Tech. Rep. Aust. Mus. Online
Number 40, pp. 1–44, 2024
https://doi.org/10.3853/j.1835-4211.40.2024.1902

Technical Reports of the Australian Museum Online
a peer-reviewed open-access journal
published by the Australian Museum, Sydney
communicating knowledge derived from our collections
ISSN 1835-4211 (online)

Sydney Basin in the Triassic—A review of the geology, flora and fauna, and ecosystems. The Hawkesbury Sandstone

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Abstract. The Australian Museum has a large palaeontological collection of Triassic specimens from the Sydney Basin, including many type specimens. This study reviewed every presently described Sydney Basin Hawkesbury Sandstone plant and animal taxa that has representative specimens held in the Australian Museum. Fifty-two taxa are included from numerous sites. These include three amphibians, twenty-eight fishes, eleven insects, one horseshoe "crab", one scorpion, three crustaceans, two molluscs and three plants. Basic taxonomic history for each taxon is noted, together with specimen registration numbers and their position in the collection. Also included are references to relevant specimens held in the Geological Survey of New South Wales and the Natural History Museum, London collections. Images of every taxa are included. To place the collection in context, particularly for educators working with students, brief descriptions of the geology that forms the Hawkesbury Sandstone, and the inferred ecosystems that existed during the Middle Triassic, are included. The results of this study will help to facilitate further researchers by providing important details of the fossil collections held at the Australian Museum.

Introduction

The Triassic rock succession of the Sydney Basin comprises three divisions: the Narrabeen Group (McLean, 2023), the Hawkesbury Sandstone (this study) and the Wianamatta Group (McLean, in prep). The Hawkesbury Sandstone was deposited after an uplift of the Lachlan Fold Belt to the southwest of the Sydney Basin at the beginning of the Middle Triassic. Tectonic tilting of the Sydney Basin to the northeast caused coarse quartzose sand to be transported and deposited in the same direction by a large system of braided rivers (Herbert, 1980a). These sands ultimately formed the Hawkesbury Sandstone over the Narrabeen Group (Herbert, 1980a).

Within the braided river systems oxbow lakes (billabongs) formed when watercourses were bypassed and blocked. This still water allowed for the deposition of fine mud. These anoxic environments preserved any organic plant and animal material that sank into the mud. The mud ultimately became shale lenses intermittently dispersed throughout the thick sandstone. The organic material eventually became thin carbon layer impressions within the shale lenses (Conaghan, 1980), fossils which preserved fine details of their original structure.

Many quarries exploiting the shale for brick manufacture were sources of fossils, particularly the Beacon Hill Quarry. Fishes, amphibians, insects, other arthropods and molluscs have been found, together with plants such as lycopsids, horsetails, seed ferns, ferns and conifers. This study details the taxonomy of every fossil species described from the Sydney Basin, and includes images of every species. The registration numbers and storage placements for these specimens in the Australian Museum palaeontological collection are listed. Other specimens held in the collections of the Geological Survey of New South Wales and the Natural History Museum, London are also noted.

Keywords: Sydney Basin, Triassic, Hawkesbury Sandstone, fossil sites, fossil fishes, fossil insects, fossil plants, temnospondyl, crustacean
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Received: 7 March 2024 **Accepted**: 29 July 2024 **Published**: 28 August 2024 (online only)
Publisher: The Australian Museum, Sydney, Australia (a statutory authority of, and principally funded by, the NSW State Government)
Citation: McLean, G. 2024. Sydney Basin in the Triassic—a review of the geology, flora and fauna, and ecosystems. The Hawkesbury Sandstone. *Technical Reports of the Australian Museum Online* 40: 1–44.
https://doi.org/10.3853/j.1835-4211.40.2024.1902

The aims of this study were to: 1) summarise the geological construction of the Hawkesbury Sandstone, 2) provide details of all plant and animal taxa discovered within the region that are held in the Australian Museum, 3) provide details of the collection locations, and 4) make inferences of the palaeoecosystems within the region based on the flora and fauna discovered so far.

Methods

Explanation of abbreviations

AM—Australian Museum.
AM F.nnnn—Australian Museum fossil specimen registration number; a slash denotes part/counterpart specimen registration numbers.
AMGC—Australian Museum General Collection (Palaeontology).
AMTC—Australian Museum Type Collection (Palaeontology).
AMNH—American Museum of Natural History.
DS nnn—specimen number from Dan Scully collection.
Fig., Figs—figures in this paper.
fig., figs—figures in cited papers.
GSNSW—Geological Survey of New South Wales, Londonderry.
GSQ—Geological Survey of Queensland, Hendra.
MF nnn—transfer specimen registration number for transfer between the Mining and Minerals Museum and the Australian Museum.
MM—Mining and Minerals Museum (now absorbed into the GSNSW collection at Londonderry).
MMF nnnn—Mining and Minerals Museum fossil specimen registration number (specimens now in Geological Survey of New South Wales collection at Londonderry).
MV P nnnn—Museum Victoria fossil specimen registration number.
NHMUK—Natural History Museum, London.
pl—plate in cited paper.
QM—Queensland Museum.
QMF nnnn—Queensland Museum fossil specimen registration number.
SUP nnnn—Sydney University Palaeontology specimen registration number.
USGD nnnn—University of Sydney Geology Department specimen registration number.
#—specimen registration number not yet matched to figured specimen in collection records.

Taxonomic conventions used

The naming and identification of individual fossils from the Sydney Basin within a taxonomic framework has, in many cases, been subject to multiple changes and many are still under periodic discussion. This is particularly apparent within the Plantae. In this review the origin of each change and the reason is discussed in the description of the specimen.

Synonymy lists within include only the papers where taxonomic names have been emended. They do not include any papers where authors have used the nominated taxonomy without change.

In this study an attempt was made to provide all names that have been applied over the years and to use the name most recently considered valid. It was not the intention in this study to offer any new taxonomic interpretations, new names, new combinations, new spellings, or new synonymies.

Where taxonomic emendments have been made to the genus and/or species of similar specimens from another region, this has usually been noted within the discussion of the relevant species. Unless the author promoting the change in the other region specifically noted that it applied to the Sydney Basin species also, the change was not applied in this document. For higher taxonomic levels the most recent consensus view has been used.

Type material conventions

Type material includes nominated types (e.g. holotype, syntypes, lectotype and paratype) as well as specimens figured or mentioned in the relevant peer reviewed journals. This follows the convention used in the AMTC where nominated types, figured and mentioned specimens are held within the Type Collection. Nominated types in this study include specimens from any site, but specimens figured or mentioned are only from the nominated site under discussion.

GEOLOGY

Sydney Basin structure

The Sydney Basin has a total area of approximately 52,000 square kms, of which 15,000 square kms is offshore (Alder *et al*., 1998; McLean, 2023; Fig. 1). It extends from Durras in the south to the Hunter Valley in the north, and its western edge runs along the western side of the Blue Mountains. The Sydney Basin is the southern part of a longitudinal chain of basins that include the Gunnedah Basin and Bowen Basin in Queensland.

Triassic rocks of the Sydney Basin are classified into three basic geological divisions, marking major changes in sediment deposition. The earliest is the Narrabeen Group on top of which lies the Hawkesbury Sandstone, then finally the Wianamatta Group. Further details of the Sydney Basin structure can be found in McLean (2023).

Sedimentation

The Narrabeen Group sedimentation in the north was synchronous with the commencement of Hawkesbury Sandstone deposition in the south (Herbert, 1980a). Transition from the Narrabeen Group sedimentation to the Hawkesbury Sandstone depositional episodes was gradual in the northern section of the basin where deltaic sedimentation matched subsidence. At this time, uplift of the Lachlan Fold Belt in the southwest tilted the strata in the south. This led to erosion of Late Permian and Early Triassic sediments in this area (Herbert, 1980a). Coarse Devonian quartzite sand from the Lachlan Fold Belt (and even further south) were transported to the northeast via a large, braided river system to form a sand sheet over 200 m thick (Herbert, 1980a). Some sediment may have also been supplied from the immediate western margins. In the north, the uplift and tectonic tilting experienced in the south shifted the prevailing palaeocurrent from southeast, through the east to the northeast (Herbert, 1980a).

Approximately 90% of Hawkesbury Sandstone is medium to coarse-grained sand and locally includes large quartz pebbles (Conaghan, 1980). The sandstone generally takes two major forms, massive and sheeted. The massive form occurs in thick beds. The sheeted form is layered and cross-bedded. A third form developed when braided river channels were cut off and fine sediments were deposited, forming mudstone, shale, siltstone and laminites as shale

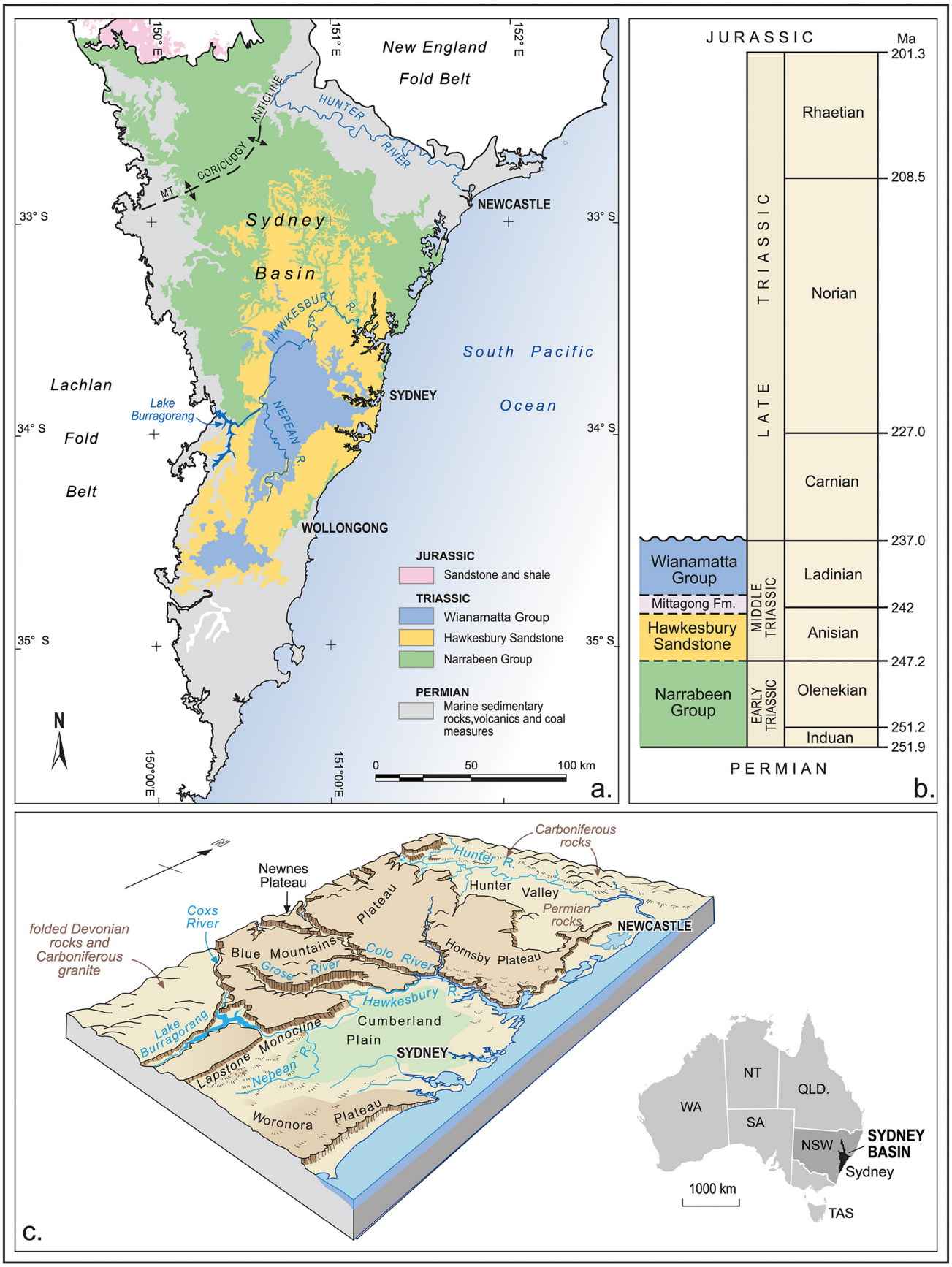

Figure 1. Sydney Basin structure. (*a*) Outcrop map of the three geological divisions of Triassic rocks in the Sydney Basin. (b) Stratigraphic relationships of the three geological divisions within the Triassic of the Sydney Basin. (*c*) Simplified topographic diagram of the central and northern sections of the Sydney Basin. Artwork by Dean Oliver. Taken from McLean (2023).

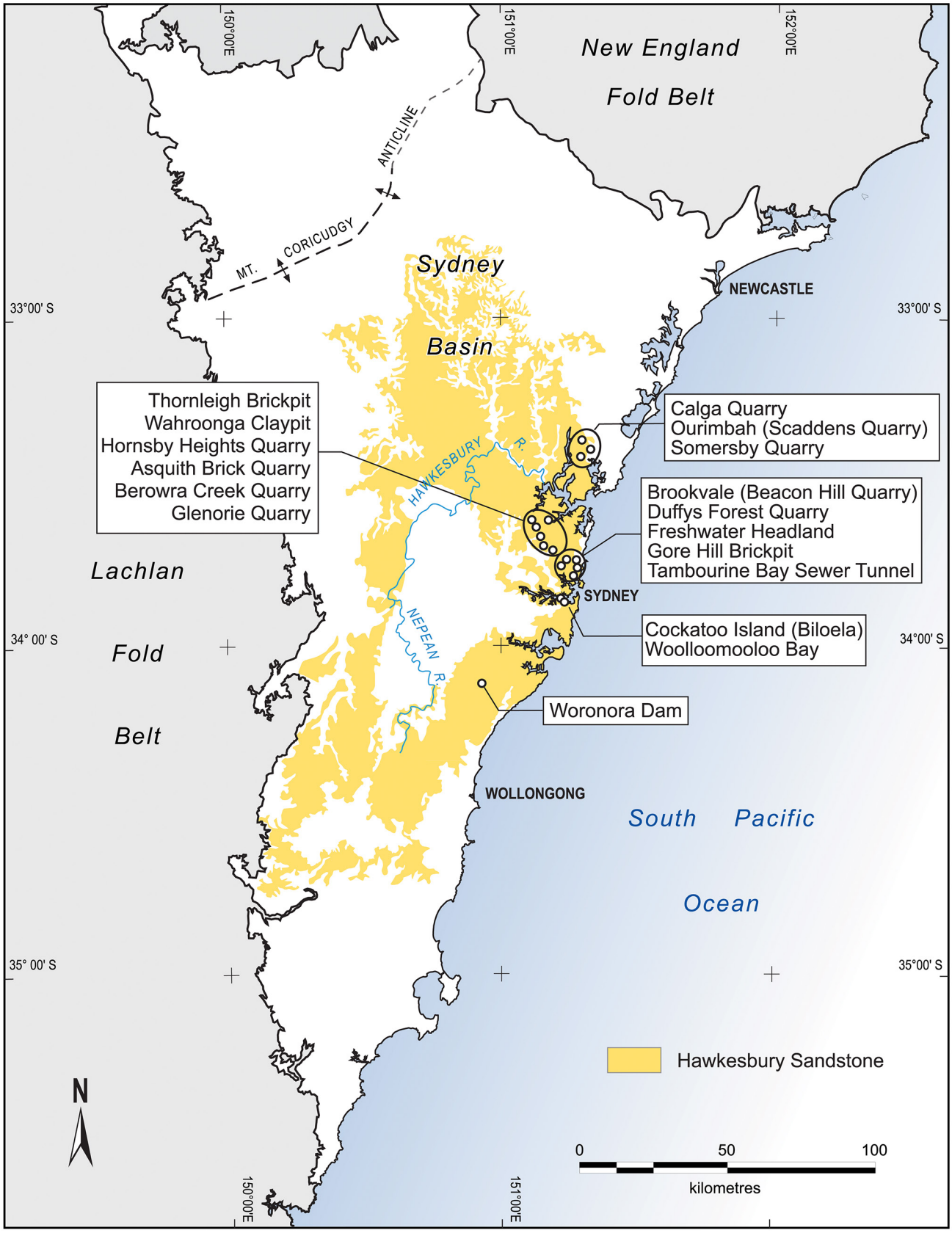

Figure 2. Hawkesbury Sandstone outcrops and fossil sites. Artwork by Dean Oliver.

lenses (Martyn, 2019). Although these make up a minor part of the Hawkesbury Sandstone, these abandoned channels are important as they are a major source of fossils that reveal the biota of the time. Today, the Hawkesbury Sandstone is exposed in a central ring reaching to the base of the Blue Mountains in the west and to the coast in the east (Fig. 2).

Palaeotopography

Sedimentation that formed the Hawkesbury Sandstone interval was dominated by braided streams which flowed from the southwest. The depositional system has been likened to the Brahmaputra delta in Bangladesh (Conaghan & Jones, 1975) and the braided rivers of Alaska (Fig. 3a). A network of streams loaded with quartz-dominated sediment wound across the basin, with frequent overbank flooding. Watercourses were periodically dammed or cut off allowing fine sediment to settle in mud sheets. The floodplain was subject to periods of prolonged inundation (Conaghan, 1980).

Stratigraphy

The Hawkesbury Sandstone has two major depositional facies, massive and sheeted sandstone. A third mudstone facies occurs sporadically in comparatively small areas which is a result of fine sediment being deposited in isolated, still waterways (Conaghan, 1980).

The massive sandstone facies usually lack grain size differentiation, with quartz being the dominant component. It is more friable than the sheeted sandstone facies and weathers at a greater rate, forming ridges, bluffs and caves (Conaghan, 1980; Fig. 3b, e).

The sheeted sandstone facies possess planar crossbedding (Fig. 3f) and has a range of grain sizes, including pebbles set within a coarse-sand matrix. As it weathers at a slower rate than the massive facies, it commonly forms ledges on exposed faces (Conaghan, 1980). The mudstone facies is comprised of thinly laminated shale which is interspersed sporadically within the sandstone facies over small areas (Conaghan, 1980).

The Mittagong Formation

Upon termination of the Hawkesbury Sandstone, subsidence caused extensive areas of floodplain to preserve as the Mittagong Formation. This formed a cap over which the Ashfield Shale of the Wianamatta Group was deposited (Herbert, 1980b).

The Mittagong Formation consists of alternating fine-grained sandstones, dark grey siltstones, and laminites. It is a thin transitional formation ranging from 6–15 m thick and is absent from some type locality regions in the basin (Herbert, 1980b). The type locality occurs at the Gibraltar Railway Tunnel near Mittagong (Martyn, 2019).

The Mittagong Formation was initially included as the basal unit of the Wianamatta Group. However, as it is composed of fine, quartz sandstone compositionally similar to, but smaller than, the Hawkesbury Sandstone, the deposit is now seen as a preserved floodplain, deposited within the channels that carried the Hawkesbury Sandstone sediments (Herbert, 1980b).

Fossiliferous deposits

Stillwater mud sediments deposited in abandoned channels (also known as oxbow lakes or billabongs) formed the isolated shale lenses spaced intermittently through the Hawkesbury Sandstone. These provided ideal environments for the preservation of plants and animals that were transported into (or died within) these abandoned channel lakes. The fine mud grains and anoxic conditions in the deposit preserved these plants and animals, with compaction transforming their bodies into thin carbonaceous fossil films. The fossils were finally exposed during quarrying and the construction of road and rail cuttings. In a few cases, bony fossils have been found preserved in coarser sedimentary rocks. The locations of the sites that produced fossils are distributed across the basin (Fig. 2).

FLORA AND FAUNA

Fossil specimens have been recovered from five major sites and numerous minor sites exposing the Hawkesbury Sandstone. The major sites were Brookvale (Beacon Hill Quarry) which produced a temnospondyl, 28 species of fishes, insects, other arthropods, crustaceans, a xiphosuran, worm burrows and some plants; Cockatoo Island which produced a temnospondyl, some fishes and a mollusc; Somersby Quarry which yielded over 600 individual fishes, including xenacanthids, an excellent specimen of a dipnoan, and some plants; Hornsby Heights Quarry which produced a range of fishes; and Berowra Creek Quarry which revealed an extensive temnospondyl trackway. Minor sites include mainly quarries and brickpits which produced a range of fishes and plants. This report does not cover data on microfossils such as algae, spores or pollen.

Brookvale (Beacon Hill Quarry)

Beacon Hill Quarry was opened in 1910 to provide shale for brickmaking by the Manly Brick and Tile Company. The quarry exposed a 7.5 m thick shale lens on the top of Beacon Hill overlooking the northern beaches of Sydney. Shale was hand hewn, and the first fossil was found in 1912 by a quarryman interested in geology and fossils (Willis & Thomas, 2005). Two quarrymen in particular worked closely with the Australian Museum and Sydney University, advising them of new finds. They were Dan Scully and William Bass. In appreciation of their efforts numerous species were named after these two men. Scully collected until 1930. Other collectors were Hatcher and Carney (Willis & Thomas, 2005).

The Rev. Dr R. T. Wade recorded that he collected specimens between the years 1925 to 1929 (Wade, 1931). He spent time in England on a research scholarship to work on the fossil fishes of Brookvale, and his major work was published by the British Museum (Natural History) in 1935.

The quarry occasionally produced fossils until 1950, when the quarry was mechanised, and men no longer split rock by hand. The quarry was closed in 1966 and subsequently reclaimed for housing and recreation (Willis & Thomas, 2005). The pit was filled and a football oval and housing were built over it. Today the top of the shale lens can be glimpsed at the back of the oval.

During quarrying activities Beacon Hill was within the suburb of Brookvale, so all records of fossil finds referred to Brookvale as the geographic name of the site. However, after activity ceased and the site was reclaimed, the quarry was included in a new suburb called Beacon Hill. To avoid confusion this paper continues to refer to the fossil site as Brookvale (Beacon Hill Quarry).

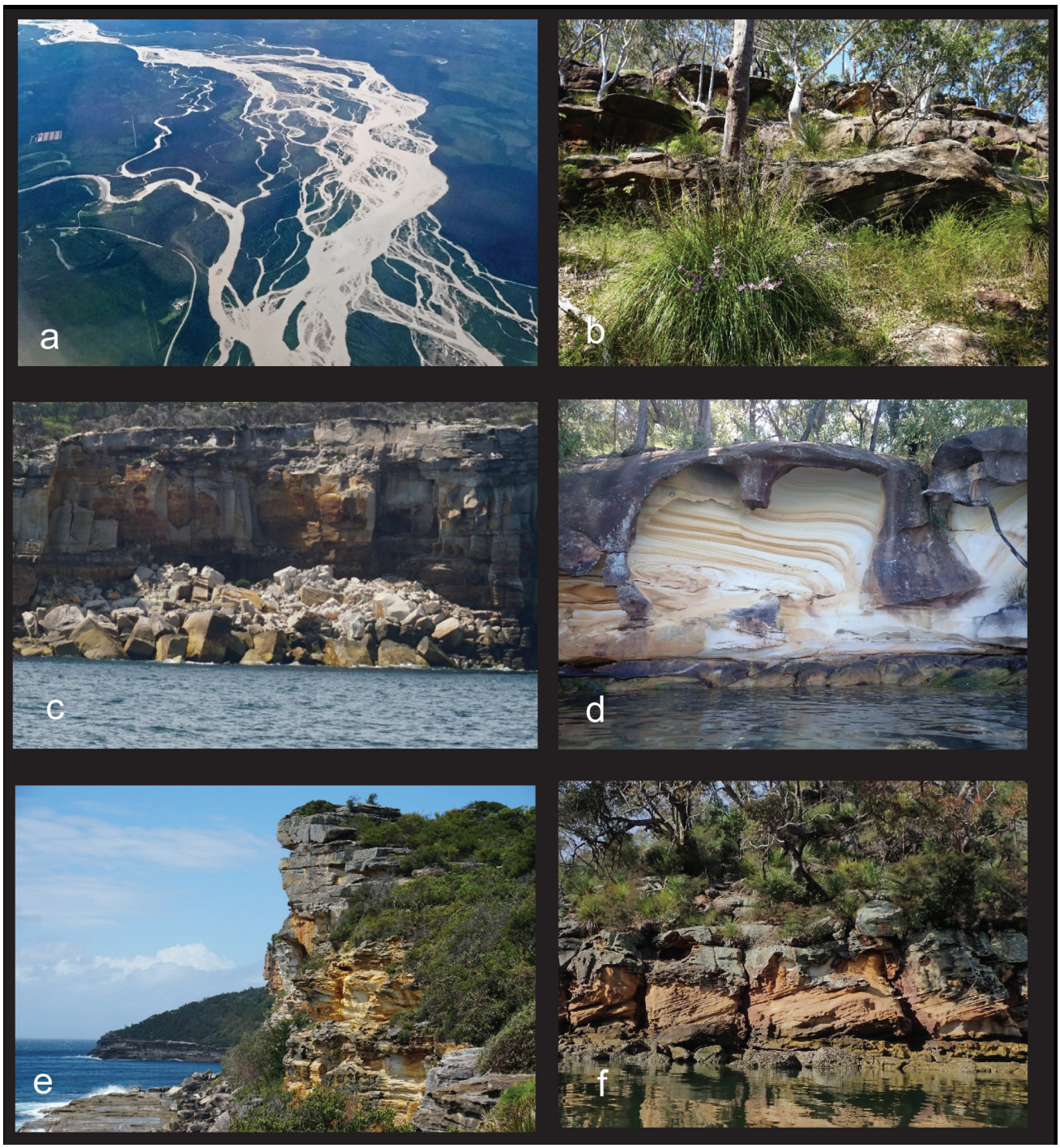

Figure 3. Hawkesbury Sandstone Structures. (*a*) Braided streams. Salcha River-Tanana River confluence, Alaska, USA. © Kira Harris and licensed for reuse under this Creative Commons Licence https://creativecommons.org/licenses/by/2.0/. (*b*) Hawkesbury Sandstone ridges support sclerophyll forests. (*c*) Marine, wind and rain erosion produce massive block rockfalls on North Head, Sydney Harbour. (*d*) A wind- scoured cave on Middle Harbour shoreline reveals iron staining. (*e*) Constant wave action erodes cliff lines, creating bluffs, rock platforms and rockfalls at the base of Shelley Beach headland. (*f*) Cross-bedded sheet sandstone is sandwiched between massive sandstone layers on Cowan Creek shoreline. Photo by Jane Barron.

Class Amphibia Gray, 1825

Temnospondyls have been found in various Sydney Basin sites exposing Triassic rocks. One temnospondyl specimen was found in Brookvale (Beacon Hill Quarry) and described by Watson (1958).

Order Temnospondyli Zittel, 1888 (in Zittel, 1887–1890)

Superfamily Mastodonsauroidea Lydekker, 1885

Family Mastodonsauridae Lydekker, 1885

Subcyclotosaurus brookvalensis Watson, 1958

Fig. 4a–c

Subcyclotosaurus brookvalensis Watson, 1958: 258, fig.15.
Parotosuchus brookvalensis—Welles & Cosgriff, 1965.
Subcyclotosaurus brookvalensis—Ochev, 1966.
Mastodonsauridae *incertae sedis*—Damiani, 2001.
Subcyclotosaurus brookvalensis—Poropat et *al*., 2023.

Figured: AM F.47499 (Fig. 4a–b)—held in the AMTC under "Watson 1958".

The specimen is an incomplete mould of the skull and resembled a small "Parotosaur", and the proportions of the skull resembled *Parotosaurus* and *Cyclotosaurus* (Watson, 1958). Watson proposed this specimen be placed in a new genus and species *Subcyclotosaurus brookvalensis*. Welles and Cosgriff (1965) revised the assignment to *Parotosuchus*, but Ochev (1966) later returned it to *Subcyclotosaurus* (Damiani, 2001).

As a result of a new phylogenetic analysis, Damiani (2001) replaced Capitosauroidea with Mastodonsauroidea and merged Capitosauridae into Mastodonsauridae. From his analysis of *Subcyclotosaurus brookvalensis* he determined that, as this specimen was incompletely known and lacked a palate and occiput, "it seems unwise to grant it type status" (Damiani, 2001: 436) and so should be classified as Mastodonsauridae *incertae sedis*. However, Poropat *et al*. (2023) recommended retaining its original taxonomic name pending re-evaluation. Figure 4c illustrates a life reconstruction of mastodonsaurids based on the Sydney Basin specimens.

Fishes

The Very Rev. Dr. R.T. Wade carried out a major taxonomic study of the Brookvale fish specimens in the 1930s and 1940s. He was a graduate of Sydney University and held a PhD from Cambridge. He spent seven years in the Falklands as Dean of Port Stanley before returning to Sydney to follow his interest in natural history. On receiving a research scholarship from the Australian National Research Council to work on the fossil fishes of Brookvale (Beacon Hill Quarry), he travelled to England to carry out this research in the British Museum. Wade remained in England for seven years, then returned to Sydney in 1936 to stay permanently (Rix, 2021).

The British Museum (Natural History), London, published three papers on Brookvale fishes by Wade in 1932,1933 and 1935. His main work was a monograph (Wade, 1935) describing 28 species, of which 15 were new genera and 20 were new species. In his conclusion, Wade (1935) noted that there were numerous and diverse palaeoniscids and catopterids. Wade also wrote two more papers on Brookvale fishes in 1941 that were published by the Royal Society of NSW (Wade, 1941a, 1941b).

Wade (1935) also noted that one outstanding feature of the Brookvale fish fauna was the absence of sharks. However, Dun (1913) had presented a short paper describing enigmatic specimens from Brookvale as *Spirangium,* with debatable plant or animal affinities. Since then, work in Europe, North America and Australia (McLean, 2014) has indicated that these specimens are shark egg cases. This is direct evidence that sharks were part of the Brookvale palaeoecosystem.

Hutchinson (1973, 1975) of the British Museum (Natural History) carried out a major re-assessment of the redfieldiiform and perleidiform fishes from Brookvale (and Bekker's Kraal, South Africa). This resulted in a high-level re-classification of many taxa, and some generic changes.

Class Sarcopterygii Romer, 1955

Superorder Dipnoi Müller, 1845

Order Ceratodontiformes Berg, 1940

Family Ceratodontidae Günther, 1871

Ariguna formosa (Wade, 1935)

Fig. 5a

Ceratodus formosus Wade, 1935: 1–3, pl. 1.
Tellerodus formosus—Martin, 1982: 25–28, figs 2B,4.
Ariguna formosa—Kemp, 1994: 650–653, figs 2,3.

Holotype: P 16828 (Fig. 5a)—complete fish—held in the NHMUK collection.

Mentioned: P 15907—scale—held in NHMUK collection. AM F.66952 (USGD 232)/AM F.66953 (USGD 237)—scale—held in the AMTC under "Wade 1935".

This specimen is the only sarcopterygian found at Brookvale, and Wade (1935) named it *Ceratodus formosus*. The specimen is small (9.5 cm long) likely a juvenile. Wade (1935) commented that *C. formosus* differed from the extant *Epiceratodus* (now known as *Neoceratodus*), especially in its shorter head, stouter body, the forward continuation of the dorsal fin and a narrow extension of the body squamation to divide the caudal fin horizontally.

Martin (1982) transferred this specimen to *Tellerodus* based on the presence of a bone similar to *Tellorodus sturii*. Kemp (1994) disagreed. She studied the skull structure of the holotype and concluded that it did not belong to any genus previously described. Therefore, she erected the new genus, *Ariguna*.

Class Actinopterygii *sensu* Goodrich, 1930

Order Palaeoniscidiformes Hay, 1902

Family Stegotrachelidae Gardiner, 1963

Megapteriscus longicaudatus Wade, 1935

Fig. 5b

Holotype: P 16827 (Fig. 5b)—complete fish—held in the NHMUK collection.

Wade (1935) placed this species in Chondrostei within Palaeopterygii. This genus has an extremely long tail and numerous fin-rays. The lone holotype specimen is nearly complete with a crushed head (Wade, 1935).

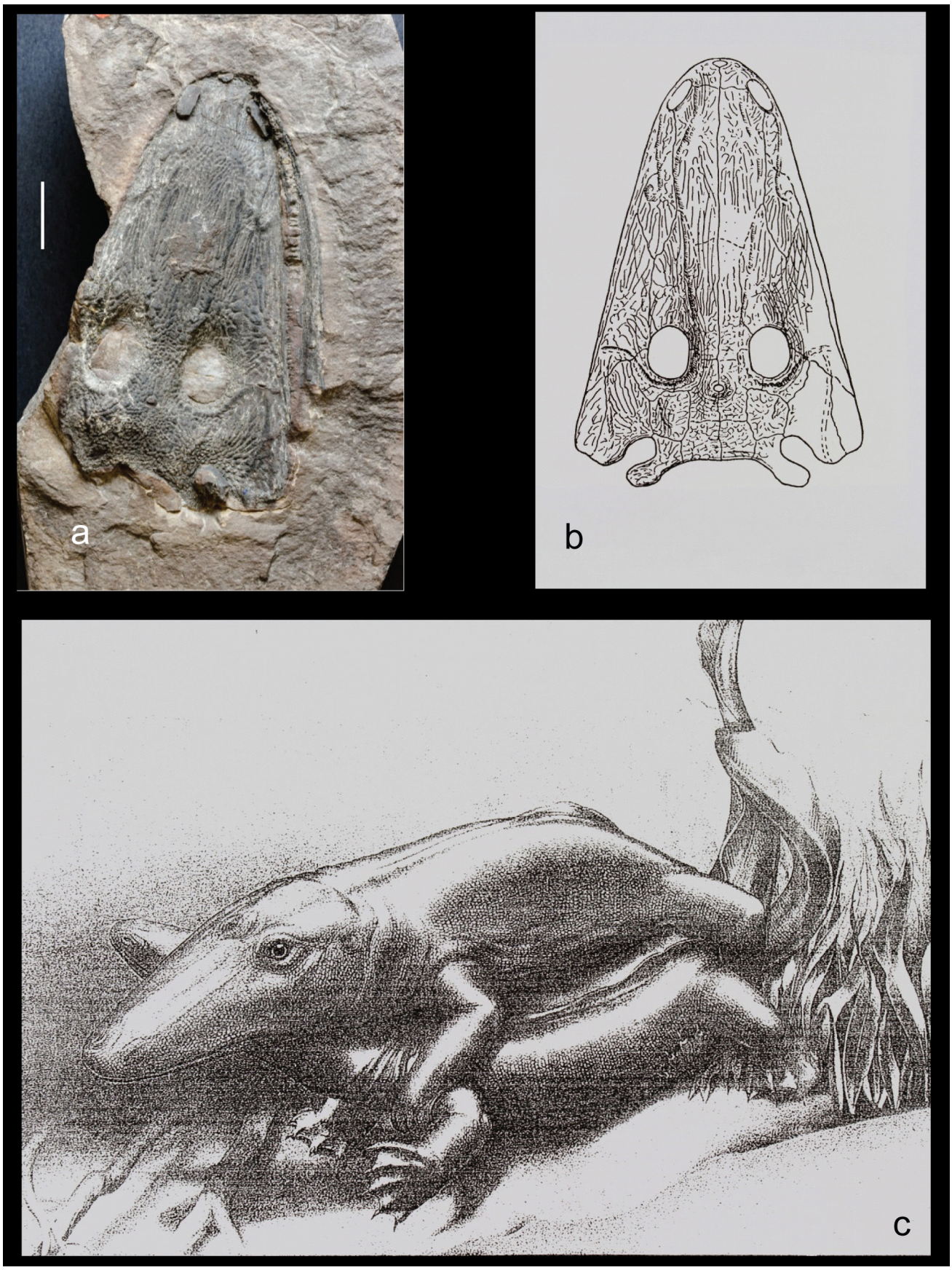

Figure 4. Brookvale (Beacon Hill Quarry). Amphibia. (*a*) AM F.47499 *Subcyclotosaurus brookvalensis*. (*b*) *Subcyclotosaurus brookvalensis*. In Watson (1958). Reproduced with permission of the Trustees of the Natural History Museum, London. (*c*) Reconstruction of members of the Mastodonsauridae based on specimens from the Sydney Basin. Drawn by Peter Schouten. From *Prehistoric Animals of Australia*. Copyright © Australian Museum 1983. Scale bar: *a* = 20 mm.

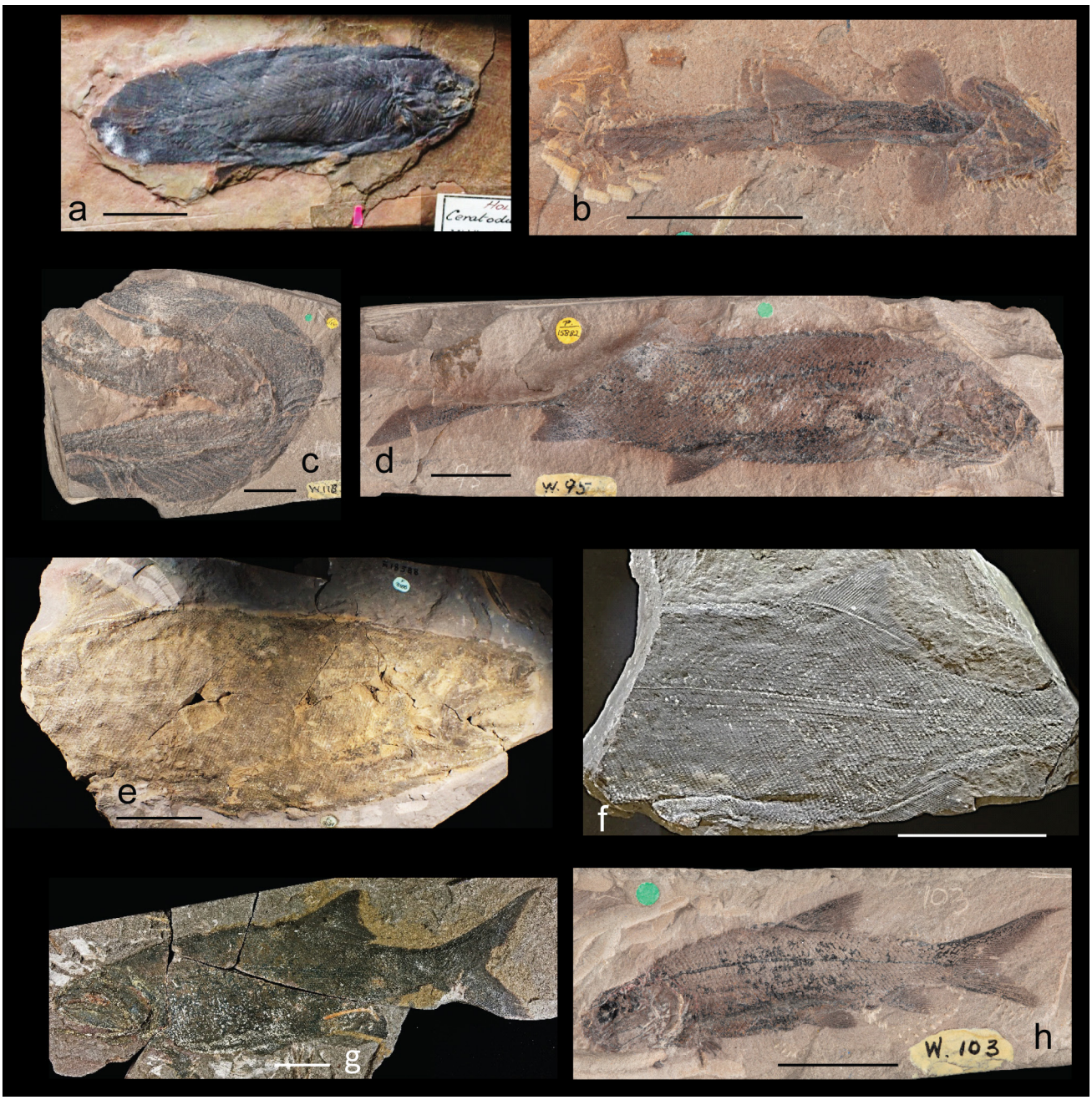

Figure 5. Brookvale (Beacon Hill Quarry). Fishes. (*a*) NHMUK P 16828. *Ariguna formosa*. (*b*) NHMUK P 16827. *Megapteriscus longicaudatus.* (*c*) NHMUK P 15890. *Agecephalichthys granulatus*. (*d*) NHMUK P 15882. *Leptogenichthys longus.* (*e*) AM F.18588. *Myriolepis clarkei*. (*f*) AM F.47000. *Myriolepis clarkei*. (*g*) AM F.66984. *Myriolepis lata*. (*h*) NHMUK P 15861. *Mesembroniscus longisquamosus*. *a–d, h* reproduced with permission. © Natural History Museum, London. Scale bars: *a, b, c, d,* and *h* = 20 mm: *e, f,* and *g* = 50 mm.

Family Palaeoniscidae Bonaparte, 1846

Agecephalichthys granulatus Wade, 1935

Fig. 5c

Holotype: P 15890 (Fig. 5c)—head only—held in the NHMUK collection.
Other specimens: Two partial specimens are held in AMGC under "Pisces/ Brookvale".

Wade (1935) placed this species in Chondrostei within Palaeopterygii. The holotype is an isolated head lacking the cranial roof and rostral area. The head size suggested the fish was about 100–120 cm long (Wade, 1935).

Leptogenichthys longus Wade, 1935

Fig. 5d

Holotype: P 15882 (Fig. 5d)—fish missing tail—held in the NHMUK collection.

Wade (1935) placed this species in Chondrostei within Palaeopterygii. The holotype is 12.3 cm from head to base of caudal fin. The species can be recognised by the cranial roof ornamentation, which resembles that of *Ptycholepis* (Wade, 1935).

Myriolepis clarkei Egerton, 1864

Fig. 5e, f

Type: Named by Egerton (1864) from a specimen from Campbelltown since lost. However, a specimen (AM F.5729), which was the subject of a photograph also used by Egerton (1864) during his taxonomic identification of this species, is held in the AMTC under "Egerton 1864".
Mentioned: AM F.18588 (Fig. 5e)—held in the AMTC under "Wade 1935".
Other specimens: AM F.47000 (Fig. 5f)—held in the AMGC under "Pisces/ Triassic/ Brookvale".

Wade (1935) identified a Brookvale specimen of *Myriolepis clarkei* and placed this species in Chondrostei within Palaeopterygii. The Brookvale specimen mentioned is the anterior portion of the fish (which was probably about 54 cm long) and had a badly preserved head which did not allow analysis to improve on the description given by Woodward (1890) of the Gosford Ballast Quarry specimen (Wade, 1935).

Myriolepis lata Woodward, 1890

Fig. 5g

Type: AM F.50974—described by Woodward (1890) from Gosford Ballast Quarry—held in the AMTC under "Woodward 1890".
Mentioned: P 15884, P 15902, P 16220, P 15804, P 15893 and P 16209—held in the NHMUK collection. AM F.66984 (USGD 225) (four pieces) (Fig. 5g)—held in the AMTC under "Wade 1935". USGD 21—missing.

Wade (1935) identified Brookvale specimens of *Myriolepis lata* and placed this species in Chondrostei within Palaeopterygii. The length of P 15884 is 21.2 cm from head to the base of the caudal fin, and the body is completely covered by scales (Wade, 1935).

Order Ptycholepidiformes Andrews, Gardiner, Miles & Patterson, 1967

Family Ptycholepididae Brough, 1939

Mesembroniscus longisquamosus Wade, 1935

Fig. 5h

Holotype: P 15861 (Fig. 5h)—complete fish—held in the NHMUK collection.
Mentioned: AM F.66962 (USGD 272)—held in the AMTC under "Wade 1935". USGD 400—missing.
Other specimens: Two specimens are held in the AMGC under "Pisces/Triassic/Brookvale".

Wade (1935) placed this species in Chondrostei within Palaeopterygii. This species can be recognised by the nature of its squamation and the large size and advanced position of the dorsal fin (Wade, 1935). Gardiner (1967) placed this species in Boreosomidae within the Ptycholepidiformes. Van der Laan (2018) lists Boreosomidae as a junior synonym of Ptycholepididae.

Order Redfieldiiformes Berg, 1940

Family Brookvaliidae Berg, 1940

Brookvalia gracilis Wade, 1933

Fig. 6a–b

Brookvalia gracilis Wade, 1933: 121, text fig. 1.
Brookvalia parvisquamata Wade,1933: 124, text fig. 3—synonymised with *B. gracilis*. by Hutchinson, 1973.
Brookvalia gracilis Wade, 1935: 21–29, Pl. 4 fig. 1, Pl. 5 fig. 1, text figs 5–14.
Brookvalia parvisquamata Wade,1935: 31–33, Pl. 5 fig. 2, text fig. 16—synonymised with B. gracilis. by Hutchinson, 1973.
Brookvalia gracilis—Hutchinson, 1973: 252–259, text figs 8,9.
Brookvalia gracilis (was *parvisquamata*)—Hutchinson, 1973: 259.

Holotype: *B. gracilis*—P 15799/P 15800 (text fig. 1)—held in the NHMUK collection.
Figured in Wade (1933*)*: *B.* "*parvisquamata*": AM F.66960 (USGD 191) (text fig. 3)—held in the AMTC under "Wade 1933".
Figured in Wade (1935): *B. gracilis*: P 15799 (pl.4 fig. 1), P. 15802 (pl. 5 fig.1)—held in the NHMUK collection. *B. "parvisquamata"*: P 15798 (pl. 5 fig.2)—nominated as the holotype of *B. parvisquamata* in Wade (1933)—held in the NHMUK collection.
Mentioned in Wade (1935): *B. gracilis*: AM F.18608, AM F.18609, AM F.18611, AM F.18636, AM F.18637 (Fig. 6a), AM F.66949 (USGD 271), AM F.66950 (DS 15, USGD 317)—held in the AMTC under "Wade 1935". AM F.18638—transferred to UNE on 4/3/57. USGD 8, USGD 11, USGD 26, USGD 33, USGD 37, USGD 135—missing. *B. "parvisquamata"*: P 15843—held in the NHMUK collection. AM F.66951 (USGD 147) (Fig. 6b)—held in the AMTC under "Wade 1935".
Mentioned in Hutchinson (1973): *B. gracilis*: P 15801 to 15811, P 15813 to 15824, P 15826 to 15833, P 15835 to 15842, P 15844 to 15851, P 15853 to 15856, P 15858, P 15860, P 15872, P 15878, P 15879, P 15905, P 15906, P 15914, P 15915, P

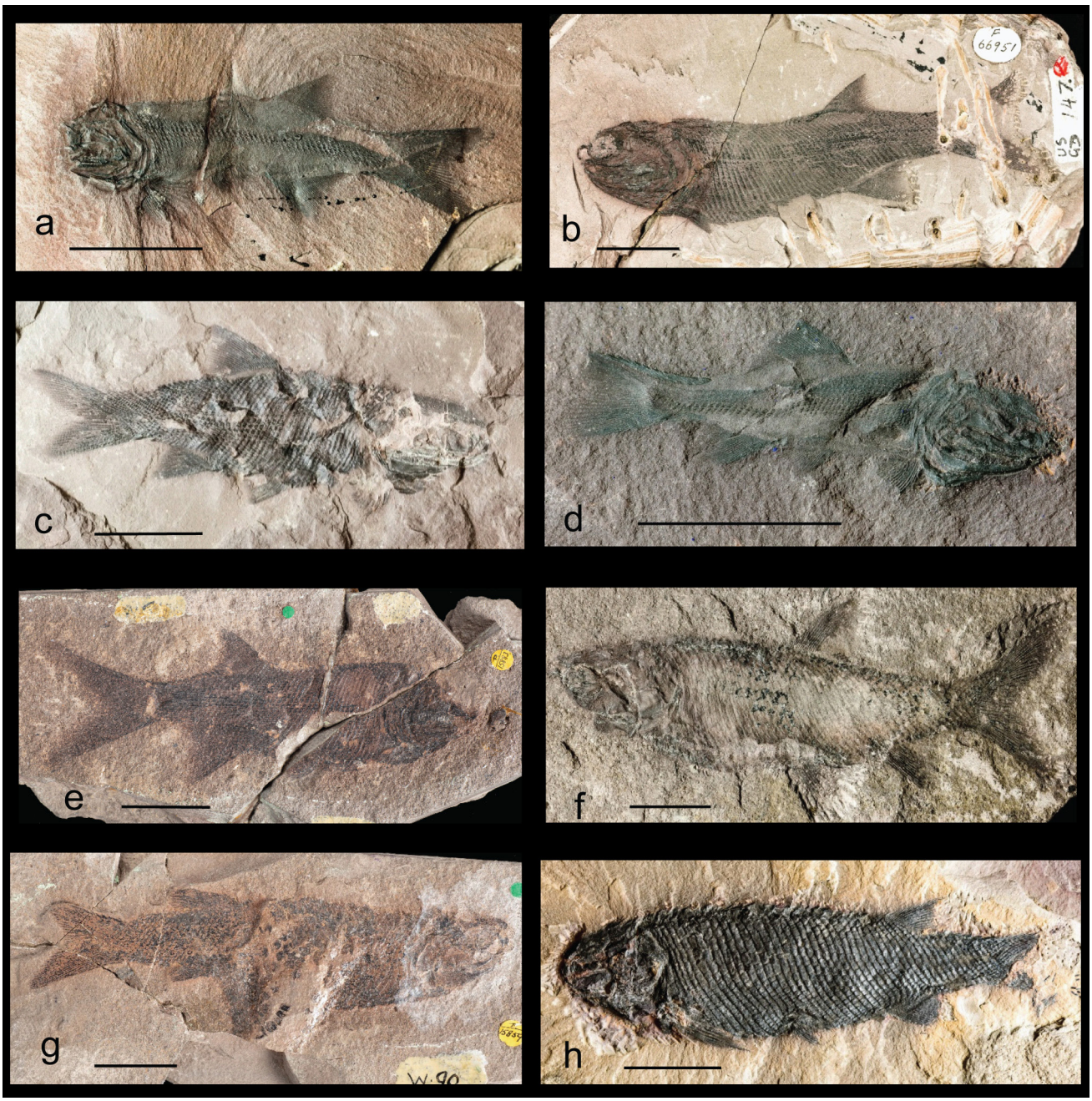

Figure 6. Brookvale (Beacon Hill Quarry). Fishes. (*a*) AM F.18637. *Brookvalia gracilis.* (*b*) AM F.66951. *Brookvalia gracilis* (was *B. parvisquamata*). (*c*) AM F.35917. *Brookvalia propennis.* (*d*) AM F.66943. *Brookvalia spinosa.* (*e*) NHMUK P 15883. *Brookvalia latipennis*. (*f*) AM F.66965. *Phlyctaenichthys pectinatus*. (*g*) NHMUK P 15859. *Geitonichthys ornatus*. (*h*) AM F.66963. *Molybdichthys junior*. *e*, *g* reproduced with permission. © Natural History Museum, London. Scale bars = 20 mm.

15926, P 15930, P 15931, P 15937, P 15939, P 15942, P 16997 to 17001, P 17005 to 17017, P 24710 to 24735—held in the NHMUK collection. USGD 2, 4, 19, 28, 29, 40 to 42, 80, 94, 141, 152, 159, 185 to 187, 205, 214, 218, 219, 238, 244, 269, 272, 274, 277, 350—held in the University Museum of Zoology, Cambridge (These specimens bear University of Sydney registration numbers (Hutchinson, 1973)). F 453, F 455—held in the Sedgewick Museum, Cambridge. Others are held in Manchester Museum in the Watson Collection. *B. "parvisquamata"*: P 15843 held in the NHMUK collection.

Other specimens: *B. gracilis*: 78 specimens are held in the AMGC under "Pisces/Triassic/Brookvale". *B. "parvisquamata"*: 2 specimens are held in the AMGC under "Pisces/Triassic/Brookvale".

Wade (1933) initially described three new species, *Brookvalia gracilis*, *Brookvalia parvisquamata* and *Brookvalia propennis* (nominating only the holotypes), before the publication of his comprehensive monograph (Wade, 1935), so that they could be compared to similar genera being examined in South Africa at the time. He then completed detailed analyses in his monograph (Wade, 1935) using more specimens.

Wade (1935) identified *B. parvisquamata* as a separate species as it is was distinguished from *B. propennis* by details of the cranial roof, and from *B. gracilis* by having rhombic parietals, smaller scales and smaller median fins. He placed these species in Catopteridae under Chondrostei and within Palaeopterygii.

Hutchinson (1973) carried out a major revision of *Brookvalia,* classifying one species (*B. parvisquamata*) as a junior synonym of *B. gracilis*, then grouping four species within the genus. The species *Brookvalia parvisquamata* thus became *B. gracilis*, and *Dictyopleurichthys latipennis* and *Beaconia spinosa* were transferred to *Brookvalia. Brookvalia propennis* kept its taxonomic position. Hutchinson (1973: 252) stated that "The members of *Brookvalia* as here constituted differ significantly from one another only in the overall body shape, in the shape of the caudal fin and in the size, shape and position of the caudal fin." He placed *Brookvalia* in Brookvaliidae within Redfieldiiformes.

Van der Laan (2018) lists Brookvaliidae as a junior synonym of Redfieldiidae, but some Australian authors post 2018 still consider Brookvaliidae to be valid (e.g. Berrell *et al*., 2020). As this assignment is still in contention, this report retains Brookvaliidae as a valid family.

Brookvalia propennis Wade, 1933

Fig. 6c

Brookvalia propennis Wade, 1933: 124, text fig. 2.
Brookvalia propennis Wade, 1935: 29, pl. 4 fig. 2, text fig. 15.

Holotype: USGD 203 (text fig. 2)—missing.

Mentioned in Wade (1933): P 15825/P 15868, P 15850—held in the NHMUK collection.

Mentioned in Wade (1935): P 15825/P 15868, P 15850, P24699, P24710—held in the NHMUK collection.

Other specimens: Three specimens, including AM F.35917 (Fig. 6c)—held in the AMGC under "Pisces/Triassic/Brookvale".

Wade placed this species in Catopteridae within Chondrostei within Palaeopterygii. This species is distinguished from others by the size and shape of its parietals, ornamentation, and advanced position of the dorsal fin (Wade, 1935). Hutchinson (1973) erected the Brookvaliidae within the Redfieldiiformes and placed this species within it. See *B. gracilis* above for comment on Brookvaliidae validity.

Brookvalia spinosa (Wade, 1935)

Fig. 6d

Beaconia spinosa Wade, 1935: 33, pl. 6 figs 1,2.
Brookvalia spinosa—Hutchinson, 1973: 264, fig. 15.

Holotype: P 16211 (pl. 6 fig. 1)—complete fish—held in the NHMUK collection.

Figured in Wade (1935): P 16212 (pl. 6 fig. 2)—imperfect specimen—held in the NHMUK collection.

Mentioned in Wade (1935): AM F.66943 (USGD 14) (Fig. 6d), AM F.66942 (USGD 33), AM F.66941 (USGD 105)—held in the AMTC under "Wade 1935".

Wade (1935) erected a new genus (*Beaconia*) for this new species and placed it in Catopteridae in Chondrostei within Palaeopterygii. The characters of the genus were a small size, large parietals, the structure of the opercular apparatus, the size and position of the dorsal fin, the shape of the caudal fin and the scale ornamentation (Wade, 1935). The length of the holotype is 3.5 cm from head to base of the caudal fin (Wade, 1935). As the skull is almost identical to *Brookvalia gracilis*, Hutchison (1973) placed this species in *Brookvalia* and therefore within Brookvaliidae and Redfieldiiformes. See *B. gracilis* above for comment on Brookvaliidae validity.

Brookvalia latipennis (Wade, 1935)

Fig. 6e

Dictyopleurichthys latipennis Wade, 1935: 36, pl. 7 fig. 31.
Brookvalia latipennis—Hutchison, 1973: 262, fig. 14.

Holotype: P 15883 (Fig. 6e)—almost complete fish—held in the NHMUK collection.

Wade (1935) erected a new genus, *Dictopleurichthys*, for this new species and placed it in Catopteridae in Chondrostei within Palaeopterygii. The characteristics of the genus are the large size of the maxilla, the narrow opercular series, the fusiform shape, the large median fins and the scale ornamentation (Wade, 1935). The holotype is 9.2 cm long from head to caudal base (Wade, 1935). Because dentary ornamentation, pectoral ornamentation, fin shape and placement are similar to *Brookvalia gracilis*, Hutchison (1973) placed this species within the *Brookvalia* and therefore within Brookvaliidae and Redfieldiiformes. See *B. gracilis* above for comment on Brookvaliidae validity.

Phlyctaenichthys pectinatus Wade, 1935

Fig. 6f

Holotype: F.66965 (USGD 200) (Fig. 6f)—complete fish—held in the AMTC under "Wade 1935".

Mentioned: AM F.66966 (USGD 183)—held in the AMTC under "Wade 1935". P 16205, P 16206—held in the NHMUK collection. DS 16—missing.

Other specimens: One specimen is held in the AMGC under "Pisces/Triassic/Brookvale".

Wade (1935) placed this new species in a new genus in Catopteridae in Chondrostei within Palaeopterygii. The holotype measures 10.9 cm from head to base of caudal pedicle. The orbit was large and the teeth sharply conical (Wade, 1935). Hutchinson (1973) erected Brookvaliidae within the Redfieldiiformes and placed this monospecific genus within it. See *B. gracilis* above for comment on Brookvaliidae validity.

Family Redfieldiidae Berg, 1940

Geitonichthys ornatus Wade, 1935

Fig. 6g

Holotype: P 15859 (Fig. 6g)—almost complete fish—held in the NHMUK collection.
Mentioned: P 15880—held in the NHMUK collection.

Wade (1935) placed this new species in a new genus, part of the Catopteridae, within Chondrostei within Palaeopterygii. This fish measures 8.8 cm from head to caudal pedicle (Wade, 1935). Hutchinson (1973) commented that this genus probably represented a redfieldiid population isolated from mainstream populations as they are not typical of the family Redfieldiidae. However, there was not enough evidence to justify the erection of a separate family.

Molybdichthys junior Wade, 1935

Fig. 6h

Holotype: P 16204—imperfect fish—held in the NHMUK collection.
Mentioned: P 16207, P 16208, P 16822, P 24695, P 24696—held in the NHMUK collection. AM F.66964 (USGD 43), AM F.66969 (USGD 146), AM F.66963 (USGD 216) (Fig. 6h) (pl. 7 fig. 2)—held in the AMTC under "Wade 1935". DS 10 (counterpart of AM F.66964 (USGD 43))—missing.
Other specimens: One specimen is held in the AMGC under "Pisces/Triassic/ Brookvale".

Wade (1935) placed this new species in a new genus within the Catopteridae, within Chondrostei, part of Palaeopterygii. The holotype measures 5.8 cm from head to caudal pedicle (Wade, 1935). Hutchinson (1973) made similar comments relating to population isolation as for *Geitoichthys ornatus* above.

Schizurichthys pulcher Wade, 1935

Fig. 7a

Holotype: P 15892—incomplete fish—held in the NHMUK collection.
Mentioned: P 15891—held in the NHMUK collection.
AM F.66998 (USGD 305) (DS 17) (Fig. 7a)—held in the AMTC under 'Wade 1935".
Other specimen: One specimen is held in AMGC under "Pisces/Triassic/Brookvale".

Wade (1935) placed this new species in a new genus within the Catopteridae within Chondrostei, part of Palaeopterygii. The holotype is incomplete and lacking the head and paired fins. AM F.66998, a smaller specimen, has a crushed head but allowed a measurement to be made from the head to caudal pedicle of 18.2 cm (Wade, 1935). Hutchison (1973) erected the Schizurichthyidae for this species and placed it within the Redfieldiiformes. Schizurichthyidae was later listed as a junior synonym of Redfieldiidae by Van der Laan (2018).

Order Perleidiformes Berg, 1937

Family Cleithrolepididae Wade, 1935

Cleithrolepis granulatus Egerton, 1864

Fig. 7b

Type: Anterior portion of a specimen from Cockatoo Island—not registered in the NHMUK collection—probably lost.
Lectotype: AM F.1471—almost complete fish—held in the AMTC under "Egerton 1864"—from Cockatoo Island.
Mentioned in Wade (1935): AM F.18580, AM F.18587 (Fig. 7b), AM F.18653, AM F.66985 (USGD 100), AM F.66980 (USGD 111), AM F.66954 (USGD 176), AM F.66955 (USGD 222), AM F.66956 (USGD 258)—held in the AMTC under "Wade 1935". AM F.18500, USGD 101, USGD 135, USGD 212, DS 1, DS 3, DS 4—missing. P 15752–15770, P 15773, P 15908, P 24674, P 24675—held in the NHMUK collection. USGD 91, USGD 167, USGD 217, USGD 203—held in the University Museum of Zoology, Cambridge (these specimens have University of Sydney registration numbers (Hutchinson, 1973)).
Other specimens: 21 specimens are held in the AMGC under "Pisces/Triassic/Brookvale".

Wade (1935) observed that it was probable *Cleithrolepis* was derived from platysomids and it should, therefore, be placed in a new family, the Cleithrolepididae within Chondrostei, part of the Palaeopterygii. This species is a small, laterally flattened fish with a deep body and large orbits (Wade, 1935). Hutchinson (1973) noted that the skull of this species is particularly deep. He placed this genus in Cleithrolepididae within the Perleidiformes.

Cleithrolepis altus Woodward, 1890

Fig. 7c

Type: MMF 128—fish with most caudal region missing—from Gosford Ballast Quarry—held in the GSNSW collection. AM F.48140 (counterpart)—from Gosford Ballast Quarry—held in the AMTC under 'Woodward 1890".
Mentioned in Wade (1935): P 16826 (Fig. 7c), P 17032, P 17033—held in the NHMUK collection.

The imperfect specimens available from Brookvale (Beacon Hill Quarry) did not allow detailed description (Wade, 1935). Hutchinson (1973) did not examine this species when he was considering the taxonomy of *Cleithrolepis granulatus* (see above), possibly due to the imperfect material available.

Family Colobodontidae Andersson, 1916

Manlietta crassa Wade, 1935

Fig. 7d

Holotype: AM F.66961 (USGD 213) (Fig. 7d)—almost complete fish—held in the AMTC under "Wade 1935".
Mentioned: P 16825—held in the NHMUK collection.

Wade (1935) placed this new species in a new genus *Manlietta* in the Perleididae in Chondrostei within the Palaeopterygii. This fish has a fusiform body, a short head, a blunt snout and orbits of moderate size anteriorly placed (Wade, 1935). Hutchinson (1973) placed this genus in the Colobodontidae within the Perleidiformes.

Figure 7. Brookvale (Beacon Hill Quarry). Fishes. (*a*) AM F.66998. *Schizurichthys pulcher.* (*b*) AM F.18587. *Cleithrolepis granulatus.* (*c*) NHMUK P 16826. *Cleithrolepis altus*. Reproduced with permission. © Natural History Museum, London. (*d*) AM F.66961. *Manlietta crassa.* (*e*) AM F.66967. *Procheirichthys ferox.* (*f*) AM F.66999 ?*Thoracopterus* sp. (*g*) AM F.66973. *Macroaethes brookvalei*. (*h*) AM F.15108. *Macroaethes altus*. Scale bars: *a, b, c, d*, *e,* and *f* = 20 mm: *g* and *h* = 50 mm.

Procheirichthys ferox Wade, 1935

Fig. 7e

Holotype: AM F.66967 (USGD 209) (Fig. 7e)—complete fish—held in the AMTC under "Wade 1935".

Wade (1935) placed this new species in a new genus in the Perleididae within the Chondrostei, part of the Palaeopterygii. This species has a deeply fusiform trunk, with wide parietals and apparent exclusion of the nasals from the orbit (Wade, 1935). Hutchinson (1973) placed the genus in Colobodontidae within the Perleidiformes.

Order Peltopleuriformes Lehman, 1966

Family Thoracopteridae Griffith, 1977

Genus ?*Thoracopterus* Bronn, 1858

Fig. 7f

Mentioned: P 15793—held in the NHMUK collection. AM F.66999 (USGD 151) (Fig. 7f)—pectoral fin—held in the AMTC under "Wade 1941b".

Wade (1941b) published a brief note on two specimens of large pectoral fins having many branching fin rays. Some Triassic fishes with large pectoral fins have been hypothesised to be "flying fishes", but Wade did not have sufficient material to determine a detailed relationship with already described genera. Therefore, he assigned these specimens to *Thoracopterus* (Wade, 1941b).

"Flying fish" in the Brookvale environment could indicate the freshwater system was expansive—present day "flying fish" need an extensive line of open water for take-off and rely on a long glide to escape predators.

Order Pholidopleuriformes Berg, 1937

Family Pholidopleuridae Abel, 1919

Macroaethes brookvalei Wade, 1932

Fig. 7g

Lectotype: AM F.66973 (USGD 130) (Fig. 7g)—two pieces (body and tail)—held in AMTC under "Wade 1932".

Mentioned: P 15774–15776, P 15778–15792, P 15796, P 15797, P 17034—held in the NHMUK collection. F 455—held in Sedgewick Museum, Cambridge. AM F.18589, AM F.18612, AM F.18614, AM F.18647, AM F.18648, AM F.18650, AM F.66955 (USGD 222), AM F.66970 (USGD 45), AM F.66971 (USGD 65), AM F.66972 (USGD 85), AM F.66974 (USGD 123), AM F.66975 (USGD 132), AM F.66976 (USGD 158), AM F.66978 (USGD 188), AM F.66979 (USGD 202), AM F.66977 (USGD 211), AM F.66980 (USGD 220), AM F.66981 (USGD 226), AM F.66982 (USGD 254), AM F.66983 (USGD 256), AM F.66970 (USGD 45)—held in the AMTC under "Wade 1935". AM F.18635 presented to AMNH on 3-8-65. USGD 247, USGD 171, USGD 134, USGD 193—missing.

Other specimens: 58 specimens are held in the AMGC under "Pisces/Triassic/Brookvale".

This species was first described by Wade (1932). He stated it was closely allied to *Pholidopleurus* and erected a new family Pholidopleuridae in Chondrostei within the Palaeopterygii to contain both *Macroaethes* and *Pholidopleurus*.

A further detailed description was made by Wade (1935). The fish has a long, slender body, a comparatively long head, a large opercular apparatus and thick scales on the anterior part of the trunk. The pectoral fins are inconspicuous, and the pelvic fins are insignificant. The median fins are very long and very remote in position and the caudal fin is large and deeply cleft (Wade, 1935).

Macroaethes altus Wade, 1935

Fig. 7h

Holotype: Originally held in the Geological Museum of Sydney University but now missing.

Mentioned: AM F.15108 (Fig. 7h)—fish without tail—held in the AMTC under "Wade 1935".

This species has a long, slender body, a shorter head, a smaller opercular apparatus, thinner scales and a much deeper trunk than *Macroaethes brookvalei* (Wade, 1935).

Order Saurichthyiformes Aldinger, 1937

Family Saurichthyidae Bleeker, 1859

Saurichthys parvidens Wade, 1935

Fig. 8a–b

Holotype: P 16216/ P 16217—head—held in the NHMUK collection.

Mentioned: P 15795, P 15886, P 15897, P 15898, P 15900, P 15901, P 16218/P 16219—held in the NHMUK collection. F 452—held in the Sedgewick Museum, Cambridge. AM F.66965, (USGD 200), AM F.66966 (USGD 183), AM F.66987 (USGD 82), AM F.66988 (USGD 90), AM F.66989 (USGD 97), AM F.66991 (USGD 107), AM F.66990 (USGD 109), AM F.66992 (USGD 112) (Fig. 8a), AM F.66994 (USGD 129), AM F.66993 (USGD 164), AM F.66995 (USGD 169), AM F.66996 (USGD 230), AM F.66997 (USGD 236), AM F.66998 (USGD 241), AM F.18646—held in the AMTC under "Wade 1935". USGD 23—missing.

Other specimens:19 specimens, including AM F.43605 (Fig. 8b), are held in the AMGC under "Pisces/ Triassic/Brookvale".

Wade erected this new species within the *Saurichthys,* a member of Chondrostei, within the Palaeopterygii. It is now placed in the Saurichthyiformes. The holotype is a part and counterpart of a head only. This species is large, with relatively small teeth (Wade, 1935). Many of the supporting specimens are only fragmentary.

Order *incertae sedis*

Family *incertae sedis*

Belichthys minimus Wade, 1935

Fig. 8c

Holotype: P 16360—slightly imperfect fish—held in the NHMUK collection.

Mentioned in Wade (1935): AM F.18649, AM F.66941 (DS 13, USGD 105), AM F.66948 (USGD 152) (Fig. 18c)—held in the AMTC under "Wade 1935".

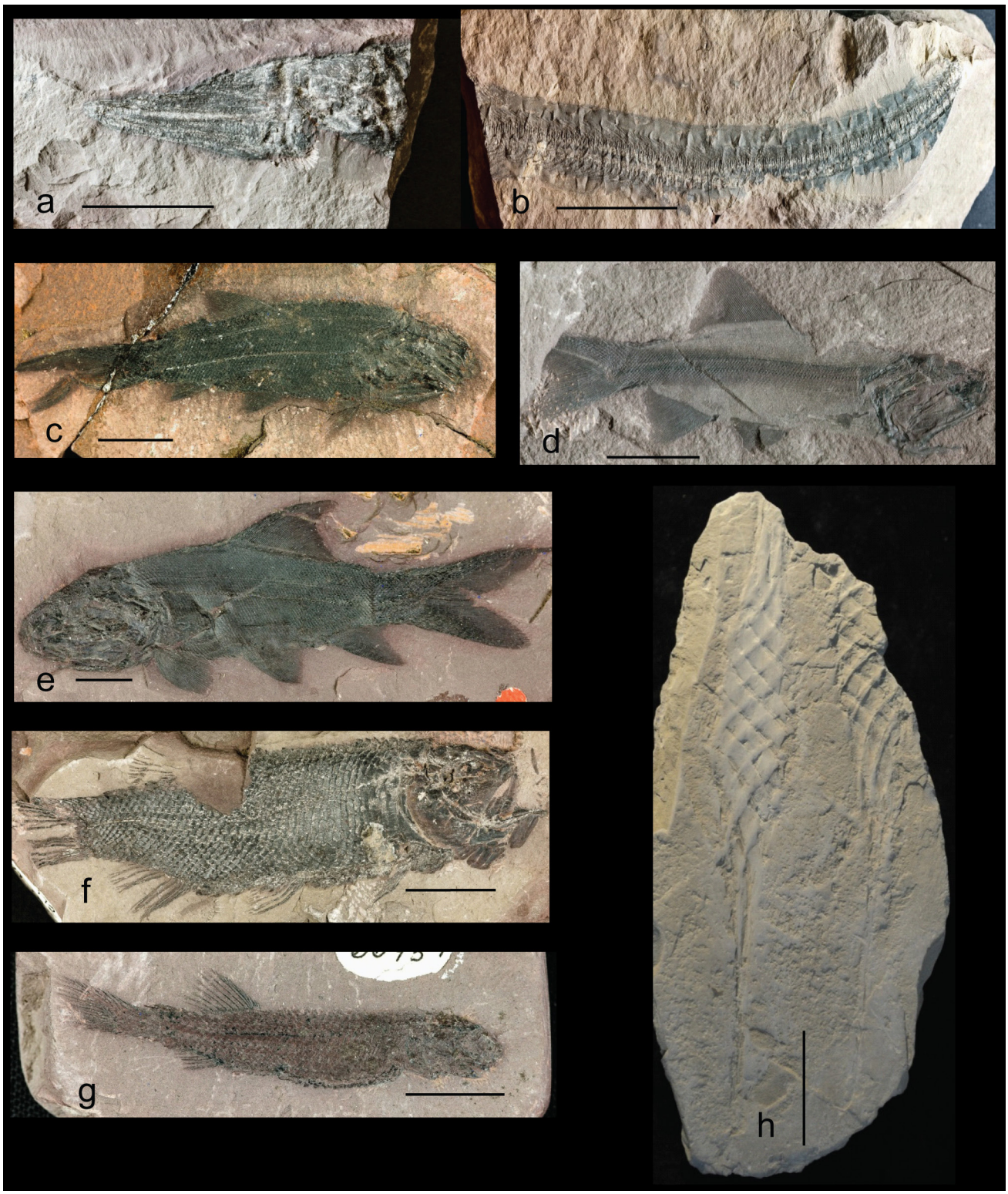

Figure 8. Brookvale (Beacon Hill Quarry). Fishes. (*a*) AM F.66992. *Saurichthys parvidens.* (*b*) AM F.43605. *Saurichthys parvidens.* (*c*) AM F.66948. *Belichthys minimus.* (*d*) AM F.66946. *Belichthys longicaudatus*. (*e*) AM F.66947. *Belichthys magnidorsalis*. (*f*) AM F.66968. *Promecosomina formosa.* (*g*) AM F.66957. *Enigmatichthys attenuatus.* (*h*) MMF 42697a,b *Palaeoxyris duni.* Scale bars: *a, b,* and *h* = 50 mm: *c, d, e, g* = 10 mm: *f* = 20 mm.

P 15812, P 15857, P 15864, P15866, P 15867, P 15869, P15870, P 15873, P 15874, P 15875, P15877, P 15911, P 15912, P 15913, P 15950, P 16210, P 16213, P 16214, P 16215, P 24702, P 24703, P 24704, P 24705, P 24706/P 24707, P 24708/P 24709, P 24736—held in the NHMUK collection.

Mentioned in Hutchinson (1975): USGD 451, L 12142—missing.

Other specimens: 13 specimens are held in the AMGC under "Pisces/Triassic/Brookvale".

Belichthys minimus was a small fish with body length from head to base of caudal fin of 4 cm (Wade, 1935). Wade distinguished the three species of this new genus by variation in the number of fin rays and the size of scales. Wade (1935) placed this species in Palaeoniscidae in the Chondrostei within the Palaeopterygii.

Hutchinson (1975) examined some character states of this species (the scales, fin rays and caudal fin) and concluded that they were of little use in determining the phylogenetic position of *Belichthys,* as they could be derived from almost any known early chondrostean. He therefore assigned *Belichthys* to Chondrostei *incertae sedis* (Hutchinson, 1975).

Belichthys longicaudatus Wade, 1935

Fig. 8d

Holotype: P 15862/P 15863—imperfect fish—held in the NHMUK collection.

Mentioned: AM F.66945 (USGD 32), AM F.66946 (USGD 156) (Fig. 18d)—held in the AMTC under 'Wade 1935".

Belichthys longicaudatus is a small fish with body length from head to base of caudal fin of 5.2 cm (Wade, 1935). For other remarks on this species, see comments above on *Belichthys minimus*.

Belichthys magnidorsalis Wade, 1935

Fig. 8e

Holotype: AM F.66947 (USGD 210) (Fig. 8e)—fish with crushed head—held in the AMTC under "Wade 1935". P 16202 (counterpart to AM F.66947)—held in the NHMUK collection.

Belichthys magnidorsalis is a small fish with body length from head to base of caudal fin of 6.5 cm (Wade, 1935). For other remarks on this species, see comments above on *Belichthys minimus*.

Subclass Neopterygii Regan, 1923

Order Parasemionotiformes Lehman, 1966

Family Promecosominidae Wade, 1941a

Promecosomina formosa (Woodward, 1908)

Fig. 8f

Semionotus formosus Woodward, 1908: 23, pl. 4 fig. 8.

Pholidophorus australis Woodward, 1908: 26, pl. 4 fig. 9—synonymised by Wade (1941a).

Acentrophorus sp.—Woodward, 1908: 21—synonymised by Wade (1941a).

Promecosomina beaconensis Wade, 1935: 80, pl. 8 figs 3, 4, text fig. 46—synonymised by Wade (1941a).

Promecosomina formosa—Wade, 1941a: 382, pl. 17, text figs 1, 2, 3.

Type: AM F.38905—as *Semionotus formosus* Woodward (1908)—from St. Peters Brickpits—held in the AMTC under "Woodward 1908".

Syntype: P 16823/P 16824—as *Promecosomina beaconensis*—held in the NHMUK collection.

Mentioned in Wade (1935): AM F.66968 (USGD 192) (Fig. 8f)—held in the AMTC under "Wade 1935".

Other specimens: Two specimens held in the AMGC under "Pisces/Triassic/Brookvale".

Wade (1935) placed two Brookvale (Beacon Hill Quarry) specimens in the new genus and species, *Promecosomina beaconensis*, which he assigned to the Semionotidae. This placed them within Protospondyli within Neopterigii at the time. This fish has a maxilla of unusual length which produced a wider gape than a normal semionotid. It also had a greater length of the upper caudal lobe, and a straight dorsal line (Wade, 1935).

Wade (1941a) re-examined the Brookvale (Beacon Hill Quarry) specimen AM F.66968 and nominated many character states that did not match those of a semionotid. Thus, he erected a new family, Promecosominidae, to contain this species and three others from the St Peters Brickpits originally named by Woodward (1908), *Semionotus formosus*, *Pholidophorus australis* and *Acentrophorus* sp. He placed this family within the Holostei. These four species all were synonymised into *Promecosomina formosa* (Wade, 1941a).

Family *incertae sedis*

Enigmatichthys attenuatus Wade, 1935

Fig. 8g

Holotype: P 15852—imperfect fish—held in the NHMUK.

Mentioned: AM F.66957 (USGD 31) (Fig. 8g), AM F.66958 (USGD 315) (DS 11)/AM F.66959 (USGD 316) (DS 12), AM F.4595—held in the AMTC under "Wade 1935".

Wade (1935) erected a new genus and species for these specimens and placed them in the Protospondyli, part of the Neopterygii, but was unable to assign them to a family (as he could not determine the outlines of the bones of the cheek, jaws and opercular apparatus). The species is now considered to be in the Parasemionotiformes. This very small, elongate-fusiform fish possesses a blunt snout and large orbits placed anteriorly (Wade, 1935).

Trace fossil

Palaeoxyris duni Crookall, 1930

Fig. 8h

Palaeoxyris sp.—Brongniart, 1828: 456, pl. 10.

Spirangium sp.—Dun, 1913: 205, pl.14.

Palaeoxyris duni Crookall, 1930: 12,13.

Holotype: MMF 42697a (Fig. 8h)—held in the GSNSW collection.

Paratype: MMF 42697b (Fig. 8h)—held in the GSNSW collection.

(The holotype and paratype are positioned on a single shale slab).

Dun (1913) described four enigmatic fossils from Brookvale, which he identified as *Spirangium*, and included a photograph of the best specimen which contained two fossil impressions. At that time there were similar specimens under discussion in Europe and North America under several generic names of *Palaeoxyris, Palaeobromelia* and *Fayolia* (Dun, 1913). Their origin was controversial—some taxonomists proposed a plant origin (a fructification), and others an animal origin, possibly shark egg cases or coprolites. The photograph published by Dun (1913) bore a close resemblance to the holotype of *Palaeoxyris regularis* illustrated by Brongniart (1828).

Crookall (1930), in a series of morphological studies of *Palaeoxyris* and other form genera, referred to the discovery of "*Spirangium*" from Brookvale (Beacon Hill Quarry) noted by Dun (1913). He described these specimens from the figure published by Dun (1913) and named them *Palaeoxyris duni*.

Fischer and Kogan (2008) provided a thorough review of the literature relating to these specimens and concluded that a "well-established egg-producer relationship exists for *Palaeoxyris* and hybodonts" (Fischer & Kogan 2008: 85).

The specimen illustrated by Dun (1913) and described by Crookall (1930) was located in the GSNSW collection at Londonderry, NSW in 2012 and described as a shark egg case by McLean (2014). Thus, recent work has established that sharks were present in the Brookvale environment, even if they were just migrating to the area for reproduction.

Class Insecta Linnaeus, 1758

Significant taxonomic work was carried out by Tillyard (1925), McKeown (1937), Riek (1950, 1954) and Evans (1956, 1963) on insect specimens gathered from the Brookvale (Beacon Hill Quarry) site.

On Tillyard's death in 1937 his widow dispersed his collection, mainly to the British Museum (now the NHMUK). This collection contained many Brookvale insect specimens, including four *Clathrotitan scullyi*, one *Mesacredites elongata*, the holotype of *Tillyardomyrmeleon petermilleri* and four *Fletcheriana triassica*.

Most specimens from Brookvale (Beacon Hill Quarry) were large compared to other specimens from other NSW sites, such as the Belmont insect beds (Late Permian). This may have been due to a collection bias. Specimens from Belmont were collected by palaeontologists, whereas the Brookvale specimens were selected by quarrymen interested in fossils but untrained in palaeontological procedures. It is most probable that they only spotted the "macro specimens", of which there were some magnificent examples.

Order Titanoptera Sharov, 1968

Family Mesotitanidae Tillyard, 1925

Subfamily Mesotitaninae Gorochov, 2003

Clathrotitan (= *Clatrotitan*) *scullyi* (Tillyard, 1925)

Figs 9a–h

Mesotitan scullyi Tillyard, 1925; 376, text fig. 1, pl. 36 fig. 1.
Mesotitan tillyardi McKeown, 1937: 34, pl. 6 fig. 2—synonymised by Riek (1954).
Clatrotitan andersoni McKeown, 1937: 32, pl. 4 fig. 1, pl. 5 figs 1, 2, 3, text figs 1, 2, 3—synonymised by Riek (1954).
Clathrotitan (= *Clatrotitan*) *scullyi*—Riek, 1954: 166, pl. 6 fig. 4.

Holotype: AM F.37189 (MMF 20270) (Fig. 9a)—as *Mesotitan scullyi*—held in the AMTC under "Tillyard 1925".

Syntypes: AM F.39789 (USGD 1935) (Fig. 9b)—as *Mesotitan tillyardi*—held in the AMTC under "McKeown 1937". AM F.36274 (Fig. 9c)—as *Clatrotitan andersoni*—held in the AMTC under "McKeown 1937".

Paratypes: AM F.39786 (USGD 1932)/AM F.39787 (USGD 1933)—as *Clatrotitan andersoni*—held in the AMTC under "McKeown 1937".

Mentioned: AM F.39788 (USGD 1934) (USGD 310) (Fig. 9d)—as *Mesotitan scullyi*—held in the AMTC under "McKeown 1937". AM F.43741—hindwing—held in the AMTC under "Riek 1954".

Other specimens held in the AMGC under "Insecta/Triassic/Brookvale": AM F.43968/AM F.43967 (Fig. 9e/Fig. 9f)—wing. AM F.46507—partial wing. AM F.72142—wing fragment.

Other specimens held in the NHMUK collection: In. 37340—as *Clatrotitan andersoni* (Fig. 9h). In. 37341—as *Clatrotitan andersoni.* In. 37342—as *Clatrotitan andersoni.* In. 46113—*Clatrotitan*—wing.

Tillyard (1925) described a single wing AM F.37189 (MMF 20270) (Fig. 9a), naming this as the holotype of a new species *Mesotitan scullyi*. It was compared closely by Tillyard (1925) to *Mesotitan giganteus*, a species he had named from the St. Peters Brickpits (Tillyard & Dunstan, 1916). Tillyard had placed *M. giganteus* in Protorthoptera (Tillyard & Dunstan, 1916), but after examining the Brookvale specimen, re-assigned it to Protohemiptera with *M. scullyi* and erected a new family Mesotitanidae to contain both these species (Tillyard, 1925).

McKeown (1937) described a further wing specimen AM F.39788 (USGD 1934) (Fig. 9d) as *Mesotitan scullyi.* He named and described another wing AM F.39789 (USGD 1935) (Fig. 9b) as *Mesotitan tillyardi* (McKeown, 1937).

McKeown also named and described a magnificently preserved wing (AM F.36274) as *Clatrotitan andersoni* (McKeown, 1937) (Fig. 9c). This syntype is a large wing (138 mm long) with a remarkable "resonating area" developed centrally (McKeown, 1937: 32). Tillyard (1925) had suggested it could be the male of *Mesotitan scullyi*, but McKeown rejected this conclusion. Along with the unique resonating grid, the wing possesses pigmentation patterns.

A photograph (Fig. 9g) of a lost specimen containing two wings was also described by McKeown (1937). The second wing was possibly a hindwing, but lack of the actual specimen prevented taking of accurate measurements. The specimen seemed to be from Brookvale (Beacon Hill Quarry) and appeared to be identical with *Mesotitan scullyi* (McKeown, 1937).

Riek (1954) disagreed with Tillyard (1925) and McKeown (1937) who had assigned the Brookvale (Beacon Hill Quarry) specimens to Mesotitanidae. He erected the Clathrotitanidae to contain only one genus, *Clathrotitan* (=*Clatrotitan*) McKeown, 1937. *Mesotitan scullyi, Mesotitan tillyardi* and *Clatrotitan andersoni* all were synonymised under *Clathrotitan scullyi*, with the genus being assigned to the Orthoptera.

Riek (1954) considered *Mesotitan giganteus* from the St Peters Brickpits as a separate genotype probably referable to Homoptera. However, Jell (2004) decided that this specimen was difficult to interpret and, although an argument to support Riek's separation of *M. giganteus* from *C. scullyi* could be made, there was reason to classify them within one family, Mesotitanidae.

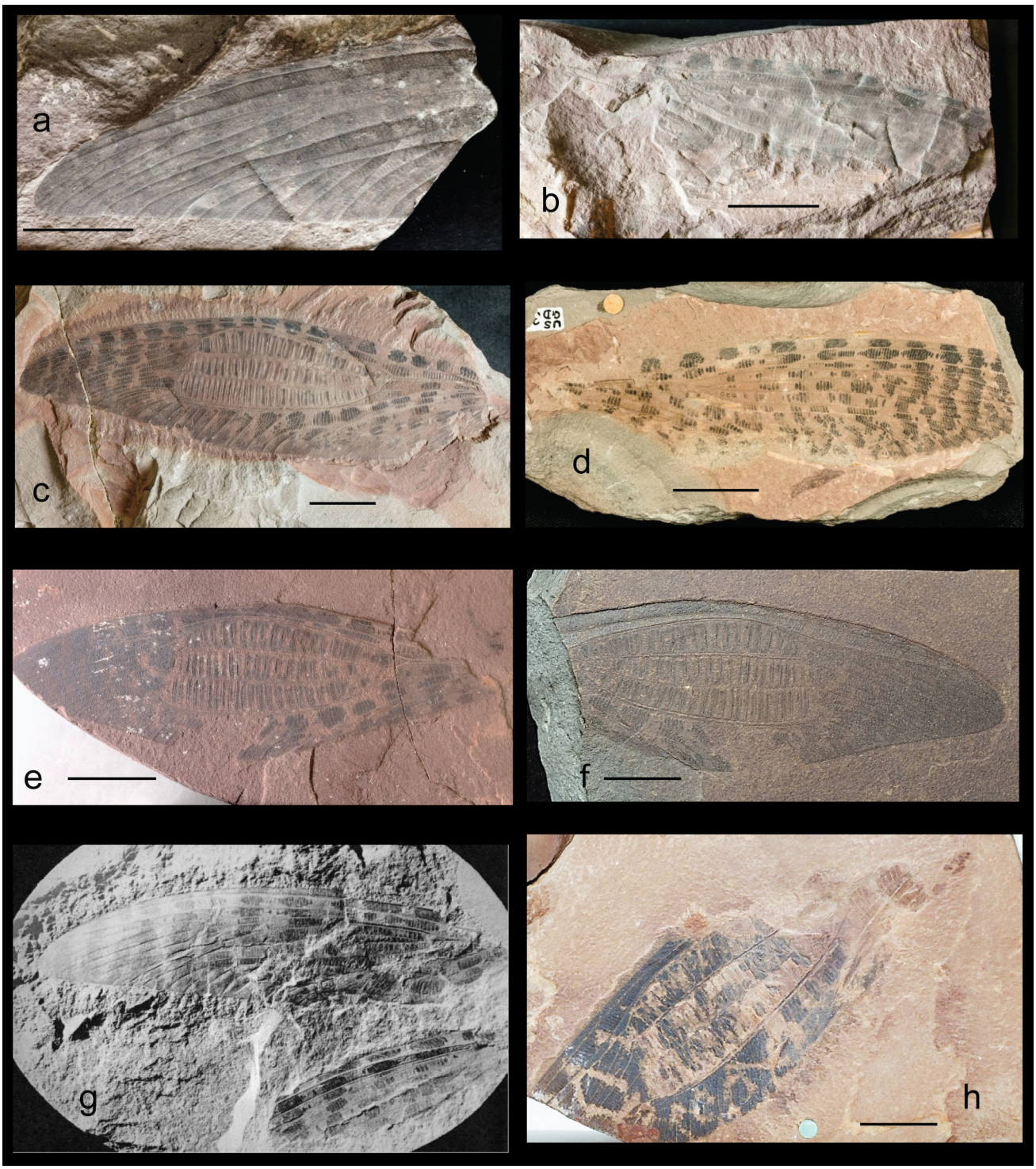

Figure 9. Brookvale (Beacon Hill Quarry). Insecta. (a) AM F.37189. *Clathrotitan scullyi.* (*b*) AM F.39789. *Clathrotitan scullyi.* (*c*) AM F.36274. *Clathrotitan scullyi.* (*d*) AM F.39788. *Clathrotitan scullyi.* (*e*) AM F.43968. *Clathrotitan scullyi*. (*f*) AM F.43967. *Clathrotitan scullyi*. Counterpart of AM F.43968. (*g*) *Clathrotitan scullyi*. (specimen lost). (*h*) NHMUK In.37340. *Clathrotitan scullyi.* Scale bars = 20 mm.

The family has been re-assigned to the Titanoptera, but currently there is still controversy about the higher-level taxonomy of these specimens (e.g. Béthoux, 2007).

Order Mecoptera Packard, 1886a

Family Orthophlebiidae Handlirsch, 1906

Choristopanorpa bifasciata Riek, 1950

Figs 10a–b

Holotype: AM F.30959 (Fig. 10a)—wing—held in the AMTC under "Riek 1950".

Paratypes: AM F.30956, AM F.39196/AM F.39186, AM F.30967, AM F.39197, AM F.38258, AM F.38263 (Fig. 10b)/AM F.35879, AM F.30962, AM F.39181, AM F.39195 and AM F.30964—all held in the AMTC under "Riek 1950".

Other specimen: One specimen held in the AMGC under "Insecta/Triassic/Brookvale".

Eleven specimens of this species of scorpionfly were described by Riek (1950). Head, antennae and thorax are observable in some cases along with some pigmentation. Riek (1950) erected a new genus for this new species, *Choristopanorpa* from the extant *Chorista* and *Panorpa* which have similar characters.

Order Grylloblattodea Brues & Melander, 1932

Family Mesorthopteridae Tillyard & Dunstan, 1916

Austroidelia perplexa Riek, 1954

Fig. 10d

Holotype: AM F.39179 (Fig. 10d)/AM F.39190—forewing—held in the AMTC under "Riek 1954".

Reik (1954) erected a new genus and species for this material, *Austroidelia perplexa*, considering it to be within the Protorthoptera, an order more typical of the Permian and Late Carboniferous. Riek (1954) estimated that this species had a wing length of about 26 mm (specimen wing was not complete).

Order Orthoptera Olivier 1789

Family Locustavidae Sharov, 1968

Mesacredites elongata Riek, 1954

Fig. 10c

Holotype: AM F.30970 (Fig. 10c)—forewing—held in the AMTC under "Riek 1954".

Other specimens: AM F.46491—held in the AMGC under "Insecta/Triassic/Brookvale". In. 46115—wing—held in the NHMUK collection.

Riek (1954) erected a new genus and species for this material, *Mesacredites elongata*, placing it in Stenaropodidae, part of Protorthoptera which are more typical in Palaeozoic strata. He estimated that this species had a wing length of about 65 mm (the specimen wing was not complete). Jell (2004) placed this species in Ideliidae, within Protorthoptera. Béthoux and Ross (2005) examined the *Mesacredites elongata* wing specimen In. 46115 from Brookvale held at the NHMUK. They determined the venation placed this species in Locustavidae, a member of Orthoptera.

Family Haglidae Handlirsch, 1906

Prohagla superba Riek, 1954

Figs 10e–f

Holotype: AM F.38264 (Fig. 10e)—forewing—held in the AMTC under "Riek 1954".

Mentioned: AM F.41290 (Fig.10f)—hindwing. AM F.43339—fore and hindwing of female—held in the AMTC under "Riek 1954".

Other specimen: In. 46104—held in the NHMUK collection.

Riek (1954) erected a new genus *Prohagla* within Prophalangopsiidae to contain this new species. The holotype is a male forewing 42 mm long and 12 mm wide, with a pigmentation pattern (Reik, 1954). A hindwing specimen (AM F.41290) has also been found, which is 38 mm long and 11 mm wide. Jell (2004) placed this genus in Haglidae within Orthoptera.

Order Plecoptera Burmeister, 1839

Family Eutheniidae Tillyard, 1921

Mesonotoperla sinuata Riek, 1954

Fig. 10g

Holotype: AM F.35877 (Fig. 10g)/AM F.35955—incomplete body with wings—held in the AMTC under "Riek 1954".

Riek (1954) erected the new genus *Mesonotoperla* to contain this new species of stonefly and placed it within Eustheniidae within Perlaria. Later, Perlaria became Plecoptera. The holotype specimen bears all four wings attached to the two thoracic segments and portions of three legs (Riek, 1954).

Order Hemiptera Linnaeus, 1758

Family Hylicellidae Evans, 1956

Triassocytinopsis paranotalis Evans, 1956

Fig. 11a

Holotype: AM F.38265 (Fig. 11a)—complete insect—held in the AMTC under "Evans 1956".

Evans (1956) erected the new genus *Triassocytinopsis* within Scytinopteridae to contain this new species of true bug. The length of the whole insect was 21 mm, with the greatest width of the tegmen being 6.8 mm.

Family Dunstaniidae Tillyard & Dunstan, 1916

Fletcheriana triassica Evans, 1956

Figs 11b–d

Holotypes: AM F.39166 (Fig. 11c)/AM F.39165—forewing— held in the AMTC under "Evans 1956". AM F.30971 (Fig.11d)—(hindwing)—held in the AMTC under "Evans 1956".

Additional Material: AM F.25234 (whole insect) (Fig. 11b), AM F.30952, AM F.39161, AM F.39162, AM F.39164, AM F.39159. AM F.35881, AM F.36273, AM F.31960, AM F.30945, AM F.38261, AM F.39170, AM F.39169, AM F.30968, AM F.39168, AM F.39163, AM F.35880, AM F.30976,

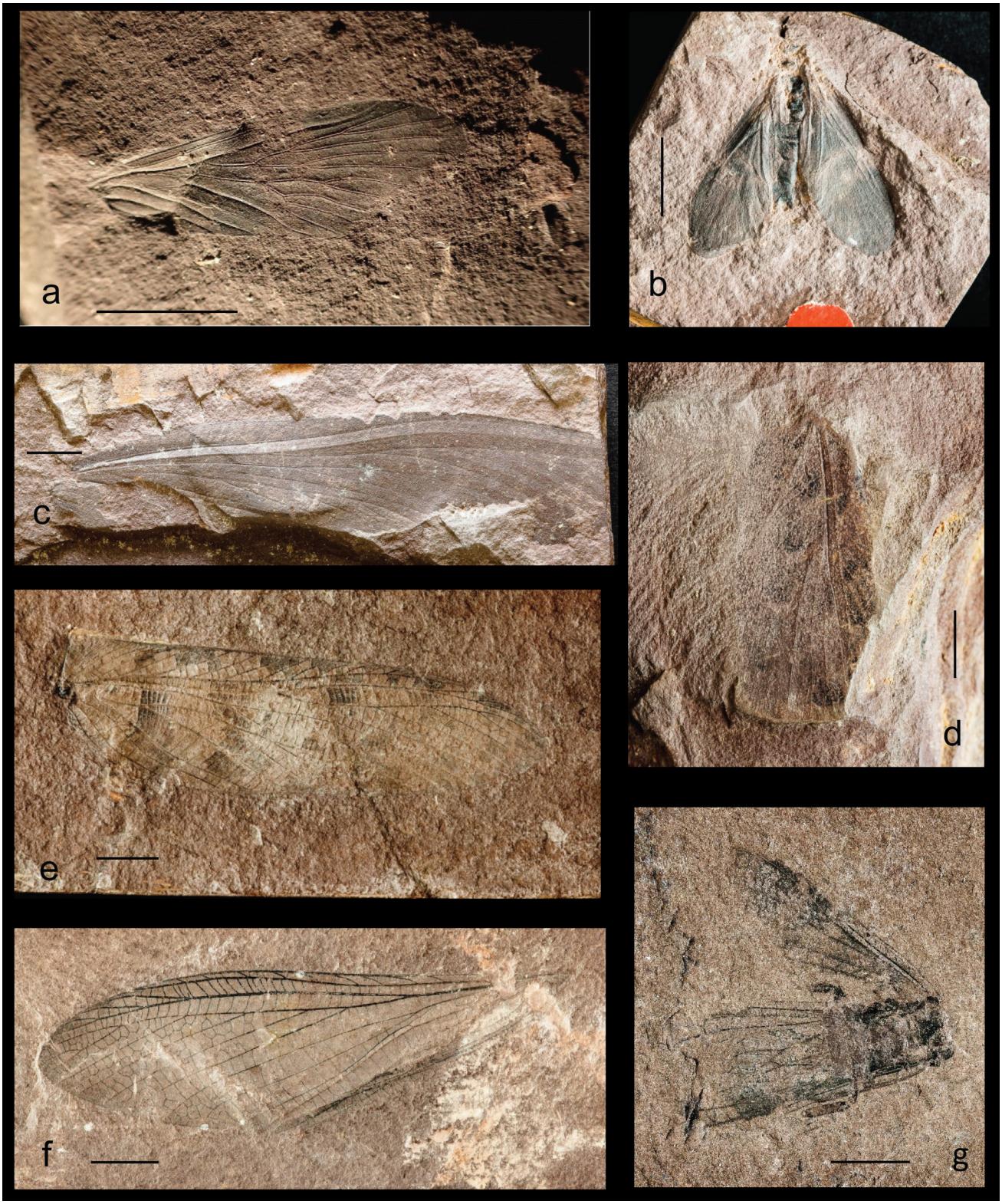

Figure 10. Brookvale (Beacon Hill Quarry). Insecta. (*a*) AM F.30959. *Choristopanorpa bifasciata*. Forewing. (*b*) AM F.38263. *Choristopanorpa bifasciata*. (*c*) AM F.30970. *Mesacredites elongata.* (*d*) AM F.39179. *Austroidelia perplexa*. (*e*) AM F.38264. *Prohaglia superba.* Forewing. (*f*) AM F.41290. *Prohaglia superba.* Hindwing. (*g*) AM F.35877. *Mesonotoperla sinuata.* Scale bars = 5 mm.

Figure 11. Brookvale (Beacon Hill Quarry). Insecta. (*a*) AM F.38265. *Triassocytinopsis paranotalis.* (*b*) AM F.25234. *Fletcheriana triassica.* (*c*) AM F.39166. *Fletcheriana triassica.* Forewing. (*d*) AM F. 30971. *Fletcheriana triassica.* Hindwing. (*e*) AM F.30974. *Beaconiella fennahi*. (f) AM F.35878. *Beaconiella multivenata*. Scale bars: *a, e*, and *f* = 5 mm: *b, c*, and *d* = 10 mm.

AM F.39171—all held in the AMTC under "Evans 1956".
Other specimens held in the AMGC under "Insecta/Triassic/Brookvale": AM F.39187 (W 30), AM F.66481, AM F.67873 (SUP 10032), AM F.70009 (USGD 301), AM F.70010 (SUP 309), AM F.72143 (USGD 305), AM F.72144 (USGD 311), AM F.72145 (USGD 300)—all wings or fragments.
Other specimens held in the NHMUK collection: In. 46096, In. 46098, In. 46102, In. 46110—all wings.

The length of the holotype forewing (AM F.39166/AM F.39165) is 58 mm, and the maximum width is 23 mm. The whole surface of the forewing is pitted (Evans, 1956). The length of the holotype hindwing (AM F.30971) is 40 mm, with its greatest width 25 mm.

Additional material included a whole insect (AM F.25234) which has been used extensively in general publications to illustrate how little change in cicada morphology has occurred over the last 245 million years (e.g., Anderson, 1935; McKeown, 1942; Fletcher, 1962).

Evans (1956) erected a new family, Cicadamorphidae, for this new genus and species. Later it was placed within Palaeontinidae, before being transferred to Dunstaniidae by Riek (1976). More recently, Wang *et al.* (2009) have commented that *Fletcheriana* is considered to represent a transition between Dunstaniidae and Palaeontinidae.

Family Curvicubitidae Hong, 1984

Beaconiella fennahi Evans, 1963

Fig. 11e

Holotype: AM F.30974 (Fig. 11e)—wing—held in the AMTC under "Evans 1963".

Evans (1963) erected a new genus and species for this specimen of plant hopper. The holotype is a wing (AM F.30974) 17 mm long with its greatest width 8.8 mm (Evans, 1963). He assigned it to Fulgoridae. Shcherbakov (1984) assigned *Beaconella* to Curvicubitidae.

Beaconiella multivenata Evans, 1963

Fig. 11f

Holotype: AM F.35878 (Fig. 11f)—tegmen—held in the AMTC under "Evans 1963".

The holotype is a tegmen (AM F.35878) 21 mm long and resembles the wing of *Beaconella fennahi* in general venation but with more profuse branching of the veins (Evans, 1963). Evans (1963) commented that, as no undoubted fulgoroids had been discovered previously in Middle Triassic strata of Australia, this discovery was of particular interest. Shcherbakov (1984) assigned Beaconella to Curvicubitidae.

Family Progonocimicidae Handlirsch 1906

Triassodoecus chinai Evans, 1963

Fig. 12a

Holotype: AM F.46398 (Fig. 12a)—held in the AMTC under "Evans 1963".

Evans (1963) erected a new genus and species for this specimen of plant hopper. He placed this genus in Actinoscytinidae. Later, Jell (2004) listed this genus within Progonocimicidae. The thorax of the holotype is preserved, but only part of the wing venation has been preserved.

Order Odonata Fabricius, 1793

Suborder Archizygoptera Handlirsch, 1906

Family Protomyrmeleontidae Handlirsch, 1906

Tillyardomyrmeleon petermilleri Henrotay, Nel & Jarzembowski, 1997

Fig. 12b

Holotype: In. 46119 (Fig. 12b)—nearly complete wing—held in the NHMUK collection.

Henrotay *et al.* (1997) reviewed the Protomyrmeleontidae, which is known from the Late Triassic of Australia and Italy, as well as the Jurassic and Early Cretaceous of Europe and Siberia. They reported on an undescribed damselfly from the Brookvale (Beacon Hill Quarry) collections in the NHMUK, which was found to be the oldest known member of the family. They named it *Tillyardomyrmeleon petermilleri*, placed it within the damselfly Suborder Archizygoptera, and carried out a phylogenetic analysis within the family. The specimen is a nearly complete wing with the costal part of the base and the petiole missing. The length of the specimen is 14.5 mm, with a probable complete length of 20 mm.

Other undescribed insect specimens

Held in the AMGC under "Insecta/Triassic/Brookvale":
Blattaria (cockroaches)—includes AM F.49496 (Fig. 12c).
Coleoptera (beetles)—includes AM F.30957 (Fig. 12d).
Hemiptera—Cicadomorpha.
Mecoptera (scorpionflies)—includes AM F.49498 (Fig. 12e).
Odonata (dragonflies)— includes AM F.39175 (Fig. 12f).
Orthoptera (crickets and grasshoppers).

Held in the NHMUK collection:
Blattaria (cockroaches).
Coleoptera (beetles).
Hemiptera (bugs)— In. 46076, In. 46132, In. 46135, In. 46139.
Heteroptera—In. 46107.
Mecoptera (scorpionflies).
Odonata (dragonflies)—In. 46116.
Orthoptera (crickets and grasshoppers)—In. 46093/In. 46080.

Class Merostomata Woodward, 1866

The Class Merostomata contains the Xiphosura (horseshoe crabs) and the Eurypterida (sea scorpions). There is ongoing debate as to whether Pycnogonida (sea spiders) and Arachnida (scorpions, spiders and mites) should be also grouped in this Class.

Order Xiphosura Latreille, 1802

Superfamily Limuloidea Zittel, 1885

Family Austrolimulidae Riek, 1968

Austrolimulus fletcheri Riek, 1955

Figs 13a–b

Holotype: AM F.38274/38275 (Figs 13a–b)—held in the AMTC under "Riek 1955".
Other specimen: Mould and cast—held in the AMGC under "Arthropoda/Xiphosura".

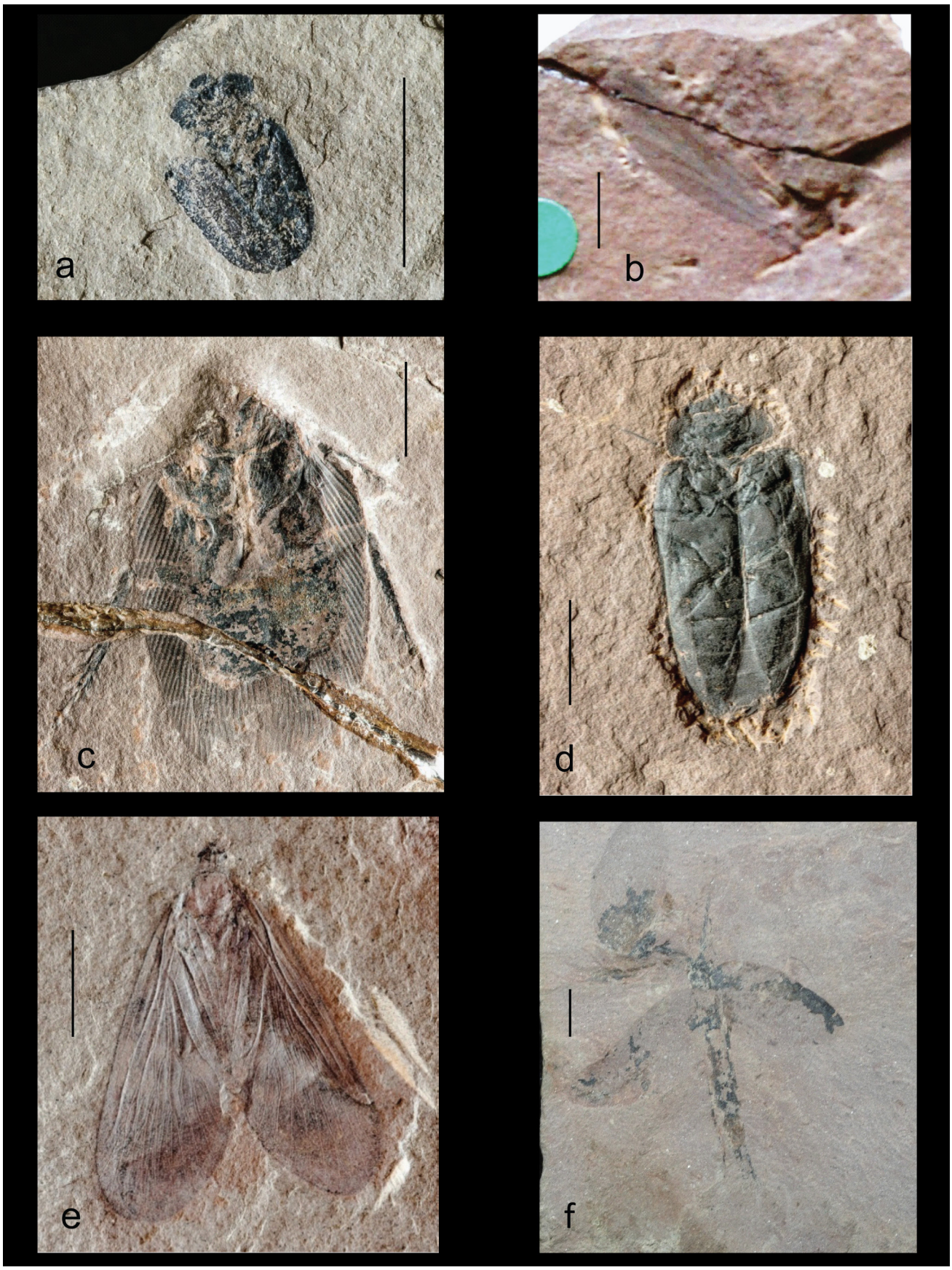

Figure 12. Brookvale (Beacon Hill Quarry). Insecta. (*a*) AM F.46398. *Triassodoecus chinai*. (*b*) NHMUK In. 46119. *Tillyardomyrmeleon petermilleri*. (*c*) AM F.49496. Blattaria. (*d*) AM F.30957. Coleoptera. (*e*) AM F.49498 Mecoptera. (f) AM F.39175. Odonata. Scale bars = 5 mm.

Figure 13. Brookvale (Beacon Hill Quarry). Xiphosura. (*a*) AM F.38274. *Austrolimulus fletcheri*. (*b*) AM F. 38275. *Austrolimulus fletcheri.* Counterpart of AM F.38274. Scale bars = 20 mm.

The holotype is an almost complete single specimen preserved in part and counterpart. The opisthosoma lacks lateral spines, and the prosoma possess very large genal spines which are directed laterally and are only slightly curved posteriorly. The telson forms a long, caudal spine and is triangular in cross section. No other specimen of this species is known (Riek, 1955). Reik (1955) placed this specimen in a new family Austrolimulidae within Xiphosura. Reik (1968) revisited this specimen to discuss its taxonomic position within the limulid families. He stated that Austrolimulidae occupied a position intermediate between Paleolimulidae and Mesolimulidae.

Pickett (1984), in an introduction to the description of the only other Triassic limulid yet found in Australia (*Dubbolimulus peetae)*, maintained the view that Austrolimulidae held only one species, *A. fletcheri,* and that this was an aberrant species derived from the mainstream of Limuloidea due to its reduced opisthosoma, exaggerated genal spines, absence of moveable spines and absence of posteriolateral facets. Bicknell *et al*. (2022) investigated the timing of morphological innovations in xiphosurid evolution of four Australian specimens using synchrotron radiation X-ray tomography, including *A. fletcheri*.

Class Arachnida Lamarck, 1801

There is ongoing debate about the higher taxonomy of the Arachnida (see Merostomata above).

Order Scorpiones Koch, 1837

Family *incertae sedis*

Genus and species *incertae sedis*

Referred material: AM F.30961—anterior section of exoskeleton.

Bicknell and Smith (2021) described a specimen previously held unidentified in the AMGC. Pedipalps and a walking leg are preserved. The right femur, patella, manus and moveable finger are also preserved. The preservation is generally poor. This is the first report of a fossil scorpion from Australia.

Subphylum Crustacea Brünnich, 1772

Only three species of Crustacea have been described from the Brookvale (Beacon Hill Quarry) site—a syncarid, a euthycarcinid and a spinicaudatan. There are also eleven undescribed spinicaudatans held in the AMGC.

Class Malacostraca Latreille, 1802

Subclass Eumalacostraca Grobben, 1892

Superorder Syncarida Packard, 1885

Order Anaspidacea Calman, 1904

Family Anaspididae Thomson, 1893

Anaspidites antiquus (Chilton, 1929)

Figs 14a–b

Anaspides? antiquus Chilton, 1929: 367, pl. 30.
Anaspidites antiquus—Brooks, 1962: 234, pl. 5 fig. 1, pl. 6, text fig. 2c.

Holotype: AM F.69765 (Fig. 14a)—held in the AMTC under "Chilton 1929".
Other specimen: AM F.25226 (Fig. 14b)—held in the AMGC under "Crustacea/Syncarida".

Chilton (1929) described this syncarid as a freshwater shrimp about 2 inches (5 cm) long with no indication of a carapace and tentatively ascribed it to Anaspidacea. He identified several similarities to the recently described Tasmanian freshwater shrimp *Anaspides tasmaniae,* (including free posterior thoracic segments, lack of carapace, a row of "setae" on the 6th abdominal segment) but hesitated to diagnose its genus and species. He suggested that it be referred to as *Anaspides? antiquus* as a matter of convention (Chilton,1929).

The Superorder Syncarida was erected by Packard (1885) and described by Packard (1886b). The diagnostic features were the absence of a carapace and loss of the first thoracic tergite through fusion. Brooks (1962) observed that, after comparing northern hemisphere fossil syncarids with fossils from the southern hemisphere, it was only the fossils from the southern hemisphere that had the first thoracic somite fused with the cephalic tagma. These fossils were *Clarkecaris brasilicus* from the Permian of Brazil and *Anaspides? antiquus* from the Triassic of Brookvale, Australia, and were the only known syncarid fossils from the southern hemisphere (Brooks, 1962). He therefore proposed a new taxonomic structure for fossil and extant Syncarida that comprised three orders—Palaeocaridacea, Anaspidacea and Bathynellacea (Brooks, 1962). Anaspidacea contained syncarids with the first thoracic somite incorporated with cephalic tagmata. This included the two southern hemisphere fossil syncarids and four extant species. Due to particular variations in morphological characteristics not consistent with *Anaspides,* Brooks (1962) erected *Anaspidites* for the Brookvale specimen. Thus, there is a close evolutionary affinity between the southern hemisphere freshwater Permian and Triassic syncarids and an evolutionary divergence between northern and southern freshwater syncarids (Brooks, 1962).

Before 2016 only two Tasmanian species of extant Syncarida were recognised, one being *Anaspides tasmaniae*. Further work by Ahyong (2016) has led to the identification of a total of seven species, all living in the high-altitude fresh waters of Tasmania's lakes, rivers and caves.

Class Branchiopoda Latreille, 1817

Subclass Euthycarcinoidea Gall & Grauvogel, 1964

Order Euthycarcinida Gall & Grauvogel, 1964

Family Euthycarcinidae Edgecombe & Morgan 1999

Synaustrus brookvalensis Riek, 1964

Fig. 14c–f

Holotype: AM F.30953 (Fig. 14c)—held in the AMTC under "Riek 1964".
Paratype: AM F.30969 (Fig. 14d)—held in the AMTC under "Riek 1964".
Mentioned: AM F.52342 (Fig. 14e)—held in the AMTC under "Riek 1964".

Riek (1964) examined three non-insect arthropod specimens from Brookvale that appeared to have a body shape similar to both Merostomata and Trilobitomorpha**.** Until 1964 no Trilobitomorpha were known in rocks younger than the middle Permian. However, Riek (1964) noted the existence

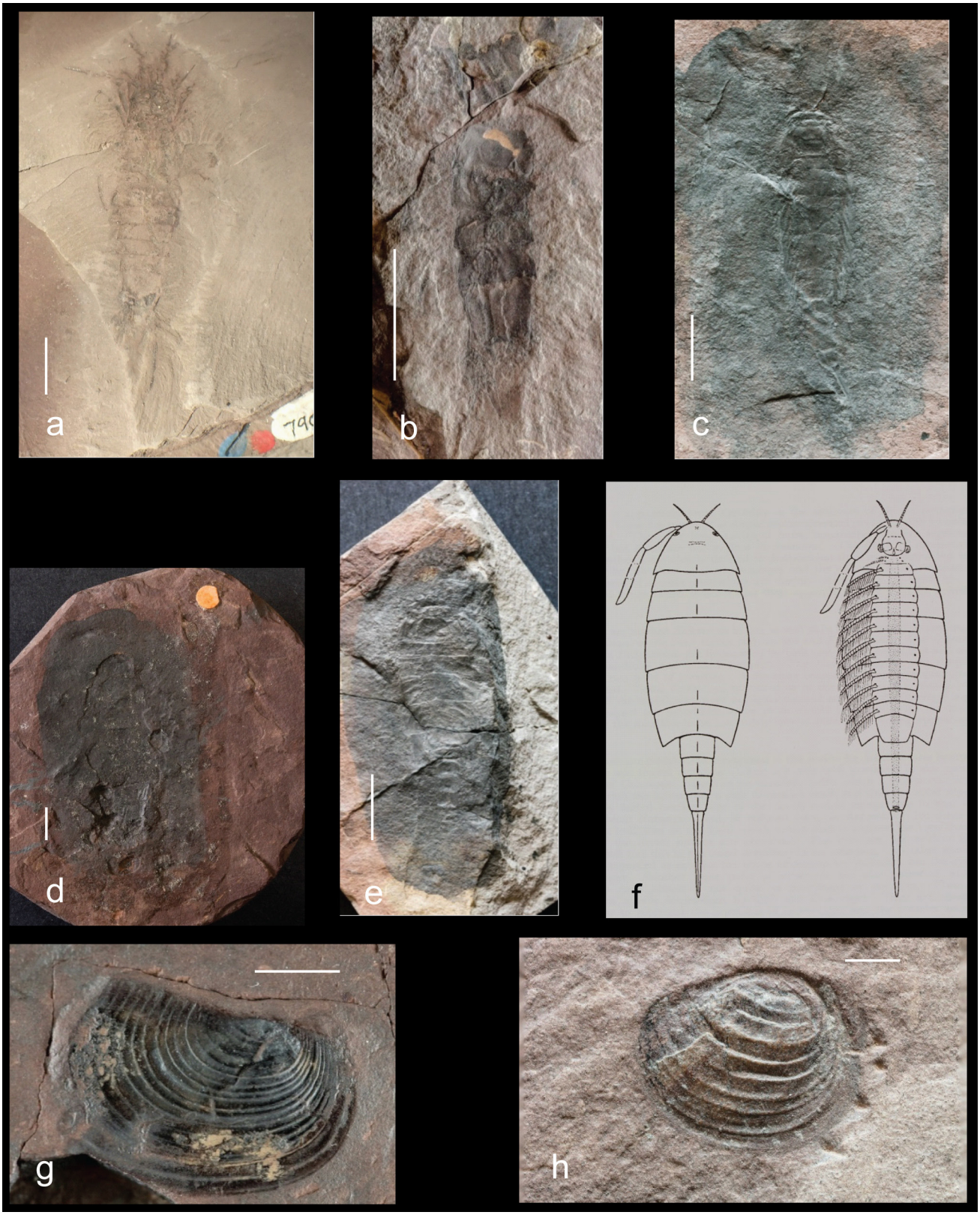

Figure 14. Brookvale (Beacon Hill Quarry). Crustacea. (*a*) AM F.69765. *Anaspidites antiquus*. (*b*) AM F.25226. *Anaspidites antiquus*. (*c*) AM F.30953. *Synaustrus brookvalensis*. (*d*) AM F.30969. *Synaustrus brookvalensis*. (*e*) AM F.52342. *Synaustrus brookvalensis*. (*f*) Reconstruction of *Synaustrus brookvalensis*. From Riek (1968). (*g*) AM F.36275. *Palaeolimnadiopsis bassi.* (h) AM F.48172. *Cyzicus* sp. Scale bars: *a, b, c, d,* and *e* = 10 mm: *g* = 5 mm: *h* = 1 mm.

of a possible glabella and short, blunt genal spines. As there were some doubts about these characters the larvae of other possible Insecta taxa were considered. Riek (1964) finally concluded that these specimens should be placed in Trilobitomorpha in a new family Synaustridae, a new genus *Synaustrus* and a new species *brookvalensis*.

After reading a review of *Euthycarcinus kessleri* (Gall & Grauvogel, 1964) Riek (1968) revisited his taxonomic assessment of *Synaustrus brookvalensis*. He stated his interpretation of a distinct glabella was in error and noted other similarities to *Euthycarcinus kessleri*. He concluded that *Synaustrus* should be classified as a crustacean within Branchiopoda (Riek, 1968).

Edgecombe and Morgan (1999) commented that euthycarcinoids had been subjected to a great range of phylogenetic assignments. They re-appraised the fossil data relating to *S. brookvalensis* and concluded that it could be more accurately classified with other taxa, notably *Euthycarcinus* in the Euthycarcinidae.

Subclass Phyllopoda Preuss, 1951

Order Diplostraca Gerstaecker, 1866

Suborder Spinicaudata Linder, 1945

Family Limnadiidae Burmeister, 1843

Palaeolimnadiopsis bassi Webb, 1978

Fig. 14g

Holotype: AM F.36275 (Fig. 14g)—held in the AMTC under "Webb 1978".

Other specimen: AM F.66474—held in the AMGC under "Crustacea/Conchostraca".

Webb (1978) described a "conchostracan" collected from Brookvale (Beacon Hill Quarry) in the 1930's. The specimen is moderately large (17.5 mm long by 12 mm high) and flattened with a small larval valve. Growth lines are distinctive in that they comprised paired ridges. These could not have been separate growth lines as they were regular at each moult, which typically takes place between 2–8 days (Webb, 1978). This period is too short for water levels and abundance of food, which affect growth of rings, to vary so regularly and markedly (Webb, 1978). The character of the postero-dorsal concavity in the shell margin led Webb (1978) to identify the specimen as *Palaeolimnadiopsis,* a genus previously identified only in Tasmania. Assessment of a range of species of this genus from the Permian of USA, Cretaceous of China, Jurassic of Zaire, Mesozoic of Angola and Triassic of Russia indicated that this was a new species, which Webb (1978) named *P. bassi*.

Cyzicus Audouin, 1837

Fig. 14h

Wade (1931) noted that two species of *Estheria* are present in samples from Brookvale, *E. coghlani* and an undescribed specimen with an unusually long hinge line. The valid genus for these specimens is *Cyzicus*, as *Estheria* was found to be a homonym.

Webb (1978) commented that the AM collection also held *Palaeolimnadia glenleensis* and some poorly preserved valves from Brookvale (Beacon Hill Quarry) site. None of these specimens has been studied or described in detail. The AMGC holds 11 specimens from Brookvale (Beacon Hill Quarry) under "Crustacea/Conchostraca/*Estheria"*. These include AM F.48172 (Fig. 14h).

Phylum Mollusca Linnaeus, 1758

Etheridge (1888) described some small bivalve shells found in brickpit quarries in Waterloo and Surry Hills, Sydney, and in the Gibraltar Railway Tunnel excavations near Bowral. All these excavations are within the Wianamatta Group shales. He placed some of them provisionally within *Unio* and named two species, *U. dunstani* and *U. wianamattensis*. He also erected a new genus, *Unionella*, and named two species within this genus, *U. bowralensis* and *U. carnei*.

McMichael (1956) revised the taxonomy of these small bivalves proposed by Etheridge (1888), placing them in Mutelidae. He erected three Mesozoic genera for these mutilids–*Prohydra, Mesohyridella* and *Protovirgus*. He noted that small *Unionella*-like bivalves occurred at Brookvale, but he did not attempt to classify them. Hocknull (2000) was the first researcher to study the molluscan specimens from Brookvale, although he mistakenly placed the Beacon Hill Quarry within the Wianamatta Group.

Class Bivalvia Linnaeus, 1758

Order Venerida Gray, 1854

Family Glauconomidae Gray, 1854

Protovirgus brookvalensis Hocknull, 2000

Fig. 15a

Holotype: AM F.19773 (Fig. 15a)—held in the AMTC under "Hocknull 2000".

Paratypes: AM F.19805, AM F.41438, AM F.41439, AM F.41440, AM F.41442a–b, AM F.43401—held in the AMTC under "Hocknull 2000".

Hocknull (2000) reviewed Australian fossil freshwater and estuarine molluscs and placed the small bivalves found at Brookvale (Beacon Hill Quarry) within *Protovirgus,* which he moved to Glauconomidae. He erected a new species, *P. brookvalensis* for these specimens. This taxon is small, equivalved, elongate and ovoid, and is differentiated from *P. dunstani* (the only other member of the genus) by its smaller size, weakly defined umbones, more rounded posterior end, and weaker anterior muscle scars (Hocknull, 2000).

Trace fossil

Brookvalichnus obliquus Webby, 1970

Fig. 15b

Holotype: AM F.68916 (SUP 21872)—held in the AMTC under "Webby 1970".

Paratypes: AM F.68917 (SUP 13043), AM F.68918 (SUP 13017) (Fig.15b), AM F.68919 (SUP 21871), AM F.68920 (SUP 21873), AM F.68921 (SUP 21874), AM F.68922 (SUP 21875a–g)—held in the AMTC under "Webby 1970".

Other specimens: Several specimens are held in the AMGC under "Trace Fossils".

The trace fossils are ribbon-like trails, some gently sinuous, running approximately parallel and cutting the substrate laminations at an angle (Webby, 1970). They are approximately 4 mm wide and represent collapsed, lined burrows in fine silty mud and are unbranched (Webby, 1970).

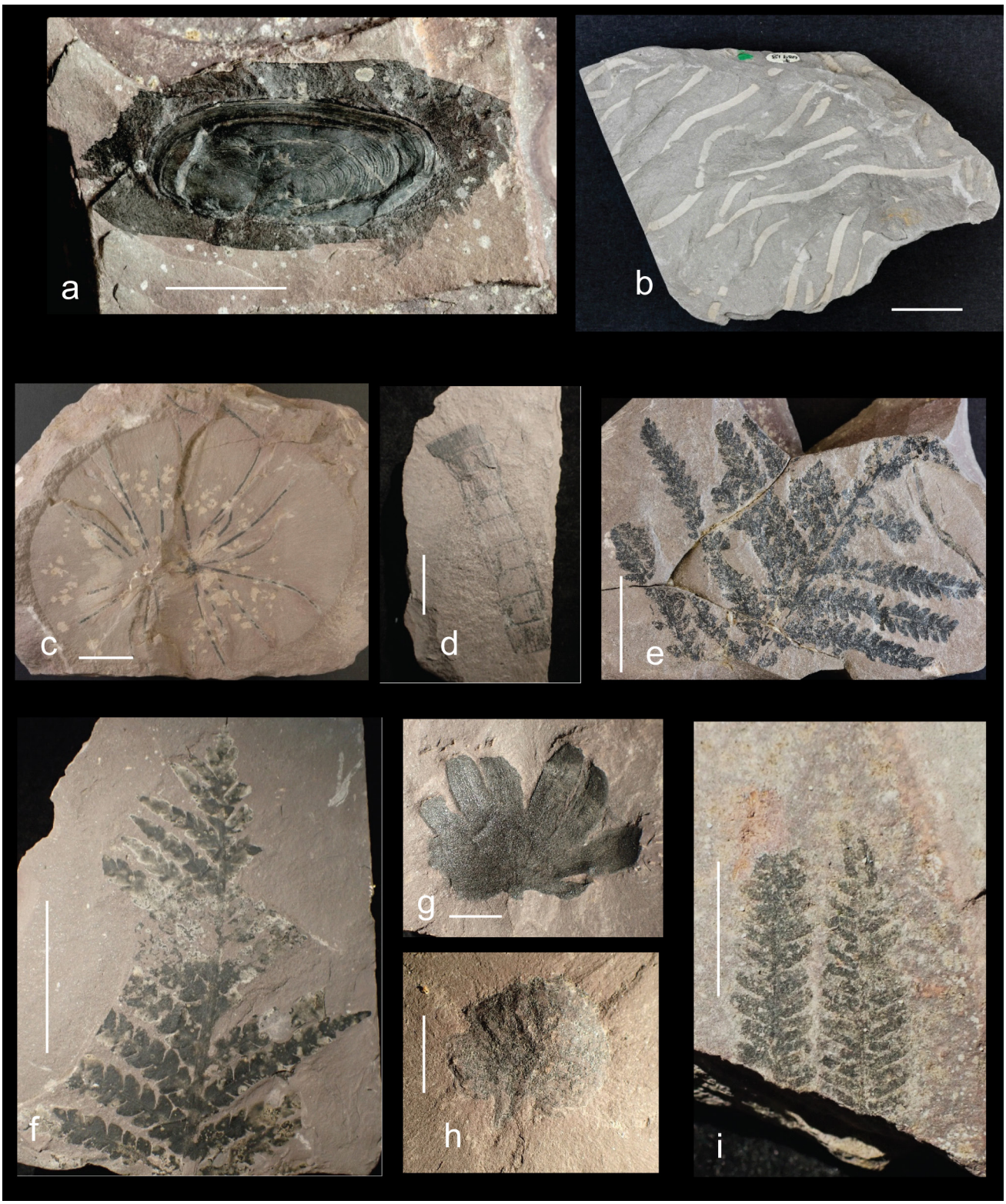

Figure 15. Brookvale (Beacon Hill Quarry). Mollusca, trace fossil, Plantae. (a) AM F.19773. *Protovirgus brookvalensis*. (b) AM F.68918. *Brookvalichnus obliquus*. (*c*) AM F.18616.*Townroviamites brookvalensis*. (*d*) AM F.35950. ?*Neocalamites* sp. (*e*) AM F.47018. *Lepidopteris madagascarensis*. (f) AM F.35948. *Dicroidium feistmenteli*. (g) AM F.18639. *Ginkgo digitata.* (h) AM F.46328. *Cylostrobus* sp.(*i*) AM F.36297. *?Cladophlebis* sp. Scale bars: *a, g, h*, and *i* = 10 mm: b, c, d, and e = 20 mm: *f* = 50 mm.

Kingdom Plantae Copeland, 1956

Various plants have been discovered in the Beacon Hill Quarry, but only one previously undescribed species was found.

Division Equisetophyta Scott, 1900

Class Polypodiopsida Cronquist, Takhtajan, and Zimmermann, 1966

Order Equisetales DC. Ex Berchtold & Presl, 1829

Family Equisetaceae Michaux, in Candolle, 1804

Townroviamites brookvalensis (Townrow, 1955)

Fig. 15c

Phyllotheca brookvalensis Townrow, 1955: 53, text figs 4A–C,5A,B.
Townroviamites brookvalensis—Holmes, 2001: 14, figs 4A–C,5A–E.

Lectotype: NHMUK V31862a.
Paratypes: NHMUK V31857, NHMUK V31859, NHMUK V31860.
Mentioned: AM F.18616 (Fig.15c), AM F.18617, AM F.38273—from Brookvale (Beacon Hill Quarry)—held in the AMTC under "Holmes 2001a".
Other specimens: 12 specimens held in the AMGC under "Plantae/Triassic/Brookvale".

Townrow (1955) described some Gondwanan *Phyllotheca* specimens, including one from Brookvale (*Phyllotheca brookvalensis*), from the Tillyard Collection housed in the NHMUK. He noted these specimens possessed leafy stems with isolated leafy nodes. No holotype or paratypes were nominated by Townrow.

Holmes (2001) revisited Townrow's diagnosis and compared it with other material available from the AM Collection. He considered the Brookvale (Beacon Hill Quarry) specimens differed from *Phyllotheca*, which is essentially a Permian genus, in possessing a reduced leaf sheath and complex nodal region. It also differs from *Neocalamites* by its basally conjoined leaves. Holmes (2001) erected the new genus *Townroviamites* to reflect his emended diagnosis. He also nominated a lectotype and paratypes from Townrow's (1955) specimens.

Division Pteridospermatophyta *sensu* Doweld, 2001

Order Peltaspermales Delevoryas 1979

Family Peltaspermaceae Townrow, 1960

Lepidopteris madagascariensis Carpentier, 1935

Fig. 15e

Lepidopteris stormbergensis Seward, 1908.
Lepidopteris stormbergensis—Townrow, 1960: 341.
Lepidopteris madagascariensis Carpentier, 1935—Townrow, 1966: 203, figs 1–3.

Mentioned: V32106—leaf—held in the NHMUK collection.
Other specimens held in the AMGC under "Plantae/Triassic/Brookvale": AM F.47018 (Fig. 15e)— part of branch. AM F.66281—as *L. stormbergensis*—branch. AM F.46330—fragment.

Townrow (1960), while redefining the pteridosperm family Peltaspermaceae, identified a fossil leaf (NHMUK V32106) from Brookvale (Beacon Hill Quarry) as *Lepidopteris stormbergensis* Seward. He stated that the same leaf was present both in Australia and South Africa, and it was more like a waterside herb than a tree or terrestrial herb.

In his later paper Townrow (1966) re-identified several Peltaspermaceae from Australia as *Lepidopteris madagascariensis* Carpentier, including the specimen NHMUK V32106. Although it did not show all the diagnostic characters of *L. madagascariensis*, it was more similar to this species than *L. stormbergensis*.

Other identified Plantae specimens from Brookvale (Beacon Hill Quarry) held in the AMGC under "Plantae/Triassic/Brookvale".

(Identifications are those made originally, with later identifications in brackets).
AM F.35950—equisetalean stem (Fig. 15d)—(?Neocalamites).
AM F.66314—*Phyllotheca* sp.—a horsetail.
AM F.35948—*Dicroidium feistmanteli* (Fig. 15f)—(Umkomasiales).
AM F.57794—*Dicroidium odontopteroides*—(Umkomasiales).
AM F.66316, AM F.66321—*Dicroidium* sp.— (Umkomasiales)
AM F.18639—*Ginkgo digitata* (Fig. 15g)—a ginkgo.
AM F.66313—*Ginkgoites* sp.—a ginkgo.
AM F.46328—*Cylostrobus* sp. (Fig. 15h)—(Pleuromeiaceae).
AM F.18618—*Taeniopteris lentriculiformis*—(*incertae sedis*).
AM F.30944, AM F.30951—Taeniopteris wianamattae—(*incertae sedis*).
AM F.46210—*Cladophlebis* sp.—(Osmundales).
AM F.39397—*Rissikia* sp—(Voltziales).
AM F.36297—*Alethopteris* sp. (Fig. 15i)—(fern) (?*Cladophlebis* sp.).

Other Plantae specimens from Brookvale (Beacon Hill Quarry)

Numerous other plant specimens were recovered from the Brookvale (Beacon Hill Quarry) and were listed in Retallack (1980). These include *Dicroidium zuberi, Xylopteris, Marchantites, Reinitsia spathulata, Asterotheca* and *Cladophlebis*.

Cockatoo Island (Biloela)

Dry docks were excavated in the Hawkesbury Sandstone on Cockatoo Island within Sydney Harbour over the period of 1851–1857. In the ensuing time some dry docks were lengthened. A new dock (Sutherland Dock) was built between 1882 and 1890. During these excavations fossiliferous shale was encountered, and some findings (but not all) were drawn to the attention of scientists in Sydney.

In an early excavation fish fossils were exposed and reported to Sir P. de M. Grey Egerton in London. Later, labyrinthodont material was discovered and C. S. Wilkinson, the New South Wales Government Geologist, dispatched C. Cullen to the site to recover it. But by the time he arrived most of the material had been dumped in the harbour.

Class Amphibia Gray, 1825

Order Temnospondyli Zittel, 1888 (in Zittel, 1887–1890)

Suborder Stereospondyli Fraas, 1889

Fig. 16a–b

Figured in Stephens (1887a): AM F.50990 (Fig. 16a)—throat plate from Cockatoo Island. AM F.69477 (Fig. 16b)—throat plate (interclavicle) from Germany—held in the AMTC under "Stephens 1887a".

One specimen handed to C. S. Wilkinson, Government Geologist, and later passed to Professor Stephens of the University of Sydney, bears the impression of a large throat plate (interclavicle) from a temnospondyl amphibian in a rough conglomerate. Stephens (1887b) recognised it as being very similar to a specimen of *Mastodonsaurus robustus* from Germany held in the Sydney University collection. Later, that same year, Stephens published images of these two specimens (Stephens, 1887a). Damiani (2001: 443) noted that the interclavicle ornamentation was unlike that of *Mastodonsaurus* and that this specimen is determinable only as a stereospondyl.

Fishes

The Rev. W.B. Clarke (of Sydney) forwarded two fish specimens and four fish photos to Sir P. de M. Grey Egerton in England for identification. From these specimens and photos Egerton named two new genera and three new species. The specimens were from three sites, Cockatoo Island, Chapel Hill near Campbelltown, and Parsonage Hill near Parramatta (Egerton, 1864).

Class Actinopterygii *sensu* Goodrich,1930

Order Palaeoniscidiformes Hay 1902

Family Palaeoniscidae Bonaparte, 1846

Myriolepis clarkei Egerton, 1864

Fig. 16c

Type: Ironstone fragment containing middle portion of fish—from site at Chapel Hill near Campbelltown—not figured in Egerton (1964)—not registered in the NHMUK collection—probably lost.

Figured: AM F.5729 (Fig. 16c)—head and anterior trunk section of fish—from Cockatoo Island—held in the AMTC under "Egerton 1864". (Photograph of AM F.5729 was studied and illustrated by Egerton (1864: pl. 1, fig. 1)).

Egerton (1864) studied an actual fragmentary specimen from Chapel Hill and the photograph of a more complete specimen (missing the posterior section only) (Fig. 16c) from Cockatoo Island and concluded it was a new genus and species within the order Ganoidei, naming it *Myriolepis clarkei.*

It is unfortunate that the type specimen from Chapel Hill was not figured. However, the specimen that was the subject of the photograph of the Cockatoo Island fossil reproduced by Egerton (1864: pl. 1 fig. 1) (AM F.5729) is available for study in the AMTC under "Egerton 1864".

Order Perleidiformes Berg, 1937

Family Cleithrolepididae Wade, 1935

Cleithrolepis granulatus Egerton, 1864

Fig. 16d–e

Type: (Fig. 16d) (pl. 1, fig. 2)—indurated shale containing anterior half of fish—from Cockatoo Island—not registered in the NHMUK collection—probably lost.

Figured: AM F.1471 (Fig.16e)—almost complete fish—from Cockatoo Island— held in the AMTC under "Egerton 1864". (Photograph of AM F.1471 studied and illustrated by Egerton (1864 pl. 1, fig. 3.))

Egerton (1864) described the articulating rib on the inner surface of the scales of this fish which lock the scales closely in place. He also noted the scales are ornamented with fine granulations. Hence, Egerton chose the generic and specific names to describe these characters (Egerton, 1864).

The actual specimen (AM F.1471) that was the subject of the photograph studied by Egerton (1864: pl. 1, fig.3) is available for study in the AMTC under "Egerton 1864". *Cleithrolepis* is well represented at many Sydney Basin sites.

Phylum Mollusca Linnaeus, 1758

Class Gastropoda Cuvier, 1795

Subclass Amphigastropoda Simroth, 1906

Superfamily Bellerophontoidea McCoy, 1852

Family Bellerophontidae McCoy, 1852

Tremanotus maideni Etheridge, 1888

Fig. 16f

Type: MMF 3126 (Fig.16f)—illustrated by Etheridge (1888: pl. 2, figs 15–17)—missing from the GSNSW collection.

This specimen was found in a matrix of limonite. Some discussion occurred about its attribution to either *Bucania* or *Tremanotus*, but evidence of its siphonal openings swayed the attribution to *Tremanotus.* This genus had only previously been found in the Silurian (Etheridge, 1888).

It is possible that this specimen is the "*Planorbis"* referred to in Stephens (1887b), as Stephens reported that the specimen he studied was obtained by Mr Maiden from Cockatoo Island, as did Etheridge (1888).

Somersby Quarry

Somersby Quarry is located in the shire of Gosford and works the Hawkesbury Sandstone to produce building and construction materials. Although it is geographically close to the Gosford Ballast Quarry, which was positioned at the top of the Narrabeen Group, the Somersby Quarry lies 60 to 70 metres above the base of the Hawkesbury Sandstone (Ritchie, 1981).

Since 1972 fossil fish have been discovered during commercial excavations. Over the next ten years at least 10 fish species were collected, including a dipnoan, and xenacanthid and hybodontid sharks. The dipnoan was

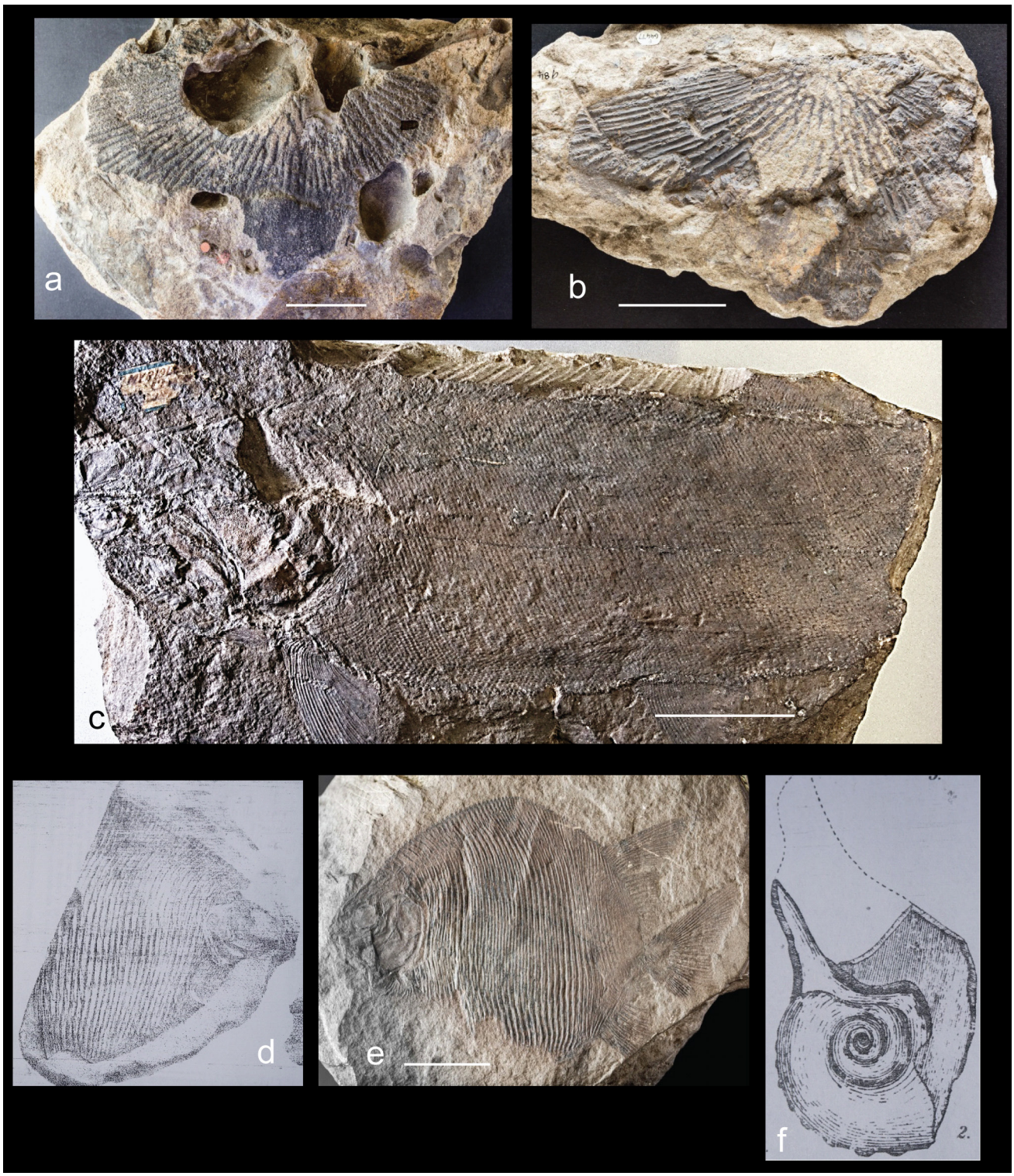

Figure 16. Cockatoo Island (Biloela). (a) AM F.50990. Temnospondyl throat plate. (*b*) AM F.69477. *Mastodonsaurus robustus* throat plate (from Germany). (c) AM F.5729. *Myriolepis clarkei*. (*d*) *Cleithrolepis granulatus*. Photo. In Egerton (1864). Reproduced from the Quarterly Journal of the Geological Society of London 20, pl. 1. (*e*) AM F.1471. *Cleithrolepis granulatus*. (*f*) *Tremanotus maideni*. In Etheridge (1888). Reproduced from the Memoirs of the Geological Survey of NSW Palaeontology No.1 pl.2. Scale bars: *a, b,* and *c* = 50 mm: *e* = 20 mm.

discovered by a quarryman, J. Costigan, and passed to a collector, C. Chidley, who passed it to the Australian Museum. It was a complete specimen, part and counterpart, and was identified and described by Ritchie (1981) as *Gosfordia truncata*. Plant specimens were found occasionally but were not abundant.

In 1986 the management of the Somersby Quarry notified the Australian Museum that a rich deposit of fossil fish had been discovered in a shale lens they were excavating. This silty shale lens was up to 3.4 m thick. They offered to provide men and equipment to aid a museum team in the recovery of these specimens. The Australian Museum organised a team of volunteers and, over an intensive period of eight weeks, recovered about 600 specimens (Ritchie, 1987a, 1987b). These specimens are held in the AMGC. It appeared that this deposit was produced by the drying out of a waterway, creating a massive fish kill.

Fishes

During the 1986 fieldwork about 95% of the specimens recovered were of one genus, *Promecosomina*. Xenacanthid sharks, *Cleithrolepis* and *Saurichthys* were also recovered.

Class Sarcopterygii Romer, 1955

Superorder Dipnoi Müller, 1845

Order Ceratodontiformes Berg, 1940

Family Ceratodontidae Günther, 1871

Gosfordia truncata Woodward, 1890

Fig. 17a–b

Gosfordia truncata Woodward, 1890: 4, pl. 1 figs 1, 2, pl. 2 figs 1, 2.

Type: AM F.50975 (389)—from Gosford Ballast Quarry—held in the AMTC under "Woodward 1890".

Figured: AM F.60621/142757 (Figs 17a–b)—part and counterpart of complete fish—held in the AMTC under "Ritchie 1981".

From this site, Ritchie (1981) described the most complete specimen of this species yet found. AM F.60621 is a well-preserved specimen in grey shale measuring 50 cm from nose to tail. Its distinctive characters are a deep bodied trunk, a sub-triangular head, and fused dorsal/caudal/anal fins surrounding a large diphycercal tail. Ritchie (1981) stated that, although *Gosfordia* has been placed in Ceratodontidae, it should be considered an aberrant offshoot from this line.

Class Chondrichthyes Huxley, 1880

Subclass Elasmobranchii Bonaparte, 1838

Order Xenacanthiformes Berg, 1955

Family Xenacanthidae Fritsch, 1889

Genus *Xenacanthus* Beyrich, 1848

Two specimens with fragmented counterparts were collected in 1986 and are held in the AMGC under "Pisces/Triassic/Somersby". They are:

AM F.78948/134987—possibly male (in litt. S. Turner).

AM F.78958—part/counterpart—possibly female (in litt. S. Turner).

They have not yet been described.

Order Hybodontiformes Patterson, 1966

Family Hybodontidae Owen, 1846

Watson (1986) reported that one specimen of a hybodontid shark had been discovered prior to the 1986 dig. This is possibly held in a private collection.

Class Actinopterygii *sensu* Goodrich, 1930

Order Parasemionotiformes Lehman, 1966

Family Promecosominidae Wade, 1941a

Genus *Promecosomina* Wade, 1935

Fig. 18a

Previously, similar specimens of this genus discovered at other sites were initially identified as *Zeuchthiscus* or *Semionotus*. However, they were subsequently placed in a new genus, *Promecosomina*, erected by Wade (1935).

Seventeen specimens of this genus were discovered in 1972 in Somersby Quarry. They are AM F.55094–55107 and are held in the AMGC under "Pisces/Triassic/Somersby".

About 95% of the approximately 600 specimens (including AM F.101718, Fig. 18a) recovered from the 1986 dig belong to this genus and are held in the AMGC under "Pisces/Triassic/Somersby". None of the specimens from this site has been described.

Order Perleidiformes Berg, 1937

Family Cleithrolepididae Wade, 1935

Cleithrolepis granulatus Egerton, 1864

Fig. 18b

Sixty specimens were collected in 1986 (including AM F.78900 (Fig. 18b)) and are held in the AMGC under "Pisces/Triassic/Somersby". Many were quite large (up to 26 cm long). None of the specimens from this site has been described.

Order Saurichthyiformes Aldinger, 1937

Family Saurichthyidae Bleeker,1859

Saurichthys gigas (Woodward, 1890)

Fig. 18c

Two specimens of this species were discovered in 1972. They are AM F.55091 and AM F.55092 (Fig.18c), held in AMGC under "Pisces/Triassic/Somersby". Seven specimens were later collected in 1986 and are held in the AMGC under "Pisces/Triassic/Somersby". No material from the site has been described.

Subphylum Crustacea Brünnich, 1772

Ritchie (1987a) reported the discovery of a shrimp-like crustacean during the 1986 dig. This specimen (AM F.78957) is held in the AMGC under "Pisces/Triassic/Somersby" and is yet to be positively identified.

Kingdom Plantae Copeland, 1956

Some plant specimens were collected during 1986.

Figure 17. Somersby Quarry. Fishes. (*a*) AM F.60621. *Gosfordia truncata.* (b) AM F.142757. *Gosfordia truncata.* (counterpart of AM F.60621). Scale bars = 50 mm.

Figure 18. Somersby Quarry. Fishes, Plantae. Freshwater Headland. Plantae. (a) AM F.101718. *Promecosomin*a sp. (b) AM F.78900. *Cleithrolepis granulatus.* (c) AM F.55092. *Saurichthys gigas*. (*d*) AM F.125853. *Phyllotheca* sp. (*e*) AM F.134949. *Reinitsia* sp. (f) AM F.57787.*Taeniopteris lentriculiformis.* Scale bars: *a, b*, and *e* = 20 mm: *c* and *d* = 50 mm: *f* = 10 mm.

However, although these were broadly identified in some instances, none of the specimens has been described. They are currently held in the AMGC under "Plantae/Triassic/Somersby". They are: Equisetaleans (eight specimens) (including AM F.125853, Fig. 18d), lycopod leaves (two specimens), Equisetalean tubers (one specimen), *Reinitzia* (one specimen, AM F.13949, Fig. 18e), lycopod stem (one specimen), indeterminate plants (many specimens).

Freshwater Headland

Freshwater Beach is the first beach north of Manly Beach, with Freshwater Headland at the northern end. Freshwater was the original name for the beach and surrounding area until it was changed to Harbord Beach in 1923. It then reverted back to Freshwater Beach in 2008. Hawkesbury Sandstone is well exposed at the headland, being south of Long Reef Headland from where the Narrabeen Group exposures extend northwards.

Dunstan (1893) described plant fossils in a fossiliferous shale stratum about 7.5 m in thickness around Freshwater Headland. Today, a carpark is located at this level on the tip of the headland, and it is likely that this fossiliferous bed was excavated to accommodate the carpark. However, this stratum can be found beneath the scrubby undergrowth further back along the headland, although after Dunstan's finds, no further significant collections have been made.

A sketch included in Dunstan's paper contained local geographical names that are at odds with the current location names. He named the headland at the northern end of Manly Beach "Curl Curl" and the adjacent lagoon "Curl Curl Lagoon". Today, the beach immediately north of Freshwater Beach is Curl Curl Beach and the lagoon behind this beach is Curl Curl Lagoon. Dunstan named the current Curl Curl Lagoon as "Manly Lagoon", whereas the current Manly Lagoon Dunstan called "Curl Curl Lagoon".

Kingdom Plantae Copeland, 1956

Dunstan (1893) stated that plant remains had been found and passed to Robert Etheridge for identification. Etheridge's initial classification of the plant remains were *Macrotaeniopteris wianamattae*, *Oleandridium*, *Phyllotheca* and ?*Podozamites* (Dunstan, 1893). Etheridge (1894) then published a specific description of the occurrence of *Oleandridium* in the Hawkesbury Sandstone, citing specimens from Gosford Ballast Quarry (later classified as being Late Narrabeen Group and not Hawkesbury Sandstone) and Freshwater Headland. Walkom (1917) later emended the genus for these specimens to *Taeniopteris.*

Division Polypodiophyta Reveal, 1995

Order Marattiales Link, 1841

Family Marattiaceae Kaulfuss, 1824

Taeniopteris lentriculiformis (Etheridge, 1894)

Fig. 18f

Oleandridium lentriculiformis Etheridge, 1894: 49, pl. 8 fig. 2.

Taeniopteris lentriculiformis—Walkom,1917: 35–37, text fig. 11.

Type: AM F.35647 (Etheridge, 1894: pl. 8 fig. 1)—complete leaf—from Gosford Ballast Quarry—held in the AMTC under "Etheridge 1894f".

Figured in Etheridge (1894): MMF 3069 (pl. 8 fig. 3)—leaf fragment—held in the GSNSW collection. MMF 3070 (pl. 8 fig. 2)—incomplete leaf—held in the GSNSW collection.

Other specimens: AM F.57787 (Fig. 18f)—complete leaf—held in the AMGC under "Plantae/Triassic/Freshwater".

The leaves studied by Etheridge (1894) were simple, elongate lanceolate, broad at the centre and attenuated towards each end. The length of leaves range between 14.5 cm and 7.5 cm. Etheridge compared these leaves with northern hemisphere *Oleandridium* species and found the closest match was *O. stenoneuron*.

Walkom (1917) stated that numerous similar specimens in Queensland went under various generic names, including *Oleandridium* and *Taeniopteris*. He proposed that all these be grouped under *Taeniopteris*.

Hornsby Heights Quarry

Sandstone and shale were quarried at this site before it was abandoned in 1974. The Australian Museum held excavations in the abandoned quarry in 1974 and collected the specimens listed below. The productive section of the quarry was subsequently backfilled by the owner. It is now owned by the Hornsby Shire Council.

Fishes

The following specimens are held in the AMGC under "Pisces/Triassic/Hornsby Heights".

Enigmatichthys Wade, 1935.

AM F.57147 (Fig. 19a), AM F.135642 (Fig. 19c) and six other specimens.

?Brookvalia Wade, 1933.

AM F.56994 (Fig. 19b).

Zeuchthiscus australis (Woodward, 1890)

AM F.135617 (Fig. 19d) and three other specimens.

Cleithrolepis granulatus Egerton, 1864

AM F.135605 (Fig. 19e), AM F.135614 (Fig. 19f), and 26 other specimens

Macroaethys brookvalei Wade, 1932

AM F.130105 (Fig. 19g) and three other specimens.

Kingdom Plantae Copeland, 1956

Equisetalean stems

Two specimens are held in the AMGC under Plantae/Triassic/Hornsby Heights.

Berowra Creek Quarry

The Berowra Creek Quarry north of Sydney supplied sandstone slabs to Sydney's construction industry in the mid-20th century. It has now been reclaimed and housing has been constructed on the site.

An extensive set of animal trackways were discovered by Geoffrey Scarrott at the Berowra Creek Quarry in 1948. Fletcher (1948) reported that the footprints were in sandstone and were certainly made by a reptile of considerable size. Recently, Farman and Bell (2020) studied these trackways using sections of the trackways and archival documentation.

Figure 19. Hornsby Heights Quarry. Fishes. (*a*) AM F.57147. *Enigmaticus* sp. (*b*) AM F.56994. ?*Brookvalia* sp. (*c*) AM F.135642. *Enigmaticus attenuatus.* (*d*) AM F.135617. *Zeuchichthys australis.* (*e*) AM F.135605. *Cleithrolepis granulatus.* (*f*) AM F.135614. *Cleithrolepis granulatus.* (*g*) AM F.130105. *Macroaethes brookvalei.* Scale bars*: a, b*, and *c* = 10 mm: *d, e, f*, and *g* = 20 mm.

Trace fossil

Fig. 20a

Holotype: AM F.145167–145171 (Fig. 20a)—trackway in sandstone—held in the AM storage facility at Castle Hill.

Farman and Bell (2020) studied five available slab sections and matched these to archival photos which showed a more complete set of nine slab sections originally displayed in the AM. The trackway is non-continuous and displays mono to tri-dactyl traces (Farman & Bell, 2020). These were interpreted as being caused by a large amphibian swimming against the flow of water in a stream, dragging only some of its five digits in the stream bed. This sub-aqueous track-making interpretation differed from Fletcher (1948) who considered the tracks were made on a sandy beach. Determining the identity of the trackmaker was difficult as accurate estimates of the body size of a buoyant animal from sub-aqueous traces cannot be easily made. However, a possible candidate is a large temnospondyl similar to *Paracyclotosaurus davidi* found in the Wianamatta Group of rocks in St Peters Brickpits (Farman & Bell, 2020).

Farman and Bell (2020) also described another separate slab which hosted a trackway of similar shape but from a larger animal than that described above (AM F.145166) (Fig. 20b). Its provenance is doubtful, but the substrate has similar properties to the Berowra specimens above. They surmised it could have come from the Berowra Quarry or another Sydney Basin Hawkesbury Sandstone site, Annangrove.

Minor unpublished sites

There were numerous sites around the Sydney Basin where specimens have been collected but have not been published in peer reviewed publications. Nevertheless, they provided valuable information on the overall Middle Triassic palaeoecology of the Sydney Basin. These specimens reside in the general collection of several organisations, including the Australian Museum where the following specimens are held in the AMGC.

(The names shown are those of the original identifications.)

Asquith Brick Quarry

The Asquith Brick Quarry was owned by the North Sydney Brick and Tile Company.

Fish

Cleithrolepis granulatus—AM F.46197, AM F.19322.

Calga Quarry

Kingdom Plantae Copeland, 1956

Reinitzia spatulata—AM F.55110 (Fig. 20c), AM F.55108, AM F.55109—presented by quarrymen in 1972.

Duffys Forest Quarry

Fish

Cleithrolepis sp.—AM F.57845 (Fig. 20e)—collected in 1976.

Glenorie Quarry

Kingdom Plantae Copeland, 1956

Equisetalean stem—AM F.58097—presented by quarrymen in 1974.

Gore Hill Brickpit

(Northern Suburbs Brick Co.)

Fish

Brookvalia gracilis—AM F.17746 (Fig. 20f)—presented in 1922.

Ourimbah (Scaddens Quarry)

Kingdom Plantae Copeland 1956

Skilliostrobus australis—AM F.72421 (Fig. 20d), AM F.72422.

Five other unidentified plant specimens—AM F.119851, AM F.11861–116864.

Tambourine Bay Sewer Tunnel

Fish

Cleithrolepis—AM F.105952 (Fig. 20g), AM F.19798, AM F.21668, AM F.106176, AM F.106194, AM F.106195, AM F.106197, AM F.106198, AM F.120207.

Thornleigh Brickpit

Fishes

Unidentified fishes—AM F.43740 (pt & cpt), AM F.154975 (pt & cpt), AM F.154976.

Wahroonga Claypit

Fish

Cleithrolepis granulatus—AM F.49912— presented by A. Linigen.

Woolloomooloo Bay

This site is positioned at the top of the Hawkesbury Sandstone and may even be within the Mittagong Formation (Retallack, 1980: 426).

Fish

Cleithrolepis granulatus—AM F.4594 (Fig. 20i), AM F.4525.

Kingdom Plantae Copeland, 1956

Dicroidium acutum—AM F.4510 (pt & cpt).
Dicroidium elongatum—AM F.4523 (pt & cpt).
Dicroidium spinifolium—AM F.4514.

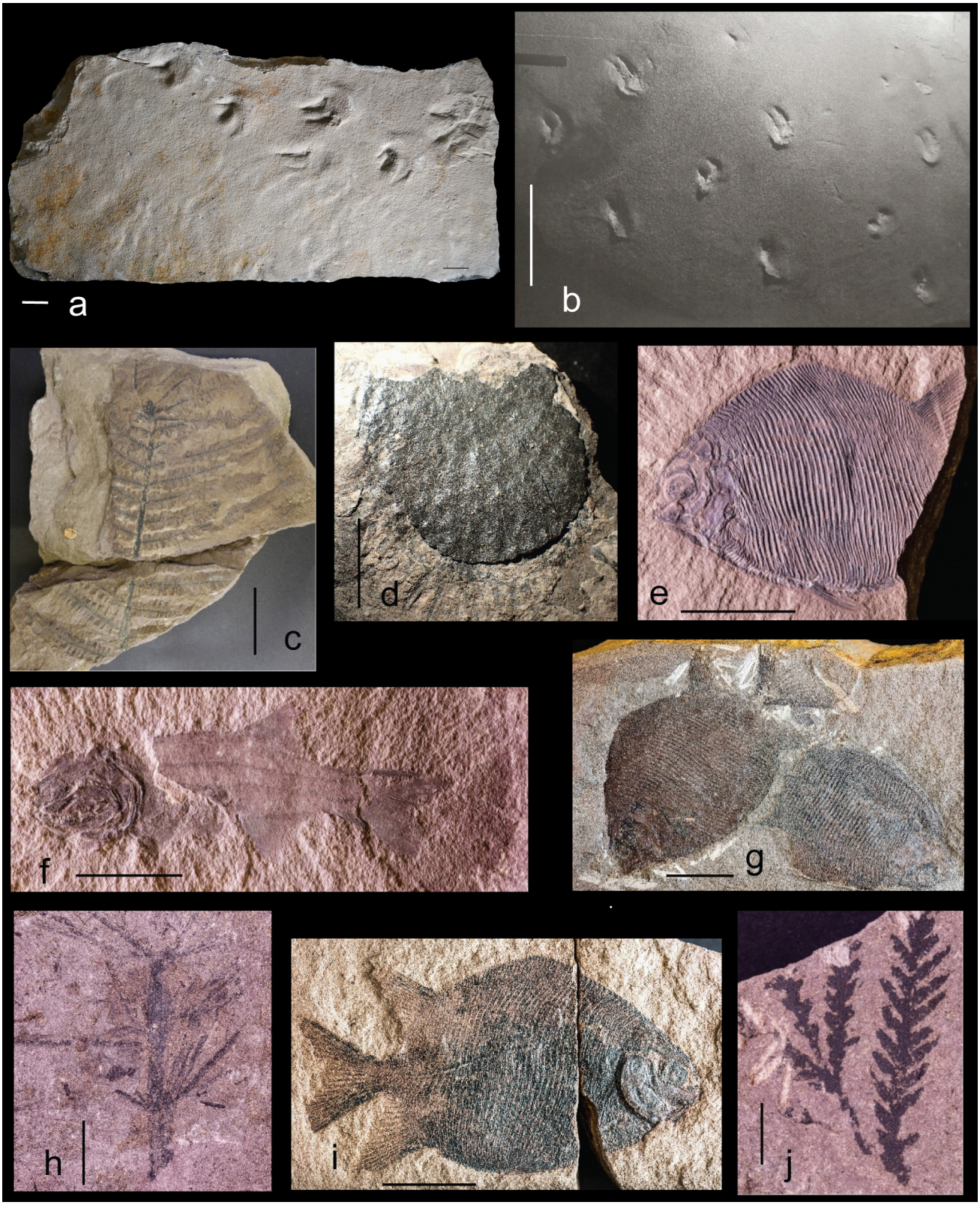

Figure 20. Berowra Creek Quarry. Trackway. Minor Unpublished Sites. Fishes and Plantae. (*a*) AM F.145169. Temnospondyl trackway. Berowra Creek Quarry. (*b*) AM F.145166. Temnospondyl trackway. Annangrove? (*c*) AM F.55110. *Reinitzia spathulata*. Calga Quarry. (*d*) AM F.72421. *Skilliostrobus australis.* Scaddens Quarry, Ourimbah. (*e*) AM F.57845. *Cleithrolepis* sp. Duffys Forest. (*f*) AM F.17746. *Brookvalia gracilis*. Gore Hill Brickpit. (*g*) AM F.105952. *Cleithrolepis granulatus*. Tambourine Bay. (*h*) AM F.4508. *Neocalamites*. Woolloomooloo Bay. (*i*) AM F.4594. *Cleithrolepis granulatus.* Woolloomooloo Bay. (*j*) AM F.4599. *Lepidopteris stormbergensis*. Woolloomooloo Bay. Scale bars: *a, b* = 500 mm: *c* = 50 mm: *d* and *i* = 20 mm: *e, f, g, h*, and *j* = 10 mm.

Dicroidium odontopteroides—AM F.4511, AM F.4520.
Neocalamites hoerensis—AM F.4508 (Fig. 20h), AM F.4522, AM F.4524 (pt & cpt).
Lepidopteris stormbergensis—AM F.4599 (Fig. 20j), AM F.4515.
Cladophlebis australis—AM F.4512, AM F.4516, AM F.4517, AM F.4519, AM F.4598.
Phyllotheca sp.—AM F.3209.
Todites narrabeenensis—AM F.4521, AM F.4518.
Stems—AM F.4507, AM F.4509.

All specimens were presented by J.W. Grimshaw in 1897.

Woronora Dam

Fish

Cleithrolepis granulatus—two specimens—presented in 1938.

ECOSYSTEMS

Although a history of scientific study of geology, flora and fauna of the Hawkesbury Sandstone has produced a significant body of knowledge, there is a scarcity of rigorous examination specific to the Hawkesbury Sandstone ecosystems. In the absence of this, one way of developing an initial view of these ecosystems is to use this body of knowledge to illustrate elements of the ecosystem.

The environment in which the Hawkesbury Sandstone flora and fauna lived was an extensive sandy plain crossed by energetic braided streams (Herbert, 1980a). The climate was warm and there is little evidence of ice at the South Pole (Price, 1999). Its proximity to the Antarctic Circle (62–64°S) meant winter nights were long, as were summer days (Müller *et al*., 2018). Atmospheric carbon dioxide levels were high (Retallack, 2001).

Retallack (1977) noted the difficulty of providing a reconstruction of a former Triassic vegetation, and that it is best to use a fossil plant association together with an indication of its likely type of formation. For the Hawkesbury Sandstone environment he envisaged sparse vegetation on sandy floodplains and channel bars wooded by shrubs and small trees of *Dicroidium*, with horsetails flourishing around abandoned channels along with ferns (Retallack, 1977). This concept is supported by specimens held in the palaeontology collections reviewed above in 'Flora and Fauna'. Horsetails were present at four sites, ferns were found at three sites, and seed ferns including *Dicroidium* at two sites. Ginkgoes, shrubs which grow in the understories, were found at two sites, and conifers which prefer the higher ground (Retallack, 1977) were present at two sites.

Within the Hawkesbury Sandstone formed from the sediments of the braided streams there are shale lenses of mudstones and laminites which appear to have been deposited in abandoned channels (Herbert, 1980a). These shale lenses are the source of many fossils. The fossil fauna from the palaeontology collections reviewed and referenced above in 'Flora and Fauna' indicate a diverse array of taxa.

Worm burrows (*Brookvalichnus*) evidence bioturbation. The bottom-dwelling freshwater mollusc *Protovirgus brookvalensi* and crustaceans including the freshwater shrimp *Anaspidites antiquus* and the clam shrimp *Palaeolimnadiopsis bassi* are present. One horseshoe "crab" *Austrolimulus fletcheri* was found. Land animals found included a scorpion and many insects. Insects were diverse and include sap sucking Hemiptera (cicadas and leaf hoppers), a scorpionfly, Orthoptera (early grasshoppers and crickets), a stonefly, a damselfly, cockroaches and beetles.

Vertebrates are represented by twenty-eight species of fishes initially identified from the Brookvale (Beacon Hill Quarry), and from ten other sites. These include a juvenile lungfish *Arigona formosa*, many small, ray-finned fishes such as *Brookvalia gracilis*, larger fishes such as *Myriolepis clarkei* and *Saurichthys parvidens,* and a shark egg case indicating the presence of sharks. Schools of *Cleithrolepis* and *Promecosomina* have been recovered from Somersby Quarry. The semi-aquatic temnospondyl *Subcyclotosaurus brookvalensis* hunted on the edge of the waterways. Temnospondyl trackways were also found in the Hawkesbury Sandstone, including in Berowra Quarry.

By the time of the Hawkesbury Sandstone episode, the range of flora and fauna held in the palaeontological collections shows that life had evolved and diversified from the initial paucity of organisms that survived the Permo-Triassic mass extinction.

Acknowledgement. My thanks go to the successive collection managers and curators of the Australian Museum, Yong Yi Zhen, Ross Pogson and Matthew McCurry, who gave me regular access to the Palaeontology collection during the extended period required to research this report. Patrick Smith of the Australian Museum provided advice on biostratigraphy and contributed to the production of the figures. Yong Yi Zhen, in his current capacity as Principal Research Scientist (Palaeontology) at the Geological Survey of New South Wales, offered access to the GSNSW palaeontology collection and records. The Australian Museum DigiVol teams, under the capable co-ordination of Leonie Prater, imaged more than 90 specimens displayed in the figures. Robert Jones, Senior Research Fellow at the Australian Museum, provided knowledge of the many fossil sites described and the specimens found there. Martin Munt and Martha Richter provided me access to the collections of the Natural History Museum, London, and selected relevant specimens for me to study. Peta Hayes, Lorna Steel, Claire Mellish, Andrew Milner and Sandra Chapman provided further data from the NHMUK collection. Emma Bernard arranged for the excellent images of the fishes from the NHMUK collections illustrated in this report.

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