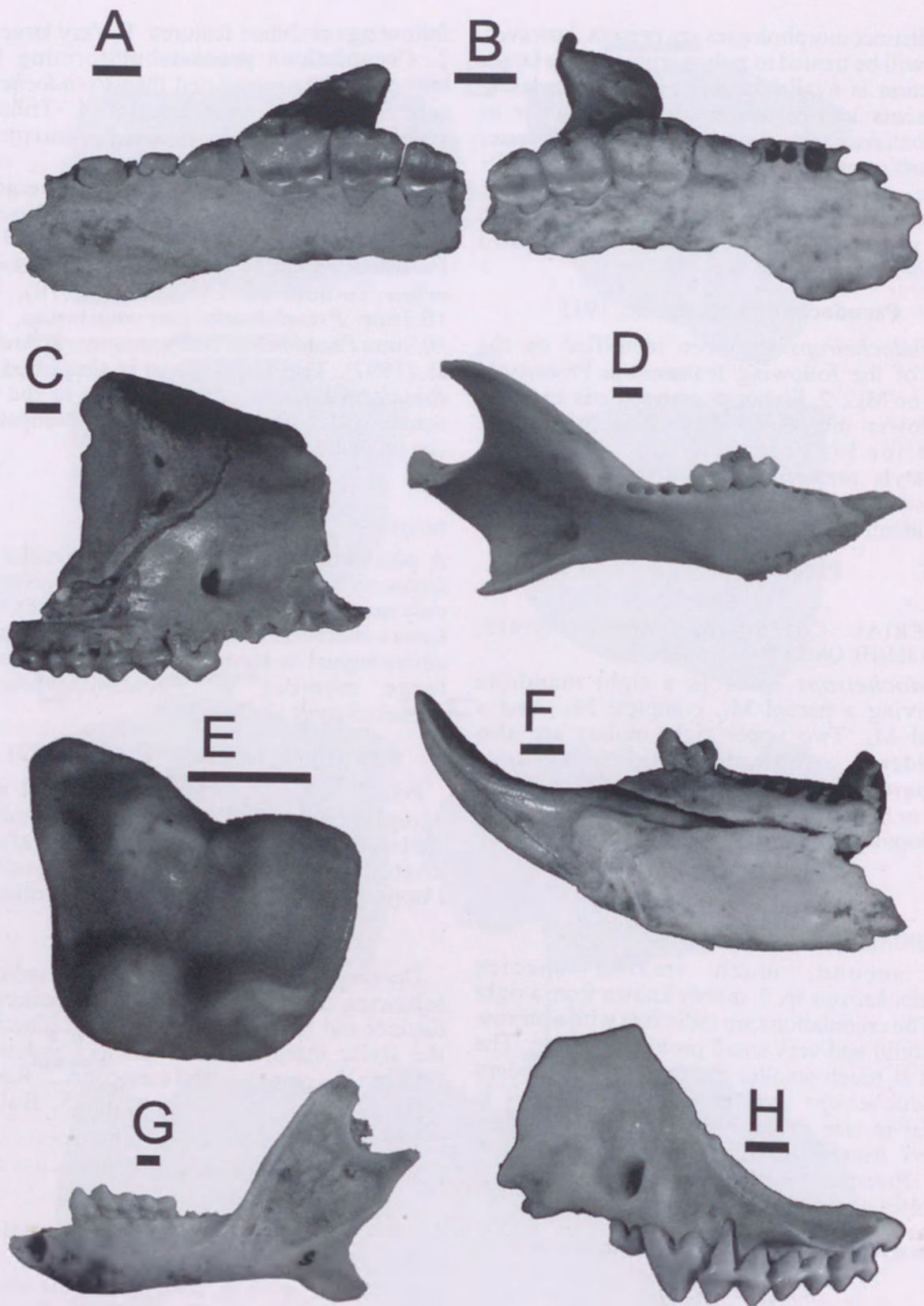


FIG 26. A-F, Petauridae, A-D, Gen. et sp. nov.; A, QMF51949, LP¹-M³. B, QMF51950, RP³-M³. C, QMF54951, partial skull. D, QMF54952, left mandible (M₁₋₂). E, *Dactylopsila* sp. 1; QMF51947, LM¹. F, *Dactylopsila* sp. 2; QMF51948, RI₁ & M₁. G-H, Burramyidae; *Cercartetus* sp.; G, QMF51984, LP₃-M₂. H, QMF51985, LP²-M³. Scale bar = 1mm.

less distinct postprotocristid. When compared to the extinct *D. kambuayai* the fossil is approximately 20% larger, however, it does possess a similar gracile profile of the M_2 .

***Dactylopsila* sp. 2**
(Fig. 26F)

MATERIAL. QMF51947-51948; QML1284.

A second, smaller species of *Dactylopsila* is represented by a fragmentary left mandible with I_1 and M_1 . The I_1 is large and recurved, procumbent. M_1 gracile in occlusal profile, rectangular ovoid with conids without bulbous exterior margins. Protoconid mesially produced. Masseteric fossa inserts below M_{2-3} . Very small alveoli for P_{2-3} .

When compared to *D. trivirigata* and *D. palpator*, *Dactylopsila* sp. 2 differs by being much smaller, a less recurved I_1 , possessing a more gracile and unbuttressed hypoconid, and a more mesially oriented protoconid on M_1 . *Dactylopsila* sp. 2 is similar in size and I_1 morphology to *D. kambuayai*, however, there are no specimens of M_2 available for direct comparison.

Gen. et sp. nov. 1 & 2
(Fig. 26A-F)

MATERIAL. Sp 1: QMF51949-51969; QML1284, QML1284a, QML1313, QML1312, QML1385, QML1384U; QML1384L; QML1420, QML1311.

MATERIAL. Sp 2: QMF51970-51973; QML1284, QML1284a.

Two species of a new medium-sized petauroid are characterised by a dentition that possesses a combination of both plesiomorphic features found in Oligo-Miocene petauroid *Djaluganji yadjana* (Brammal, 1998), and the derived characteristics seen in modern *Petaurus*. The upper molar row is distinctly straight, not possessing the upward inflexion toward the posterior as seen in all modern petaurids. The presence of a distinct stylar basin in M^1 and M^2 distinguish this taxon from both the modern and described Oligo-Miocene petaurids. The reduction of the premolars and molar gradient is shared with *Petaurus* and *Gymnobelidius*, but not to the extent seen in these taxa. Two distinct species are present from the sites and can be distinguished from each other (and the Hamilton Fauna petaurids) on the state of the metaconule, postprotocristae, premetaconule cristae and stylar basin. The greater number of features shared with *Petaurus* and *Gymnobelidius*

warrant its placement in the Petauridae at the present time.

Family BURRAMYIDAE (Broom, 1898)

Burramyids were identified on the basis of their small-sized, square molars with reduced stylar shelf and distinctly high paracone and metacone. They were differentiated from acrobatids by possessing reduced P_1 and P_2 and the presence of M_4 . Burramyid specimens comprise the majority of the very small possums collected from the possum-rich localities of the present study. A conspicuous absence from the burramyid fauna is *Burramys*, with all of the specimens being placed within *Cercartetus*.

***Cercartetus* Gloger, 1841**

***Cercartetus* sp.**
(Fig. 26G-H)

MATERIAL. QMF51984-52002; QML1284, QML1284a, QML1385, QML1311(H), QML1313.

Several nearly complete mandibles, well preserved maxillae, dozens of isolated molars and premolars represent *Cercartetus*. These specimens have been placed within *Cercartetus* based on their size and the absence of the distinctly plagiaulacoid P^3/P_3 , which is distinct in the only other burramyid, *Burramys*. On comparison with the four known species of *Cercartetus*, the fossil specimens differ least from *Cercartetus caudatus* by being very close in size, retaining M_4 and possessing a P^3 with a single conical cusp. The specimens differ from all other species of *Cercartetus* by possessing an M_4 . *Cercartetus* sp. differs from *Cercartetus caudatus* by possessing a larger and double rooted P^1 and P^2 , a larger C^1 root and a shorter diastema between C^1 and P^1 . Additionally, it differs from all extant species of *Cercartetus* by only possessing two individual roots between I_1 and P_3 , instead of three. The homology of the missing root is unknown. With further analysis, *Cercartetus* sp. probably represents a new extinct species closely related to *Cercartetus caudatus*.

SUPERFAMILY INCERTAE SEDIS

Gen et sp. nov.
(Fig. 27B-C)

MATERIAL. QMF51974-51981; QML1284, QML1284a, QML1311(H), QML1385.

A medium-sized possum, similar in size to *Petaurus*, represents a new taxon of uncertain affinities. The closest morphologies to this taxon can be found within both the Acrobatidae and the

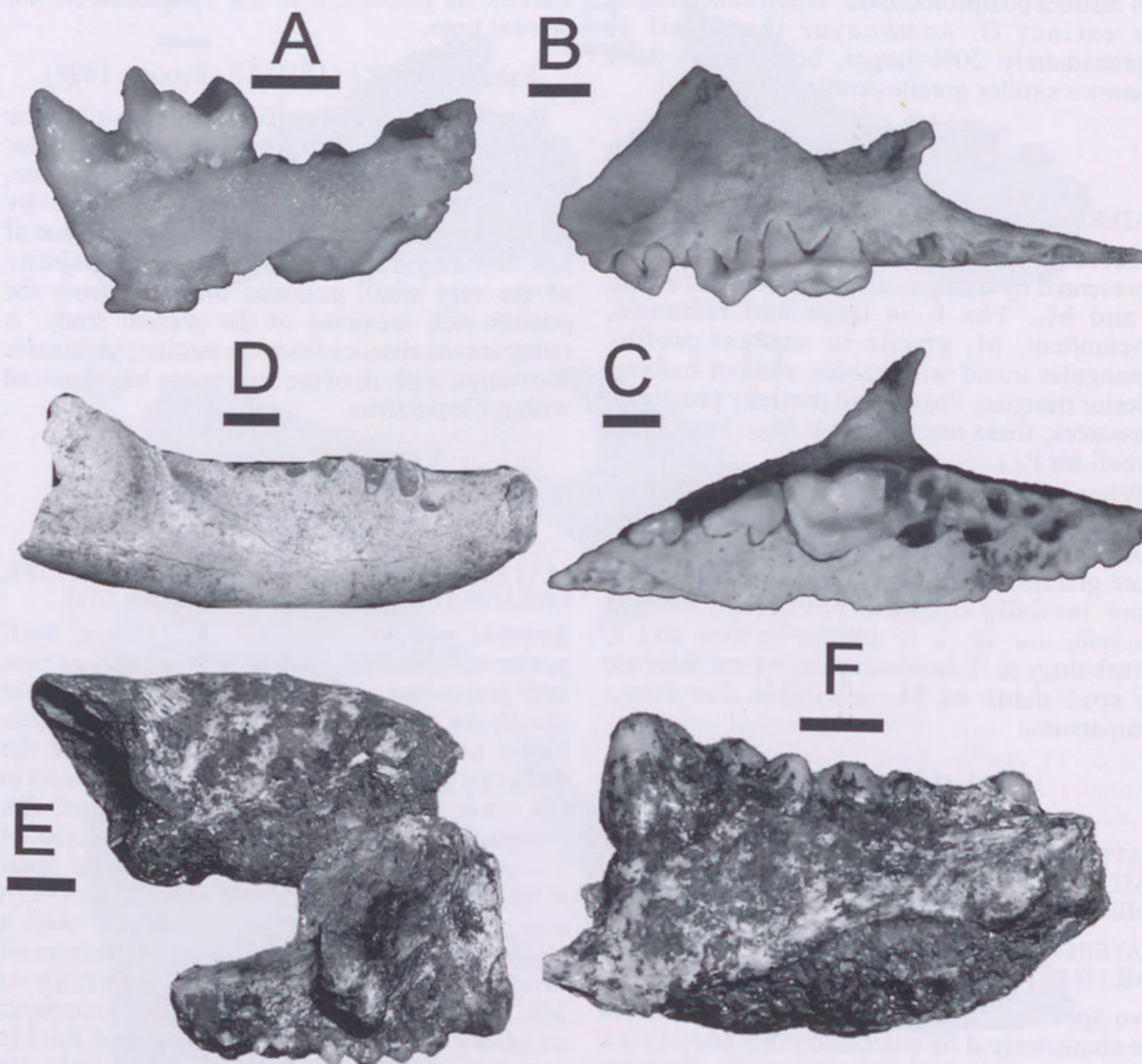


FIG 27. A, Acrobatidae; *Acrobates* sp.; QMF51982, RP₃-M₁. Scale bar = 1mm. B-C, Superfamily incertae sedis; QMF51974 in buccal & occlusal view. Scale bar = 1mm. D-F, Phalangeridae; D, *Trichosurus* sp. 1; QMF52009, right mandible. E, *Trichosurus* sp. 2; QMF52012, partial skull. F, *Strigocuscus* sp.; QMF52003, LP₃-M₃. Scale bar = 5mm.

Burramyidae, where features they share include: 1. Enlarged paracones and metacones on M¹⁻⁴. 2. Very reduced styler margin. 3. Distinct molar size gradient from M¹⁻⁴. 4. Double-rooted P²⁻³. The taxon differs from the majority of these taxa by features that are considered plesiomorphic within the two families (Archer, 1984), including: 1. Presence of M⁴ (*Burramys parvus* and *Cercartetus caudatus*). 2. Subequal metaconule with protocone. 3. Double-rooted P².

The taxonomic placement within either of these families would require further material and a review of pygmy-possum higher taxonomy, which is under considerable confusion at present (Archer, 1984; Strahan, 1998).

Family ACROBATIDAE Aplin, 1987

Acrobatids are easily distinguished and are here represented by the very small-sized *Acrobates*. The fossil specimens have been

identified as acrobatid based on the large sized premolars and the premolariform shape to the M_1 trigonid (Archer, 1984).

Acrobates Desmarest, 1818

Acrobates sp.
(Fig. 27A)

MATERIAL. QMF51982- QMF51983; QML1385, QML1284.

Acrobates sp. has been identified based on its diminutive size and the presence of a large P_3 , which distinguishes it from the only other member of the Acrobatidae, the New Guinea genus *Distoechurus*. On comparison with *Acrobates*, the specimens are very similar in size and overall morphology. There is only a slight difference in the posterobuccal morphology of the P_3 . The variation of this feature is unknown, therefore, the identification will remain conservative.

Family PHALANGERIDAE Thomas, 1888

Phalangerids have been found in most localities and either represent rainforest phalangerids or the more sclerophyl woodland species of *Trichosurus*. There is considerable difficulty when identifying phalangerids from partial jaws and isolated teeth because the best diagnostic features seem to be from the periotic (Crosby, pers.com.) and basicranial region (Flannery et al., 1987). Morphological conservatism obvious in fossil phalangerid taxa, including the Miocene *Strigocuscus reidi* and Early Pliocene *Strigocuscus notialis*, makes identification of this material particularly difficult. However, using features defined by Flannery et al. (1987) it is possible to refine the identification of phalangerids to generic level.

Strigocuscus Gray, 1862

Strigocuscus sp.
(Fig. 27F)

MATERIAL. QMF52003-QMF52008, QMF52071; QML1284, QML1284a, QML1384U, QML1385, QML1384L.

Strigocuscus sp. is represented by two partial right mandibles, a partial left mandible and several isolated premolars and molars. The specimens are placed within *Strigocuscus* based on the presence of the following features: 1. P_3 at an oblique angle to the molar row. 2. P_3 has more than four cuspules. 3. P_3 hypertrophic. 4. P_3 highest anteriorly. 5. Molars without complex crenulations. 6. Preprotocrista contacts parastyle

on M^1 . The fossils share their greatest similarity with *S. gymnotis* and *S. notialis*, which includes a distinctly large, antero-buccally oriented P_3 and a single-rooted P_2 . The specimens differ from *S. gymnotis* by being only slightly larger, possessing more cuspules on P_3 and having a distinct contact of the preprotocrista to parastyle. [Note: AMR22155, *S. gymnotis* from Parkop Village PNG does possess an M^2 with a preprotocrista contacting the parastyle albeit not as distinct as the fossil]. *S. reidi* Flannery & Archer, 1987 from the Miocene and *S. notialis* Flannery et al., 1987 from the Early Pliocene are phenetically very similar to *S. gymnotis*, however both possess distinct preparacristae contacting the parastylar corner of M^1 . Additionally *S. reidi* is larger than *S. gymnotis* and *S. notialis* is smaller. On balance, *Strigocuscus* sp. shares most features with *S. notialis*, except for being larger.

Trichosurus Lesson, 1828

Trichosurus sp. 1
(Fig. 27D)

MATERIAL. QMF52009-QMF52011; QML1312, QML1314, QML1420.

Trichosurus sp. 1 is represented by an edentulous right and a partial left mandible, two left partial maxillae, isolated molars and premolars. *Trichosurus* sp. 1 has been identified based on the following combined features: 1. P_2 absent. 2. P_3 , rectangular-shaped in lateral profile (as high anteriorly as posteriorly). 3. Gracile mandible in lateral profile.

Archer (1978) could not adequately differentiate modern species of *Trichosurus* based on molar morphology and size, this mainly being due to the extreme variation seen in the cosmopolitan *T. vulpecula*. One feature of note, present in both fossil mandibles, is a large cavity situated above the posterodorsal margin of the mandibular symphysis, which penetrates the lower incisor alveolus. This feature has not been seen in any phalangerid examined for this study yet the feature is present in both mandibles referred to *Trichosurus* sp. 1. Also, both jaws are from different faunas, being split by almost 100km. The association of the cavity with the incisor root suggests that this may be a pathology, which affected a large population of *Trichosurus* in central eastern Queensland.

Trichosurus sp. 2
(Fig. 27E)

MATERIAL. QMF52012, QMF52070; QML1311(H), QML1384L.

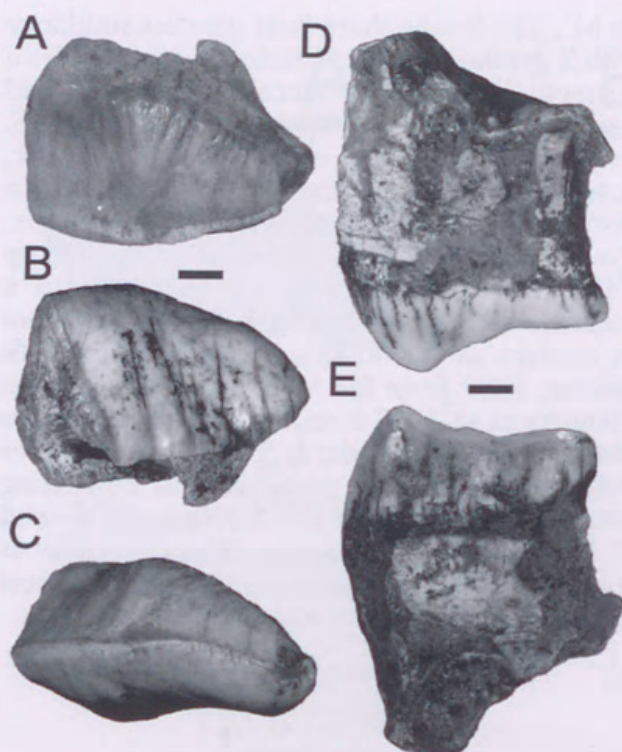


FIG 28. A-E, Thylacoleonidae; A-C, *Thylacoleo* sp.; QMF52069, RP³ in lingual, buccal & occlusal views. D-E, *Thylacoleo hilli*; QMF52013, RP³ in buccal & lingual views. Scale bar = 5mm.

A second, small species of *Trichosurus* is known from a single left mandible fragment preserving P₃ and M₁ and a portion of skull with right maxilla (P³-M⁴). The specimen is placed within *Trichosurus* based on: 1. A rectangular P₃ in lateral profile. 2. M₁ with distinct metaconid, positioned posterolingually to protoconid. 3. Reduced P₃ cuspules. 4. P₃ smaller than M₁. 5. Preprotocristid crest to paraconid. When compared to *T. vulpecula* and *T. caninus*, the fossil species is markedly smaller with a relatively larger M₁ to P₃. *Trichosurus* sp. 2 differs from the Early Pliocene *T. hamiltonensis* by possessing a smaller P₃ relative to M₁ and by being smaller in overall size. *Trichosurus* sp. is closest in morphology and size to *T. dicksoni* from the Miocene of Riversleigh. Because direct comparison to all trichosurin phalangerids, such as *T. arnhemensis*, was not possible a specific assignment will be left for a later analysis.

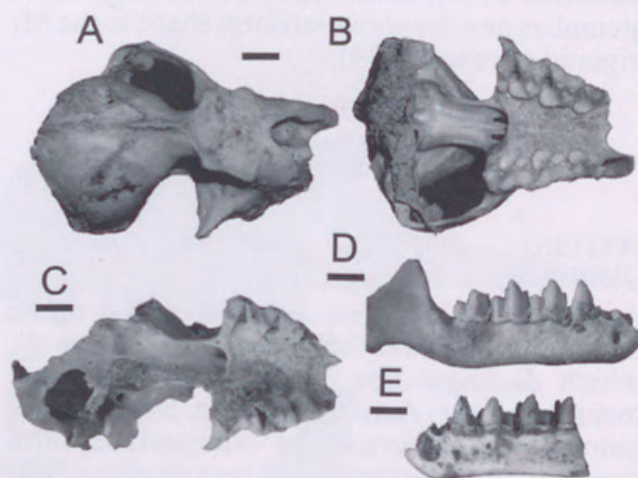


FIG 29. A-E, Megadermatidae; *Macroderma gigas*; A-B, QMF48021, partial skull in dorsal & ventral views. C, QMF48022, partial skull. D, QMF48006, RP₃-M₃. E, QMF48591, LP₄-M₃. Scale bar = 5mm.

Family THYLACOLEONIDAE Gill, 1872

Thylacoleo Gervais, 1852

Thylacoleo sp. (Fig. 28A-C)

MATERIAL. QMF1338, QMF52069; QML1420, QML1384L.

An isolated P₃ (QMF1338) and P³ (QMF52069) represent the distinctive marsupial carnivore, *Thylacoleo*. Comparison of the premolars with *Thylacoleo carnifex* and *T. crassidentatus* does not resolve its taxonomic position, because the posterior portions of both premolars are broken, thus a full morphometric analysis was not possible. Interestingly, both specimens show very little wear.

Thylacoleo hilli Pledge, 1977 (Fig. 28D-E)

MATERIAL. QMF52013; QML1311(H).

A single left P³ represents the smallest known species of *Thylacoleo*, *Thylacoleo hilli*. Identification of small thylacoleonid P₃'s has been subject to speculation that they may be deciduous premolars of larger species (Pledge, 1977; Archer, 1984; Archer & Dawson, 1982b). Archer & Dawson (1982) suggest that *Thylacoleo* probably did not have a significant deciduous premolar since no thylacoleonid material so far found preserves a dP³. The lack of a molariform premolar, resorption pits for the

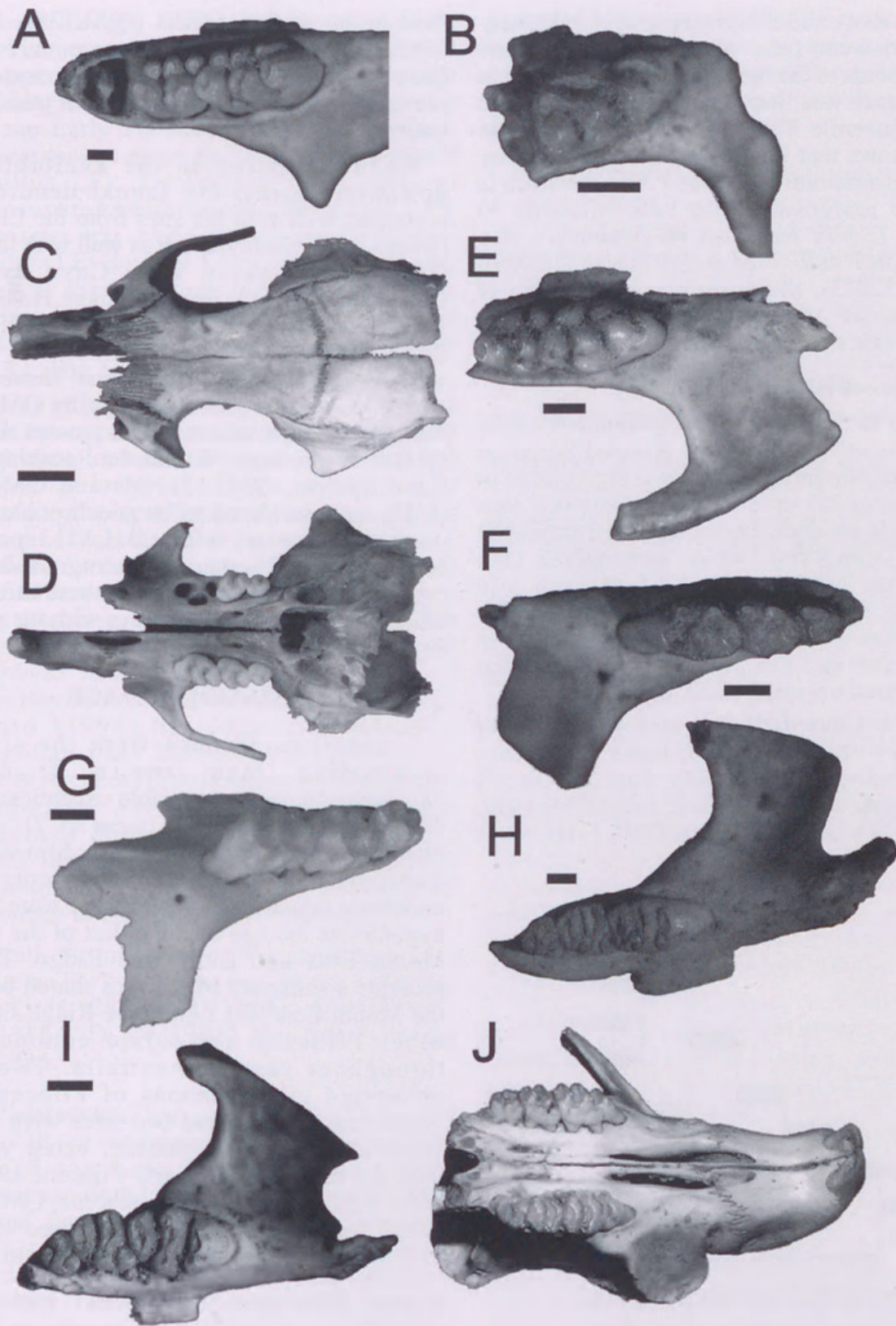


FIG 30. A-I, Muridae; A, *Conilurus* sp.; QMF52052, LM¹⁻². B, *Leggadina* sp.; QMF52040, LM¹. Scale bar = 1mm. C-D, *Uromys/Melomys* sp.; QMF52014, skull in dorsal & ventral views. Scale bar = 5mm. E-F, *Pseudomys* spp.; E, QMF52043, LM¹⁻². F, QMF52044, RM¹⁻³. G, *Pogonomys* sp.; QMF52022, RM¹⁻³. H, *Zyzomys* sp.; QMF52053, RM¹⁻³. Scale bar = 1mm. I, *Notomys* sp.; QMF52036, RM¹⁻³. J, *Rattus* sp.; QMF52033, partial skull. Scale bar = 5mm.

premolar roots and the presence of a relatively well used wear facet along the longitudinal shearing blade of the fossil premolar indicate that this specimen was from an adult. Comparison to obvious juvenile *T. carnifex* from Naracoorte Caves, shows that *Thylacoleo* did not have any deciduous dentition (pers. obs.). The specimen is therefore assigned to the Late Miocene to Pliocene *T. hilli* based on its diminutive size (24.4mm in *T. hilli* (Pledge, 1977) and 22.23mm for QMF52013), simplified posterior margin of the premolar and overall similarity to the holotype described by Pledge (1977).

BIOCHRONOLOGY

In order to develop a faunal chronology of the sites, each site needed to be grouped based on their faunal similarity and these groups placed in geochronological order. Presence/absence data was used to produce a dendrogram of similarity for sites using small-sized mammalian taxa (excluding bats) represented at each site (Appendix 1; Fig. 31). The analysis grouped sites with progressively dissimilar faunas from those of the present day. Fig. 31 shows the relationship of sites based on small-sized mammal fauna.

Olsen's Cave fauna shares the greatest similarity with the present day fauna. Five faunas fall successively further away from the Olsen's Cave fauna, first QML1312, then QML1420, QML1384U, QML1384L and QML1311C/D. A

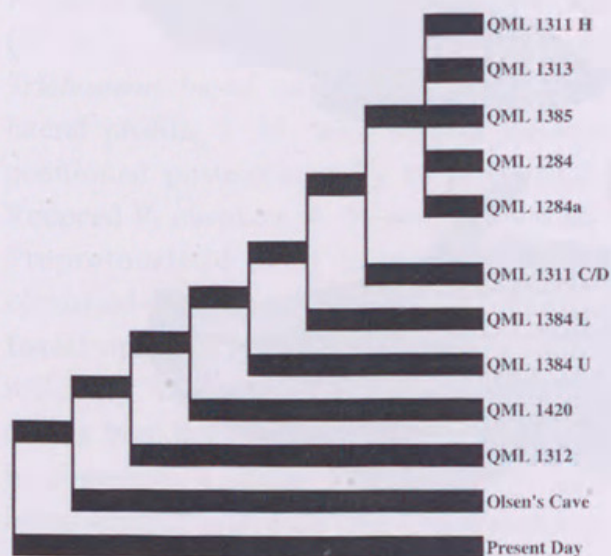


FIG 31. Dendrogram illustrating faunal similarity derived from small-sized mammal species from sites presented herein. Present day small-sized mammal fauna placed as the outgroup.

final group of five faunas (QML1284, 1284a, 1385, 1313 and 1311H) remain unresolved (polytomy) by the analysis and are considered to possess, equally, the least number of taxa shared with the present day.

When compared to the available site geochronologies, the faunal dendrogram correlates well with the sites from the Elephant Holes Cave System but not as well with the sites from the Speaking Tube Cave System. Geochronologically, the Elephant Hole Cave System sites range from the oldest (QML1385) through QML1384L and QML1384U to the youngest (QML1312). The faunal dendrogram correlates with the geochronology, by QML1312 sharing the most taxa with the present day and QML1385 the least. Within the Speaking Tube Cave System, QML1311(H) and QML1311 (C/D) are considered to be geochronologically contemporaneous, with QML1313 possibly being younger. The faunal dendrogram does not provide any further resolution to these sites, all of which share similarly few taxa with the present day.

ASSEMBLAGE AGE

A complete absence from the sites of mammalian taxa known from the Oligocene-Miocene (possible exceptions being *Thylacoleo hilli* and *Trichosurus* sp. 2) confines biocorrelation to sites of post Late Miocene age. Radiometrically-dated and biocorrelated vertebrate faunas from the Pliocene were used to hypothesise the age of the oldest of the sites at Mount Etna and Limestone Ridge. Table 4 presents a summary of the taxa shared between the Mount Etna and Limestone Ridge sites and other Pliocene vertebrate communities throughout eastern Australia. Two sites possessed mixed faunas of Pliocene and Pleistocene taxa. These two sites were simply classified as Plio-Pleistocene, being younger than the biocorrelated Early Pliocene sites and older than the dated late Pleistocene, QML1312. Table 5 summarises the hypothesised ages for each site yielding fauna identified herein.

Early Pliocene. The most dissimilar assemblages to those of the present day fauna possess several taxa confined to the Pliocene in other parts of Australia. These taxa include, *Thylacoleo hilli*, *Kurrabi* sp., *Protemnodon* sp. cf. *P. devisi* and the new perameloids. Of these taxa, *Thylacoleo hilli* and *Kurrabi* sp. are confined elsewhere in Australia to the Early

Pliocene (Pledge, 1977; Flannery & Archer, 1984; Flannery et al., 1992). Several undescribed taxa presented here share their closest morphological similarities with taxa only known from the Early Pliocene. These taxa include, *Strigocuscus* sp. close to *Strigocuscus notialis* (Hamilton LF); *Trichosurus* sp. 2 close to *Trichosurus hamiltonensis* (Hamilton LF); *Petauroides* spp. close to *Petauroides stirtoni* (Hamilton LF; Big Sink LF); *Pseudochirulus* sp. 1 close to *Pseudocheirus marshalli* (Hamilton LF); *Pseudokoala* sp. close to *P. erlita* (Hamilton LF); and *Kurrabi* sp. close to *K. merriwaensis* (Bow LF; Big Sink LF).

Noticeable occurrences of believed Pleistocene-aged taxa are also present in these assemblages, including *Macropus agilis siva* and *Sarcophilus lanarius*. There is uncertainty surrounding the identification of *Macropus agilis siva* in the fauna, therefore it may be incorrectly identified. *Sarcophilus lanarius* is positively identified here and is considered to be the earliest age for this taxon, rather than a younger age of the fauna. The previously oldest record of *Sarcophilus* is from the early Pleistocene of Nelson Bay (Gerdtz & Archbold, 2003) although Tedford (1994) has identified possible *Sarcophilus* from Parwan (Early Pliocene). Gerdtz & Archbold (2003) record the presence of *Sarcophilus harrisii* and *Sarcophilus moornaensis* during the early Pleistocene of Victoria, indicating a pre-Pleistocene origin of *Sarcophilus* and supporting the presence of *Sarcophilus* in the Pliocene of Australia.

Overall, the majority of biocorrelatable taxa indicate an Early Pliocene age for the following sites: QML1284, QML1284a, QML1384L, QML1311 C/D, QML1311 H, QML1313 and QML1385.

Plio-Pleistocene. Two sites, QML1384U and QML1420 are considered to be dated sometime between the Late Pliocene and middle Pleistocene. Both sites possess similar small mammal faunas, with QML1384U sharing a similar large portion of its small mammal fauna with the Early Pliocene sites. Unfortunately QML1384U is yet to yield megafauna, however, it is considered to be faunally intermediate between the Early Pliocene assemblage and QML1420. QML1420 fauna lacks the restricted Early Pliocene taxa and possesses Plio-Pleistocene and Pleistocene species, including; *Palorchestes* cf. *P. parvus*, *Macropus titan*, *Macropus agilis siva*, and *Megalania*

prisca. Additionally, QML1420 is considered to be pre-late Pleistocene in age based on its intermediate small mammal fauna between the Pliocene-aged assemblages and the dated late Pleistocene QML1312 fauna.

Late Pleistocene. QML1312 has been TIMS U-series dated using *Petrogale* dentition, providing a minimum age of 149,000 +/- 611 ybp. Faunally, QML1312 is intermediate between QML1420 and Olsen's Cave. The only distinctly Pleistocene taxon within the deposit is *Sarcophilus lanarius*. There are some elements of the fauna that show a lingering relationship to the older faunas, namely *Dendrolagus*, new genus of petauroid and *Thylacinus cynocephalus*.

Holocene. Olsen's Cave and QML1314 are considered to be post-late Pleistocene and probably Holocene in age based on the complete lack of megafauna (even though QML1314 site does collect large-sized macropodines) and the exclusive presence of extant taxa. Olsen's Cave fauna possesses the most similar small mammal fauna to the present day and the accumulation is subfossil in preservation.

FAUNAL SUCCESSION

To adequately reconstruct the faunal and palaeoecological succession from Early Pliocene through to the present day taphonomic processes must be considered and the maximum available source area of fauna must be estimated for each fossil site. This may be predicted by examining the gross taphonomic processes dominating the deposition of each faunal assemblage.

Two predominantly allochthonous accumulation modes are identified as accounting for all of the sites; these being pit-trap and/or predator accumulations. Thus, all large-sized fauna, which would have been too large for owls and Ghost Bats to dispatch, would have been derived from the immediate vicinity of the cave/fissure entrance. There is no indication for denning of large marsupicarnivores or major fluvial deposition as evidenced by the lack of gnaw marks on long bones and fluvially transported sediments. Smaller vertebrates would have been collected from the vicinity of the cave entrances as either allochthonous or autochthonous (cave dwelling) assemblages. Additionally, small vertebrates would have also been collected within the hunting ranges of both the Ghost Bat and owl, the only known cave-dwelling predators within the deposits.

	Mount Etna LF	Bluff Downs LF	Rackham's Roost LF	Chinchilla LF	Big Sink LF	Bow LF	Kanunka LF	Town Well Cave	Hamilton LF
MYA	QLD Early Pliocene 3.8	QLD Early Pliocene 3.8	QLD Early Pliocene 3-5	QLD late Early Pliocene 3.4	NSW Early Pliocene 3-5	NSW Early Pliocene 3-5	SA Late Pliocene 3.4	Mio-Pliocene	VIC Early Pliocene 4.46
<i>Thylacinus</i>	<i>cynocephalus</i>			<i>cynocephalus</i>					
<i>Antechinus</i>	spp.				sp.				
<i>Sminthopsis</i>	<i>murina</i>		sp.		sp.				sp.
<i>Dasyurus</i>	sp.	<i>dunmalli</i>		<i>dunmalli</i>		<i>dunmalli</i>			
Perameloid	gen. nov.			<i>bowensis</i>	gen. nov.	gen. nov.			
<i>Perameles</i>	sp. 1 & sp. 2					<i>bowensis</i>			cf. <i>Peroryctes tedfordi</i>
<i>Thylacoleo</i>	sp.	<i>allinghamensis</i>				<i>allinghamensis</i>			
<i>Thylacoleo</i>	<i>hilli</i>	<i>crassidentatus</i>		<i>crassidentatus</i>		<i>crassidentatus</i>			
<i>Protemnodon</i>	cf. <i>devisi</i>					<i>hilli</i>			
<i>Kurrabi</i>	sp.	<i>snewini</i>	cf. <i>snewini</i>	<i>devisi</i>	<i>devisi</i>	<i>chinchillaensis</i>	cf. <i>devisi</i>		sp.
<i>Bohra</i>	sp.			<i>wilkinsonorum</i>	cf. <i>merrriwaensis</i>	<i>merrriwaensis</i>	sp.		<i>plechenorum</i>
<i>Dendrolagus</i>	sp.								
<i>Macropus</i>	sp.					sp.	sp.		sp.
<i>Thylagale</i>	spp.	spp.		spp.		spp.	spp.		sp.
<i>Palorchestes</i>	cf. <i>parvus</i>	<i>selestiae</i>		<i>parvus</i>					ignis
Vombatidae	<i>Vombatus</i>	<i>Ramsayia</i>		? <i>Vombatus</i>		cf. <i>parvus</i>			sp. nov.
<i>Strigocuscus</i>	sp.					<i>Phascogonus</i>	<i>Vombatus</i>		gen. indet.
<i>Trichosurus</i>	sp. 2								<i>notialis</i>
Burramyidae	<i>Cercartetus</i>				<i>Cercartetus</i>				<i>hamiltonensis</i>
<i>Pseudokoala</i>	sp.								<i>Burramys</i>
<i>Pseudocheirus</i>	spp.								<i>erlita</i>
<i>Petauroides</i>	spp.								<i>marshalli</i>
<i>Pseudocheirops</i>	spp.	<i>winteri</i>			cf. <i>stirtoni</i>				<i>stirtoni</i>
Petauridae	gen. nov.								
<i>Macroderma</i>	<i>gigas</i>		<i>gigas</i>		<i>koppa</i>				<i>Petaurus</i>

TABLE 4. Biocorrelations of taxa in the hypothesised Early Pliocene Mount Etna Local Fauna.

Owls have hunting ranges of up to 10km² (Lindsey, 1992) and *Macroderma gigas* ranges over an area of 2km² (Toop, 1985; Nelson, 1989). Thus owls would have had the potential to collect vertebrates from both the limestone bluff and the surrounding lowlands. The present day range of an owl at Mount Etna would encompass both closed vegetation typical of limestone bluffs out into lowland open vegetation. Small creeks are present within the owl's range and thus provide a third possible hunting habitat along riverine areas. Ghost Bat foraging areas would be considerably smaller and source the majority of its prey from the immediate vicinity of the feeding roost.

Owls are not considered to be an active accumulator at Marmor Quarry and Ghost Bats are considered to have had little input into the small vertebrate accumulation, therefore, Marmor Quarry is considered to have collected most of its fauna from the immediate vicinity of the pit-trap entrance.

Where possible, fossil sites were equally sampled to remove any potential collecting bias at each of the sites. Only presence/absence data are used for faunal and palaeoecological successions, with no analysis of relative abundance, which would be most affected by sample size. Collections from QML1312 are restricted due to the site's destruction prior to the expeditions in 2000.

On balance, the majority of faunas described here are considered to have been representative of the ecologies in direct vicinity of the cave entrances for both Mt Etna and Marmor Quarry.

Anurans. Greatest diversity of frogs occurs in the Early Pliocene sites from Mount Etna and Limestone Ridge. Of the 22 frog taxa identified here, 20 are found in the Early Pliocene sites. *Cyclorana* is restricted to the Holocene Olsen's Cave fauna and is not present in any of the older sites. New fossil frog records for Australia include the Early Pliocene species of *Nyctimystes*, *Etnabatrachus maximus* and microhylids. New frog records for the Early Pliocene include species of *Crinia*, *Kyarannus*, *Lechriodus*, *Limnodynastes* and *Litoria*. The majority of the species present in the Early Pliocene are locally extinct by the late Pleistocene, leaving only a single species of *Limnodynastes*. Species of *Litoria* and *Cyclorana* occur in the Holocene assemblages. The present day frog fauna includes at least, *Cyclorana*, *Litoria*, *Limnodynastes* and

TABLE 5. Summarised ages for The Caves & Marmor fossil sites.

Holocene	Olsen's Cave QML1314
Late Pleistocene	QML1312
Plio-Pleistocene	QML1420 QML1384U
Early Pliocene	QML1313 QML1384L QML1311C/D QML1311H QML1284 QML1284a QML1385

Pseudophryne. The retention of *Litoria* and *Limnodynastes* into the present day fauna is not surprising as these genera are cosmopolitan in their distribution and habitat preferences.

Occurrence of *Neobatrachus* in the Early Pliocene is peculiar, representing a burrowing frog with a present day distribution restricted to arid areas. *Neobatrachus* has been recorded from the Pliocene of South Australia (Tyler, 1988; Tyler, 1994) in a palaeoecology that was wetter than today. Its presence within a predominantly rainforest frog fauna may be explained in a similar way as to the presence of the marsupial mole family, Notoryctidae, which occurs in a predominantly rainforest mammal fauna in the Oligo-Miocene of Riversleigh, yet it is confined to the arid zone of Australia today (Long et al., 2002). Adaptation for burrowing in soft rainforest soils may have allowed notoryctids to be pre-adapted to a later arid environment with soft sands. Similarly, it may be conceived that a burrowing frog that originated in rainforest would then be pre-adapted to life in the arid zone.

Chelids. Turtle fossils are restricted to the Early Pliocene localities and are a rare component of the assemblages. Freshwater turtles occur throughout the region today and are almost never encountered on the limestone karst. Turtle fossils would become absent from the record as karstification developed inhospitable ground for turtles to traverse.

Crocodylians. Crocodile specimens are generally restricted to the Early Pliocene sites and are rare. A single specimen is known from QML368 which has yet to yield a contemporaneous large-sized fauna that can be biocorrelated, however, the small-mammal fauna suggests a Pleistocene age.

Squamates. Agamids (Dragons) are rare, but have been found in all deposits from the Early Pliocene through to the present. Early Pliocene agamid remains are mostly unidentifiable, however, a single specimen is referable to a species of *Hypsilurus*. Diversity of agamids is greatest in the late Pleistocene with species of *Amphibolurus*, *Pogona* (small-morph) and *Tympanocryptis* present. *Diporiphora* replaces these in the Holocene. The present agamid fauna includes, *Diporiphora*, *Chlamydosaurus* and *Pogona barbata* (large-morph).

Gekkonids (Geckoes) have been found throughout the Pliocene to present, except in QML1420. Absence of gekkonids from QML1420 is considered an artefact of small collection size and the absence of a distinct predator accumulation. The large gekkonid form is present in the Early Pliocene sites but missing in the late Pliocene to present day. Due to their general rareness within the Early Pliocene sites, it is uncertain whether the absence of the large gekkonid from younger sites is a taphonomic bias or a Plio-Pleistocene extinction. The small gekkonid forms are present throughout the Pliocene to the present, however, they probably constitute several distinct taxa.

Large scincids (Skinks) are conspicuous in the Early Pliocene deposits. *Tiliqua* is known from the Early Pliocene and Holocene, but does not occur in the Late Pliocene-Pleistocene or late Pleistocene faunas. Species of *Tiliqua* are rare within any assemblage, represented by single specimens. Its absence from sites cannot be determined as either ecological or taphonomic. *Cyclodomorphus gerrardii* is the most common large skink and is found from the Early Pliocene to the present day, with the exception of site QML1312. The absence of *Cyclodomorphus* from QML1312 is not considered to be due to taphonomic bias because abundant remains of other large-sized skinks are present in this fauna. Instead, *Cyclodomorphus* is considered to have become locally extinct due to late Pleistocene aridity. By the present day, *Cyclodomorphus* had dispersed back into the Mt. Etna region. *Egernia* sp. is present throughout the Early Pliocene to Holocene. Large skinks found at Mount Etna today include *Tiliqua scincoides* and *Cyclodomorphus gerrardii*.

Varanids (Goannas & Monitors) are found from the Early Pliocene to the present day, with the exception of the Holocene faunal assemblage. This absence at Olsen's Cave is considered to be a taphonomic bias against large squamates (as with

large mammals) because the deposit is derived from an owl roost. Two varanids are present in the Early Pliocene, one the size of modern *Varanus varius*, the second much more massive but not attaining the size of Pliocene or Pleistocene species of *Megalania*. These two taxa persist into the late Pleistocene, however, are missing from QML1420. Varanids are represented at QML1420 by the giant varanid *Megalania prisca*.

Elapids (Venomous snakes) are found from the Early Pliocene to the present day. Conspicuous size difference can be seen when comparing the largest vertebrae of elapids in the Pliocene-Pleistocene with those from the late Pleistocene. The late Pleistocene elapids are up to twice the size of their Early Pliocene relatives.

Pythonines are found from the Early Pliocene to the present day. Madtsoiids have not been found. Python vertebrae tend to remain large-sized throughout the Pliocene to present day.

Typhlopids (Blind snakes) are only found in the Early Pliocene sites. This is the second record of fossil blind snakes in Australia and the first from the Pliocene. The first record was from the Oligo-Miocene Riversleigh deposits from far north Queensland (Archer et al., 1995b).

Typhlopids are a peculiar fossorial group with a cosmopolitan range today. A nocturnal ant/termite feeder, typhlopids represent a specialised niche within the Early Pliocene faunal assemblage at Mount Etna. The typhlopids seem to represent yet another group of fossorial animals, like the notoryctids (marsupial moles) and leptodactylids (*Neobatrachus*), which have utilised their adaptation for burrowing in ancient rainforests as an adaptative advantage with subsequent increasing aridity.

Aves. Four bird groups have been identified, including the quails (Galliformes), button quails (Gruiformes), song birds (Passeriformes) and owls (Strigiformes). The owls are a conspicuous component of all the fossil assemblages except QML1420. Their absence at QML1420 is considered to be due to taphonomic processes. All four groups exist in the area today. The Early Pliocene occurrence of owls is the oldest known in Australia.

Thylacinidae. *Thylacinus cynocephalus* is present from the Early Pliocene to late Pleistocene. *Thylacinus cynocephalus* is absent

from the Plio-Pleistocene site QML1384U, which is probably due to the taphonomic bias in that deposit toward smaller-sized mammals. *Thylacinus* is absent by the Holocene.

Dasyuridae. *Antechinus* spp. are present from the Early Pliocene through to the present day. During the Early Pliocene, *Antechinus* is represented by two species. By the late Pleistocene, these two species are extinct, having been replaced by *Antechinus flavipes* and *Antechinus swainsoni*. *Dasyurus* spp. are also present from the Early Pliocene through to the present day. During the Pliocene *Dasyurus* is represented by a medium-sized species. This species is replaced by *Dasyurus hallucatus* and *Dasyurus viverrinus* during the late Pleistocene. *Dasyurus hallucatus* and *Dasyurus maculatus* are found in the Holocene and present day fauna respectively. *Phascogale* has a possible appearance in the Early Pliocene with a small undescribed species. This species continues into the Pleistocene, however, it is extinct by the late Pleistocene, having been replaced with *Phascogale topoatafa*. *Planigale maculata* appears in the late Pleistocene and remains in the Holocene and present day fauna. An extinct, undescribed, small planigale-like dasyurid is present in the Pliocene but is extinct by the Pleistocene. Species of *Sarcophilus* are present from the Early Pliocene to late Pleistocene and possibly Holocene. *Sarcophilus lanianus* is known to occur from the Early Pliocene to late Pleistocene. A single specimen of *Sarcophilus harrisii* is present in the late Pleistocene-Holocene from Lower Johansen's Cave (QML1314). Species of *Sminthopsis* occur in the Early Pliocene but are rare within the Pliocene assemblages. During the late Pleistocene *Sminthopsis* represents the most abundant small-sized dasyurid, represented by two species, *Sminthopsis murina* and *Sminthopsis macroura*.

Vombatidae. A species of *Vombatus* is represented by three specimens, one in the Early Pliocene and two in the Plio-Pleistocene site QML1420. *Vombatus* is not present in the area by the late Pleistocene.

?*Zygomaturine*. This large-sized diprotodont is only known in the region from the Plio-Pleistocene (QML1420).

Palorchestidae. *Palorchestes* sp. cf. *P. parvus* is present in the Early Pliocene and in the Plio-Pleistocene (QML1420).

Macropodidae. *Bohra* sp. is only present in the Early Pliocene. Species of *Dendrolagus* are present from the Early Pliocene to late Pleistocene. Species of *Thylogale*, *Petrogale* and *Macropus* are all present from the Early Pliocene to the present day. *Protemnodon* sp. cf. *P. devisi* and *Kurrabi* are only present in the Early Pliocene. *Macropus titan* is restricted to the Plio-Pleistocene of Marmor Quarry and is absent from the late Pleistocene. This is the first record in Australia of *Dendrolagus* in the Pleistocene and the second record of *Bohra* in the Pliocene (Dawson, 2004).

A conspicuous absence from the macropod fauna are the morphologically distinct potoroids, in particular *Potorous* and *Hypsiprymnodon*. Although they may turn up in future collections, the sample sizes at present suggest that this may be unlikely and that this group of macropods was absent from the Early Pliocene of Mt. Etna. Interestingly, the small macropod fauna at Mt. Etna includes several small-sized macropodids, namely *Thylogale* sp. 1, which is very similar to the Irian Jayan *Thylogale christenseni*. Furthermore, there are no potoroids known from the present day or fossil record of Papua New Guinea and Irian Jaya, yet the small macropodid faunas tend to be either species of *Thylogale* or *Dorcopsis*. The disjunct nature of this macropodid fauna, where the Early Pliocene Mt. Etna fauna more closely resembles those from Papua New Guinea and Irian Jaya, is also seen in the Pseudocheiridae.

Pseudocheiridae. Pseudocheirids are considerably diverse during the Pliocene but are locally extinct by the late Pleistocene, returning in the Holocene as a rarity and abundant in the present day as a single taxon, *Pseudocheirus peregrinus*.

Pseudochirulus spp. are present in the Early Pliocene, including *Pseudochirulus* sp. 1 which is very similar to the Early Pliocene Hamilton Fauna *Pseudochirulus marshalli* and the modern Papua New Guinean *Pseudochirulus canescens* and *Pseudochirulus mayeri*. Similarly, taxa referred to here as *Petauroides* share closer taxonomic affinities with species from both the Early Pliocene Hamilton Fauna and the late Pleistocene Irian Jayan Fauna, than they do to the modern *Petauroides* and *Hemibelideus* from far north Queensland forests and rainforests.

Petauridae. The new genus of petaurid is present with two species in the Pliocene and one species in the Plio-Pleistocene and late Pleistocene. It is

extinct by the Holocene. *Dactylopsila* is present in the Pliocene but is locally extinct by the Pleistocene. This is the first post Miocene, and pre Holocene, record of *Dactylopsila* in Australia. *Dactylopsila* sp. 2 is diminutive in size relative to any living species, however, it is very close to the extinct Irian Jayan taxon, *Dactylopsila kambuayai*, which along with the macropodids and pseudocheirids illustrates a possible faunal connection to Papua New Guinea and Irian Jaya during the Early Pliocene.

Superfamily incertae sedis. A new genus and species of possum with unknown phylogenetic and taxonomic affinities is present in the Early Pliocene but has yet to turn up in younger sediments.

Acrobatidae. *Acrobates* occurs in the Early Pliocene and has not been found in younger sediments. This is the first record of acrobatids in the Pliocene of Australia.

Burramyidae. *Cercartetus* occurs in the Pliocene but is not found in younger sediments. The only other Pliocene record of *Cercartetus* is from the Big Sink Fauna (Dawson et al., 1999).

Phalangeridae. *Strigocuscus* is present in the Pliocene but is absent by the Pleistocene. *Trichosurus* is represented by two species, the first confined to the Early Pliocene and the second found in the Pleistocene, Holocene and present day.

Thylacoleonidae. Two species of *Thylacoleo*, one small and one large species, occur in the Early Pliocene whilst one large species has been found in the Plio-Pleistocene (QML1420). No remains of *Thylacoleo* have yet been found in late Pleistocene deposits.

Peramelidae. Species of *Perameles* occur throughout the Pliocene and into the present day. During the Pliocene and Plio-Pleistocene times, *Perameles* was represented by two extinct species. By the late Pleistocene to Holocene, these species were replaced by *Perameles bougainville* and eventually *Perameles nasuta*. *Isodon* occurs in the Plio-Pleistocene to present day. *Isodon* is represented by two small-sized species in the Plio-Pleistocene and late Pleistocene sites, *Isodon obesulus* and *Isodon* sp. During the Holocene, small-sized *Isodon* were replaced with the larger *Isodon macrourus*. During the late Pleistocene both *Chaeropus* and *Macrotis* appeared, leaving no further record.

Perameloid incertae sedis. An enigmatic family of bandicoots possibly related to the Oligo-Miocene Yaralidae are restricted to the Pliocene-aged deposits.

Muridae. Rodents are a conspicuous element of every deposit. Early Pliocene rodents include the first records of many rainforest taxa with no previous fossil records in Australia. Several taxa are found to dominate the Pliocene sites with possible Plio-Pleistocene records. These include *Melomys/Uromys*, *Pogonomys* and *Mesembriomys*. *Zyzomys* is present from the Pliocene to late Pleistocene. *Leggadina* is found in the late Pleistocene to Holocene. *Conilurus* is found in the late Pleistocene. *Rattus* is found from the Plio-Pleistocene to present day. *Pseudomys* is found from the Pliocene to present day. *Notomys* is restricted to the late Pleistocene. *Hydromys* has been recovered from the Early Pliocene, Plio-Pleistocene (QML1420) and present day faunas.

Microchiropterans. Bats are found in all deposits, except QML1420. *Macroderma gigas* is found from Early Pliocene to the present day.

PALAEOECOLOGICAL SUCCESSION

EARLY PLIOCENE

Nonseasonal, Mesothermal, angiosperm-dominant rainforest with emergent gymnosperms; minor grassy understory.

Rainforest has been indicated both locally by the fauna and regionally through palynological studies of the Early Pliocene. Two pollen cores, Aquarius Well (Fig. 1A,5) (Hekel, 1972) and ODP815 (Fig. 1A,4) (Martin & MacMinn, 1993), located off the central eastern Queensland coast are close to the fossil sites. The Aquarius Well core was taken from the edge of the Capricorn Trough, which is located to the NE of Mount Etna and Marmor Quarry (Fig 1). Hekel (1972) published the palynological record of Aquarius Well, showing a dramatic increase in rainforest flora in the region post Late Miocene and dominating the entire Early Pliocene.

ODP815 drill core (Martin & MacMinn, 1993) from the Marion Plateau to the NE of Mount Etna shows an Early Pliocene dominated by rainforest flora. Macphail (1997) reviewed both the Aquarius Well and ODP815 records and concluded that the dominant vegetation type during the Early Pliocene would have been an angiosperm-dominated mesotherm rainforest with Araucaraceae. Low pollen counts for

rainforest angiosperm taxa were considered to be an artefact of taphonomic bias toward more dispersible taxa, however, no conclusions could be drawn as to how dominant or complex the rainforest angiosperms were. Macphail (1997) suggests that the climate required to support such a vegetation structure would include temperatures greater than 20°C, and an annual precipitation rate of between 1300 and 2000mm.

Fauna recovered from Early Pliocene-aged sites within the local area of Mount Etna and Limestone Ridge support the presence of rainforest at the time, as follows;

Anurans. Microhylids are recorded from the Early Pliocene deposits and, although rare, indicate a very moist rainforest environment. *Nyctimystes* is presently known from rainforests of far north Queensland and Papua New Guinea, whilst *Lechriodus* is known from rainforest in southeastern Queensland and Papua New Guinea. *Kyarranus*, although not exclusively rainforest dwelling, is restricted to areas of constant moisture in areas close to or within montane rainforest or wet sclerophyll. Interestingly, the suite of frog genera identified in the Early Pliocene is similar to that recorded from the interpreted rainforest ecologies present during the Oligo-Miocene of Riversleigh (*Litoria*, *Limnodynastes*, *Kyarranus*, *Lechriodus*, and *Crinia*) (Tyler, 1991; Tyler 1994) and to those identified from the montane rainforests of Papua New Guinea (Menzies et al., 2002).

The overall abundance and diversity of small-sized frogs and the presence of only a single, rare, monotypic giant frog (*Etnabatrachus maximus*) indicates that the area experienced a reliable (non-seasonal) precipitation regime (Tyler, 1994).

Squamates. Several squamates indicate a predominantly rainforest ecology during the Early Pliocene. The most abundant large-sized squamate present in any of the Early Pliocene deposits is *Cyclodomorphus gerrardii*. Although also found in dry sclerophyllous vegetation today, *Cyclodomorphus gerrardii* is most frequently encountered in wet sclerophyll and rainforest. *Hypsilurus* sp. has been identified from the Early Pliocene. This agamid genus is rainforest-restricted, present only in rainforests of southeastern Queensland, the Wet Tropics and Papua New Guinea.

Mammals. Several analyses of Australian mammal biogeography have focussed on determining correlative values that describe the patterns seen in rainforest mammal distributions (Braithwaite et al., 1985; Williams, 1997; Kanowski et al., 2001; Kanowski et al., 2003; Winter, 1988; Winter, 1997; Laurance, 1997; Nix & Switzer, 1991). These correlative values encompass several different categories into which the mammals found in rainforests have been placed. These categories include broad definitions such as "Rainforest Specialists Species", "Forest Generalists Species", "Rainforest Ecotone Species", "Generalist Species" and "Independent Species" (Winter, 1988); or more specific definitions, such as the eleven defined tropical mammal guilds of Braithwaite et al. (1985). Williams (1997) used Braithwaite et al.'s guilds to describe patterns seen in mammal species of the Wet Tropics rainforest. Other authors (Kanowski et al., 2001; Kanowski et al., 2003; Winter, 1997; Laurance, 1997; Nix & Switzer, 1991) have either focussed on a single or a combination of ecological parameters to describe patterns in rainforest mammal species-richness. These parameters include; modelled palaeoclimate, floristics, altitude, geology, precipitation, rainforest shape and size, latitude, temperature, habitat fragmentation and predators. These criteria developed for modern rainforest mammals have been utilised here in identifying the palaeoecological parameters of the Early Pliocene environment, since several extant mammal genera (and possibly species) with obvious rainforest affinities occur in the Early Pliocene sites.

Ecological Specialisation.

Forteen extant mammal species were identified by Winter (1988) to be rainforest specialists and restricted to northern Queensland. Of these taxa, eight are considered to be rainforest specialist genera (*Phalanger*, *Uromys*, *Pogonomys*, *Pseudocheirops*, *Pseudochirulus*, *Hypsiprymnodon*, *Hemibelideus* and *Dendrolagus*). In the Early Pliocene assemblages, five of these eight genera are present, with the absence of *Phalanger*, *Hypsiprymnodon* and *Hemibelideus*.

Rainforest-restricted mammal species were determined for Australia and New Guinea by using Strahan (1995) and Flannery (1994) respectively. The genera *Strigocusus* and

Fossil Taxon	Present Day Analogue	Guild
Thylacinidae		
<i>Thylacinus</i>	<i>Thylacinus cynocephalus</i>	VLTC
Dasyuridae		
<i>Antechinus</i> sp. 1	<i>Antechinus</i>	SSI
<i>Antechinus</i> sp. 2	<i>Antechinus</i>	SSI
<i>Dasyurus</i> sp.	<i>Dasyurus</i>	MSI/C
<i>Phascogale</i> sp.	<i>Phascogale</i>	SSI
<i>Sarcophilus lanarius</i>	<i>Sarcophilus harrisii</i>	LTC
<i>Sminthopsis murina</i>	<i>Sminthopsis murina</i>	SSI
dasyurid new	<i>Planigale</i>	STI
Vombatidae		
<i>Vombatus ursinus mitchelli</i>	<i>Vombatus ursinus</i>	VLTH
<i>Palorchestes</i> sp. cf. <i>P. parvus</i>	None	VLTH
diprotodont indet	None	VLTH
Macropodidae		
<i>Bohra</i> sp.	None	LSH
<i>Dendrolagus</i> spp.	<i>Dendrolagus</i>	LAH
<i>Thylogale</i> sp. 1	<i>Thylogale christenseni</i>	MTH
<i>Thylogale</i> sp. 2	<i>Thylogale stigmata</i>	LTH
<i>Petrogale</i>	<i>Petrogale</i>	LTH
<i>Macropus</i> sp. 1	<i>Macropus dorsalis</i>	LTH
<i>Protemnodon</i> cf. <i>P. devisi</i>	None	VLTH
<i>Kurrabi</i>	None	LTH
Pseudocheiridae		
<i>Pseudochirulus</i> sp. 1	<i>Pseudochirulus mayeri</i>	SAH
<i>Pseudochirulus</i> sp. 2	<i>Pseudochirulus canescens</i>	MAH
<i>Pseudochirulus</i> sp. 3	<i>Pseudochirulus herbertensis</i>	SAH
<i>Pseudocheirus</i> spp.	<i>Pseudocheirus</i> spp.	SAH
<i>Petauroides</i>	<i>Petauroides/Hemibelidius</i>	SAH
<i>Pseudocheirops</i> sp. 1	<i>Pseudocheirops</i>	MAH
<i>Pseudocheirops</i> sp. 2	<i>Pseudocheirops</i>	MAH
<i>Pseudokoala</i>	None	LAH
Petauridae		
gen. et sp. nov. 1	<i>Petaurus</i>	SAN-I
gen. et sp. nov. 2	<i>Petaurus</i>	SAN-I
<i>Dactylopsila</i> sp. 1	<i>Dactylopsila</i>	SSI
<i>Dactylopsila</i> sp. 2	<i>Dactylopsila</i>	SSI
Incerti Sedis		
gen. et sp. nov.	None	SAN-I
Acrobatidae		
<i>Acrobates</i> sp.	<i>Acrobates</i>	SAN-I
Burramyidae		
<i>Cercartetus</i> sp.	<i>Cercartetus</i>	SAN-I
Phalangeridae		
<i>Strigocuscus</i>	<i>Strigocuscus</i>	LAH
<i>Trichosurus</i> sp. 2	<i>Trichosurus</i>	LAH

Fossil Taxon	Present Day Analogue	Guild
Thylacoleonidae		
<i>Thylacoleo hilli</i>	None	LSC
<i>Thylacoleo</i> sp.	None	VLSC
Peramelidae		
<i>Perameles</i> sp. 1	<i>Perameles</i>	MTO
<i>Perameles</i> sp. 2	<i>Perameles</i>	MTO
Perameloid fam. Incertae sedis		
gen. et sp. nov. 1	<i>Perameles/Peroryctes</i>	MTO
gen. et sp. nov. 2	<i>Perameles/Peroryctes</i>	MTO
Muridae		
<i>Hydromys</i>	<i>Hydromys</i>	MQO
<i>Pseudomys</i> spp.	<i>Pseudomys</i>	STO
<i>Zygomys</i>	<i>Zygomys</i>	STO
<i>Uromys/Melomys</i>	<i>Uromys/Melomys</i>	SSH
<i>Pogonomys</i>	<i>Pogonomys</i>	SSH
<i>Mesembriomys</i>	<i>Mesembriomys</i>	MSO

TABLE 6. Mammalian guilds defined for the Early Pliocene. Guild traits expanded from Braithwaite et al., (1985). Abbreviations: Size: S. Small, <200g; M. Medium 200g-3kg; L. Large 3kg-20kg, VL Very Large >20kg. Microhabitat: A. Arboreal, T. Terrestrial, S. Scansorial, Q. Semi-aquatic. Diet: N - Nectarivore, I - Insectivore, O - Omnivore, C - Carnivore, H - Herbivore.

Dactylopsila are presently rainforest-restricted and are found in the Early Pliocene at Mt Etna.

Additionally, *Cercartetus* sp. is considered to be very close to, if not conspecific with, *Cercartetus caudatus*, and although *Cercartetus* is not a rainforest-restricted genus, *Cercartetus caudatus* is a distinct rainforest specialist (Winter, 1988). *Antechinus* sp. 1 is considered to be very close to the rainforest-restricted *Antechinus adustus* (Van Dyck & Crowther, 2000).

Mammal guilds and species richness

Palaeoecological reconstruction using extant rainforest-restricted and specialist taxa as analogues provides good evidence for the presence of rainforest during the Early Pliocene. Defining the different mammalian guilds and the species richness present at sites allows for an extension of the palaeoecological reconstruction to include possible correlations with floristic diversity and climate as seen in modern day rainforest studies (Braithwaite et al., 1985; Heads, 2002; Williams, 1997).

Braithwaite et al. (1985) defined Australian tropical mammal guilds on the basis of three

traits; 1. Body size (small <200g, medium 200-3kg, and large 3kg-10kg); 2. Microhabitat (arboreal, scansorial and terrestrial); and 3. Diet (insectivore, nectavore, folivore/frugivore (here classed as herbivore), carnivore, omnivore and granivore). Allocation of these three traits to the taxa from the Early Pliocene was achieved by choosing the closest living analogue or determining each trait from morphology. Table 6 lists the Early Pliocene mammalian fauna, their modern analogues and defined guild type based on Braithwaite et al.'s traits.

Most of the fossil taxa were able to be assigned to their equivalent modern day analogue by means of genus-level identity. Most species within the analogue genus shared traits defined for that genus' guild, with the possible exception of size. For genera with unknown modern analogues, the closest living taxon to the extinct taxon was used, with inferences drawn for each trait based on family-level trait similarity. For example, *Pseudokoala* was defined as being a large-sized (>3kg), arboreal herbivore, based on its much larger size when compared to the largest living pseudocheirid (*Pseudocheirops* - <3kg); and because all living pseudocheirids are arboreal and herbivorous.

The remaining taxa are those with no family-level trait similarities to modern groups (Diprotodontidae, Palorchestidae and Thylacoleonidae). All three of these families are characterised by being very large-sized (>20kg), with the exception of *Thylacoleo hilli*, which is considered here to be large-sized (between 10 and 20kg) (Wroe et al., 2004). Based on the very-large size of these mammals, a fourth body size trait is added here. Two mammal families are considered to be terrestrial in their microhabitat due to their very large size, with the exception of *Thylacoleo*, which is here considered to be scansorial. Diprotodontidae and Palorchestidae are considered to be herbivores and members of the Thylacoleonidae to be carnivores.

All of the guilds defined by Braithwaite et al. (1985) were present in the Early Pliocene at Mt Etna. Nine new guilds were identified that did not fit the 11 guilds defined by Braithwaite et al. (1985) and are here considered to be either present in the Wet Tropics, Papua New Guinea/Irian Jaya or extinct from rainforests today. These nine guilds were; 1. Small-sized, arboreal, herbivore (SAH) (e.g. *Pseudochirulus mayeri*, *Pseudochirulus* sp 1., *Pseudocheirus* sp.

1-2). This guild is present today in Papua New Guinea and Irian Jaya; 2. Medium-sized arboreal herbivore (MAH) (e.g. *Pseudochirulus* spp., *Pseudocheirops* spp.). Today present in the Wet Tropics, Papua New Guinea and Irian Jaya; 3. Large-sized, scansorial carnivore (LSC) (e.g. *Thylacoleo hilli*), which is extinct; 4. Medium-sized terrestrial herbivore (MTH) (e.g. *Thylogale* sp. 1, *Thylogale christenseni*), recently extinct in Irian Jaya (Hope, 1981); 5. Medium-sized, semi-aquatic omnivore (MQO) (e.g. *Hydromys*), present in the Wet Tropics, PNG and Irian Jaya; 6. Large-sized, scansorial herbivore (e.g. *Bohra* sp.), which is now extinct; 7. Very large-sized, terrestrial herbivore (VLTH) (e.g. *Palorchetes*, diprotodont), extinct; 8. Very large-sized terrestrial carnivore (VLTC) (e.g. *Thylacinus*), extinct; and 9. Very large-sized scansorial carnivore (VLSC) (e.g. *Thylacoleo*), extinct.

Braithwaite et al. (1985) illustrates that the greatest number of mammalian guilds found in the Australian tropics are located in the habitat classified as rainforest. Williams (1997) illustrates that three guilds; small, scansorial, insectivores; large, arboreal, herbivores; and small, scansorial, omnivores, are important in determining species richness in modern rainforest of the Wet Tropics and are also the most extinction prone. All three of these guilds are present in each of the interpreted Early Pliocene sites at Mt. Etna.

Williams (1997) also shows that overall species richness in rainforest is positively influenced by guild diversity, rainforest shape, area and habitat diversity (rainfall and vegetation diversity). According to Williams (1997), the number of small to large-sized mammalian guilds present in the most species rich locations of the present day Wet Tropics is nine. The number of small to large sized mammalian guilds from individual sites in the Early Pliocene of Mount Etna ranges from ten to thirteen.

Williams (1997) identifies two regions of the northern Queensland Wet Tropics that possess the greatest species richness (21-26 spp), greatest number of endemic mammal species (4-8 spp.) and thus the greatest number of guilds (9) of rainforest mammals in Australia. These two areas are defined by Williams as the Windsor and Carbine Uplands, and the Lamb, Atherton, Bellenden-Ker/Bartle-Frere & Kirrama Uplands. Both regions have their greatest area above 1000m altitude and possess the greatest

vegetation diversity of the Wet Tropics. The present day climatological parameters needed to sustain such a large number of guilds and high species richness for these two upland regions is a high consistent (nonseasonal) precipitation rate (>2000mm) with a moderately cool to cool annual temperature regime (meso-megathermal; 21-23°C) (Nix, 1982; Winter, 1997).

Rainforest areas of the Papua New Guinean central highlands show similar species richness of mammals (24-29 spp) (Heads, 2002). These regions are defined by Nix (1982) as a nonseasonal mesothermal-microthermal (12-14°C) climate.

The similarities seen here for both the Wet Tropics and Papua New Guinea suggest that both regions possess their greatest mammalian species richness and guild diversity in areas that have a relatively cool climate with nonseasonal high annual rainfall. Each of the Early Pliocene sites from Mt. Etna possess from at least 21 to 30 small to large-sized mammal species. This species richness is similar to that found in Papua New Guinea and the Wet Tropics of today, however, this does not account for the very large-sized taxa also present in the Early Pliocene.

When considered together; guild diversity, species richness, specialist and endemic taxa, the Early Pliocene faunal assemblage strongly indicates the presence of a diverse rainforest habitat, which was subject to regular nonseasonal high rainfall in a mesothermal climate regime (20-23°C). The entire fauna strongly indicates a vegetation structure that included several levels of complexity to house diverse guilds containing, arboreal, scansorial, terrestrial, fossorial, semi-aquatic and aquatic niches. On the basis that the fossil sites are not found higher than 200m above sea level today, the Early Pliocene rainforest could be considered to be lowland rainforest. The diversity of mammalian nectavores, herbivores and insectivores indicates the presence of an equally diverse angiosperm flora, possibly more diverse than what is indicated in the ODP 815 and Aquarius Well pollen cores. The very rare occurrence of grazing macropods and a single wombat specimen indicates the presence of small areas of grasslands or grassy understorey within the Mt. Etna area.

PLIO-PLEISTOCENE.

Seasonal, mesothermal, mosaic rainforest-sclerophyll forest with chenopod, asteraceae and grassy understorey.

The Plio-Pleistocene pollen record for central eastern Queensland shows an increased seasonality toward the end of the Late Pliocene and into the Pleistocene with an increase in the sclerophyllous vegetation and decrease in several rainforest groups (Martin & McMinn, 1993). Podocarps, aruarcarians and ferns decrease with an increase in Casuarinaceae in the Aquarius Well core (Hekel, 1972). Similarly gymnosperms, rainforest angiosperms and ferns decrease during the Plio-Pleistocene of ODP815. A sudden increase in Chenopodaceae and Asteraceae is seen in the Plio-Pleistocene Aquarius Well record (Hekel, 1972), and a steady increase in these two floristic groups is seen toward the Late Pliocene and Pleistocene in the ODP815 core (Martin & McMinn, 1993).

Two sites record the Plio-Pleistocene vertebrate record of central eastern Queensland (QML1384U and QML1420). This is due to the intermediate faunal similarity between the Early Pliocene rainforest faunal assemblage and the late Pleistocene faunal assemblage. QML1384U retains the distinct rainforest signal found in the Early Pliocene, however, there are a number of differences that may reflect a more seasonal climate. Additionally, QML1420, has a fauna that shows a more seasonal, open habitat.

Frogs. Only two frog species have been identified in the Plio-Pleistocene faunal assemblage, *Litoria* and *Kyarranus*. Although specimens are abundant at QML1384U, the presence of so few frog taxa may reflect a less complex vegetation and precipitation regime during this time. Neither taxon is specifically rainforest-dwelling, however, *Litoria* sp. indicates an arboreal environment and *Kyarranus* sp. indicates areas of permanent moisture.

Squamates. The presence of *Cyclodomorphus gerrardii* indicates a closed, wet, forest system.

Mammals. Although the mammal species are similar to those from the Early Pliocene, several taxa have been replaced by species with a broader environmental tolerance. *Antechinus flavipes* is present in the Plio-Pleistocene and possibly possesses a broader ecological range than that hypothesised for *Antechinus* sp. 1 and *Antechinus* sp. 2, which it replaces. *Sminthopsis macroura* also appears in Plio-Pleistocene, which may indicate a dry, open environment based on its present day distribution. Extant *Sminthopsis macroura* are commonly found in chenopod shrublands throughout central Australia

(Strahan, 1998), therefore the presence of chenopods in the Plio-Pleistocene pollen record could have provided suitable habitat for this species.

Arboreal possums continue to constitute a large portion of the QML1384U fauna, less so QML1420. Pseudocheirids are represented by three genera (*Pseudochirulus*, *Pseudocheirus* and *Petauroides*), petaurids with two genera (*Dactylopsila* and new genus), burramyids by *Cercartetus*, and phalangerids by *Strigocuscus*. The abundance of arboreal herbivores, insectivores and nectavores, indicates the retention of some rainforest and a dominance of angiosperms in the vicinity of Mt Etna.

Bandicoot diversity shows changes from the Early Pliocene with the appearance of two species of *Isodon*. *Isodon obesulus* possibly indicates a more mosaic vegetation structure (Strahan, 1998).

Macropod diversity remains high at QML1420, with a strong component of grazing macropodids, indicating the presence of more extensive grasslands at Marmor Quarry.

The mammal assemblage at QML1420 indicate a mosaic of environments present in the area, including open areas with grasses (*Macropus* spp., *Vombatus*, *Megalania prisca*, zygomaturine), closed forest (*Dendrolagus*, *Thylogale* sp. 2, *Trichosurus*, Petauroid new genus and *Melomys/Uromys*) and semi-aquatic (*Hydromys*).

LATE PLEISTOCENE (ca. 149, 000 ybp)

Dry, open arid-zone with closed 'refugial' forest.

The pollen record for the late Pleistocene is absent at Aquarius Well and ODP815, demarcated by a hiatus of deposition and correlated with sea level fall (Hekel, 1972; Martin & McMinn, 1993). As an alternative, Lynch's Crater (Fig. 1A, 2), far north Queensland provides a better late Pleistocene record for Queensland (Kershaw, 1986). Kershaw (1986) estimates an annual precipitation rate which is 50% lower than the present day approximately 150,000 years ago. If it is hypothesised that the Mt. Etna area experienced a similar relative decrease in annual precipitation rate during this period of time, then the annual precipitation rate would have been less than 500mm (present day annual rainfall is between 800-1000mm, Data from Bureau of Meteorology: www.bom.gov.au). An annual precipitation rate of below 500mm is equivalent to the precipitation rate currently recorded in central western Queensland,

approximately 600kms to the west of Rockhampton. The late Pleistocene faunal assemblage reflects the very dry components of this ecology, however, it also records remnants of more mesic, probably refugial, environments.

Frogs. Frog diversity is low with only a single taxon so far positively identified and a complete absence of hylids (tree frogs).

Squamates. Squamate diversity is high, with most taxa identified, presently existing in the Australian arid zone. The squamates comprise, three agamids, all of which are currently restricted to the arid zone of central Australia; at least three species of skink; two large-sized varanids and several elapids. The absence of *Cyclodomorphus gerrardii* supports the contention for a very dry habitat.

Mammals. A distinct faunal change demarcates the late Pleistocene mammal assemblage from the older faunas of the same area. The small to large-sized dasyurids illustrate a diversity of insectivorous and carnivorous niches available within the ecology. There is retention of *Antechinus flavipes*, *Dasyurus hallucatus*, *Sminthopsis murina* and *Sminthopsis macroura* from older assemblages, with the addition of *Antechinus swainsonii*, *Dasyurus viverrinus*, *Planigale maculata* and *Phascogale topoatafa*. *Antechinus swainsonii* indicates the presence of closed wet environments, as do *Antechinus flavipes*, *Sminthopsis murina* and *Planigale maculata*. The remaining three new taxa lend evidence to the presence of dry sclerophyll in the region because all three extend into these environments today. Macropodines also indicate the presence of both open and closed environments with *Macropus* indicating grasses and *Thylogale* sp. 2 and *Dendrolagus* occupying closed forest. Possums are almost entirely absent with only two taxa present, *Trichosurus* sp. 1 and the new genus of petauroid.

Perameles bougainville appears in the record during the late Pleistocene, indicating the presence of dry open environments with shrubby, possibly chenopod-dominant ground cover. *Isodon obesulus* remains in the faunal assemblage, supporting the mosaic nature of the palaeoenvironment. *Chaeropus ecaudatus* and *Macrotis lagotis* both strongly indicate a dry climate. Additionally, they illustrate the presence of grasses, possibly tussock grasses, in the area (Strahan, 1998). The rodent fauna also suggests a combination of distinctive dry and woodland species. The presence of species of *Notomys* and

Leggadina suggest an open environment, whilst *Conilurus* sp. suggests woodland.

On balance, the faunal assemblage indicates mosaic vegetation with areas of open grassland/chenopod shrubland, sclerophyll forest and a closed refugial forest. Such refugial forest is seen today in the semi-evergreen vine forest on Mount Etna, where the vine thickets are restricted to the wetter microclimates of limestone, whilst being surrounded by dry sclerophyll woodlands.

CONCLUSION

Analysis of faunal and palaeoecological succession spanning the Early Pliocene to Holocene in central eastern Queensland is made possible by the long accumulation histories of cave and fissure systems in this region. As with the Wellington Caves of New South Wales (Dawson et al., 1999), Mount Etna provides a unique opportunity to document environmental change over ca. 4 million year period and the fauna associated with this change.

The Pliocene sites from Mount Etna are distinguished from all other sites in Australia of similar age by the presence of a distinct and dominant rainforest fauna, with the exception of the Hamilton Local Fauna. All other Pliocene sites in Australia differ from those at Mount Etna and Hamilton by possessing none or minor components of the fauna which are rainforest-adapted. In addition, the Mount Etna Fauna provides biogeographic links to Papua New Guinea and Irian Jaya by possessing taxa that are now restricted to these areas today or have only recently gone extinct there.

The mammalian fauna of the Early Pliocene at Mount Etna suggests biogeographic connectivity to Papua New Guinea and Irian Jaya during or just prior to this time. The murid fauna indicates a much earlier dispersal event of rainforest murids into Australia and questions the late Pleistocene or Holocene arrival previously suggested (Flannery, 1995; Winter, 1997). Combining an Early Pliocene record of rainforest specialist murids at Mount Etna with the incredibly diverse and endemic murid fauna from Rackham's Roost, Riversleigh, far north Queensland, substantially increases the probability that murids entered Australia before the Early Pliocene and probably in the Late Miocene (Archer et al., 1991; Long et al., 2002). The Pliocene possum and macropod faunas from Mount Etna illustrate connectivity between New

Guinea and Australia also, by possessing taxa (or lineages) with affinities to taxa now extant or recently extinct in New Guinea.

Although the fossil record is patchy between the Early Pliocene and late Pleistocene, there is a distinct trend in the fauna to become arid-adapted, with an arid-adapted fauna by the late Pleistocene. The late Pleistocene fauna adds new records for the palaeodistribution of arid-adapted taxa, with several extant central Australian taxa being found extremely close to the eastern Australian coastline. Evenso, several mesic-adapted taxa persist into the late Pleistocene, probably existing in refugia offered by the limestone bluffs in the Mount Etna area, as is seen today.

The Mount Etna and surrounding fossil deposits offer a unique opportunity to document the evolution of the central Queensland environment over 4 million years of climate change, including the extinction of a diverse rainforest community, the expansion of the arid zone interior and the isolating effects on fauna utilising the refugial nature of limestone bluffs.

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QML	1311H	1311CD	1313	1385	1384L	1384U	1312	1284	1284a	1420	Olsens	Present
<i>Antechinus</i> sp. 1	0	0	1	0	0	0	0	0	1	0	0	0
<i>Antechinus</i> sp. 2	1	1	1	1	1	0	0	1	1	1	0	0
<i>Antechinus flavipes</i>	0	0	0	0	0	1	1	0	0	0	0	1
<i>Antechinus swainsoni</i>	0	0	0	0	0	0	1	0	0	0	0	0
<i>Dasyurus hallucatus</i>	0	0	0	0	0	0	1	0	0	0	0	1
<i>Dasyurus viverrinus</i>	0	0	0	0	0	1	1	0	0	0	0	0
<i>Dasyurus</i> sp.	0	0	1	0	0	0	0	0	0	0	0	0
<i>Phascogale</i> sp.	0	0	1	0	0	0	0	1	0	1	0	0
<i>Phascogale topoatafa</i>	0	0	0	0	0	0	1	0	0	0	0	1
<i>Planigale maculata</i>	0	0	0	0	0	0	1	0	0	0	1	1
<i>Sarcophilus lanarius</i>	1	1	0	0	1	1	1	0	0	1	0	0
<i>Sarcophilus harrisii</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Sminthopsis macroura</i>	0	0	0	0	0	1	1	0	0	0	1	0
<i>Sminthopsis murina</i>	0	0	1	1	0	1	1	1	1	1	1	1
dasyurid (gen. et sp. nov.)	1	0	1	1	0	1	0	1	1	0	0	0
<i>Dendrolagus</i> spp.	1	1	1	1	1	0	1	1	1	1	0	0
<i>Thylogale</i> sp. 1	1	1	0	1	1	1	0	1	1	0	0	0
<i>Thylogale</i> sp. 2	0	0	0	0	0	0	1	0	0	1	0	0
<i>Petrogale</i>	1	1	1	1	1	1	1	0	0	1	1	1
<i>Pseudochirulus</i> sp. 1	1	1	1	1	1	0	0	1	1	0	0	0
<i>Pseudochirulus</i> sp. 2	1	1	1	1	0	1	0	1	1	0	0	0
<i>Pseudochirulus</i> sp. 3	1	1	1	1	0	1	0	1	1	0	0	0
<i>Pseudocheirus</i> cf <i>peregrinus</i>	0	0	0	0	0	0	0	0	0	0	1	1
<i>Pseudocheirus</i>	1	1	1	1	0	1	0	1	1	0	0	0
<i>Petauroides</i>	1	1	1	1	0	0		1	1	0	0	0
<i>Pseudocheirops</i> sp. 1	1	0	0	0	1	0	0	0	0	0	0	0
<i>Pseudocheirops</i> sp. 2	0	0	0	0	0	0	0	1	0	0	0	0
<i>Pseudokoala</i>	0	1	0	1	0	0	0	0	0	0	0	0
gen. et sp. nov. 1	1	1	1	1	1	1	1	1	1	1	0	0
gen. et sp. nov. 2	1	0	1	0	0	0	0	1	1	0	0	0
<i>Dactylopsila</i> sp. 1	1	0	1	1	0	1	0	1	1	0	0	0
<i>Dactylopsila</i> sp. 2	0	0	0	0	0	0	0	1	0	0	0	0
Incerti sedis gen. et sp. nov.	1	0	0	1	0	0	0	1	1	0	0	0
<i>Acrobates</i> sp	0	0	0	1	0	0	0	1	0	0	0	0
<i>Cercatetus</i> sp.	1	1	1	1	1	0	0	1	1	0	0	0
<i>Strigocuscus</i>	1	1	0	1	1	1	0	1	1	0	0	0
<i>Trichosurus</i> sp. 1	0	0	0	0	0	0	1	0	0	1	0	1
<i>Trichosurus</i> sp. 2	1	0	0	0	1	0	0	0	0	0	0	0
<i>Perameles</i> sp. 1	1	1	1	1	1	1	0	1	1	1	0	0
<i>Perameles</i> sp. 2	1	1	1	1	0	1	0	1	1	0	0	0
<i>Perameles bouganville</i>	0	0	0	0	0	0	1	0	0	0	1	0
<i>Isodon obesulus</i>	0	0	0	0	0	1	1	0	0	1	0	0
<i>Isodon</i> sp.	0	0	0	0	0	1	1	0	0	0	0	0
<i>Chaeropus ecaudatus</i>	0	0	0	0	0	0	1	0	0	0	0	0
<i>Macrotis lagotis</i>	0	0	0	0	0	0	1	0	0	0	0	0
perameloid gen. et sp. nov. 1	1	1	1	1	1	1	0	1	1	0	0	0

QML	1311H	1311CD	1313	1385	1384L	1384U	1312	1284	1284a	1420	Olsens	Present
perameloid gen. et sp. nov. 2	1	0	0	0	0	0	0	0	0	0	0	0
<i>Notomys</i> sp. 1	0	0	0	0	0	0	1	0	0	0	0	0
<i>Notomys</i> sp. 2	0	0	0	0	0	0	1	0	0	0	0	0
<i>Hydromys</i>	0	0	0	0	0	0	0	0	0	1	0	1
<i>Pseudomys</i>	1	1	1	1	1	1	1	1	1	1	1	1
<i>Rattus</i>	0	0	0	0	0	1	1	0	0	1	1	1
<i>Conilurus</i>	0	0	0	0	0	0	1	0	0	0	0	0
<i>Zyzomys</i>	1	1	0	1	0	0	1	0	0	0	0	0
<i>Leggadina</i>	0	0	0	0	0	0	1	0	0	0	1	0
<i>Uromys/Melomys</i>	1	1	1	1	1	1	0	1	1	1	0	0
<i>Pogonomys</i>	1	1	1	1	1	1	0	1	1	0	0	0
<i>Mesembriomys</i>	1	1	1	1	0	0	0	1	1	0	0	0
Microchiropteran	1	1	1	1	1	1	1	1	1	0	1	1
<i>Macroderma gigas</i>	1	1	1	1	1	1	1	1	1	0	1	1

Appendix 1. Small-sized mammalian fauna data matrix. 0 = Absent, 1 = Present.



Hocknull, Scott A . 2005. "Ecological succession during the late Cainozoic of central eastern Queensland: Extinction of a diverse rainforest community." *Memoirs of the Queensland Museum* 51(1), 39–122.

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