Evidence for Placoderms from the Mid-Palaeozoic Sandon Beds of North-western New South Wales, Australia

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Armoured jawed fishes known as placoderms are a well-documented group with a fossil record spanning the Silurian to end-Devonian. They have a global distribution and a marked diversity within Devonian deposits of Australia. Despite their notable Gondwanan fossil record, new material is occasionally identified and can present important stratigraphic information for otherwise under-explored deposits. A unique find from the so-called Sandon beds is presented here and expands the record of placoderms from New South Wales. This specimen presents insight into a previously unknown macrofossil record from the deposit and suggests a more Devonian age for the unit, rather than the previously suggested Carboniferous date. We also summarise the macrovertebrate record of Devonian placoderms from Australia, highlighting and discussing changes in their Gondwanan taxonomic diversity across the time period.

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KEYWORDS**:** Devonian, Famennian, placoderm, Sandon beds

INTRODUCTION

Placoderms are armoured fishes with a fossil record spanning the Silurian through to the end-Devonian (Lelièvre and Goujet 1986; Burrow 2006), with peak diversity and disparity during the Devonian (Young 2010; Pan et al. 2015). An exceptional record of their evolutionary radiation is known globally due to the high preservational potential of the heavily armoured head, thoracic shields, and scales of placoderms (Denison 1978; Burrow and Turner 1998, 1999; Young 2005b). In Devonian-aged deposits of Australia over 100 taxa across 20 families have been documented (e.g., Burrow 1996, 2006; Young 2003, 2004; Long and Trinajstic 2010). Material is known from every state in Australia and the specimens are often identified to species level (Table 1, see page 18). Here we extend the record of Australian placoderms by describing a unique specimen from the Sandon beds, north-west New South Wales (NSW) (Cuddy 1978). As no vertebrate macrofossils are otherwise known from this latest Devonian to earliest Carboniferous deposit, the specimen presents important insight into the age of this unit.

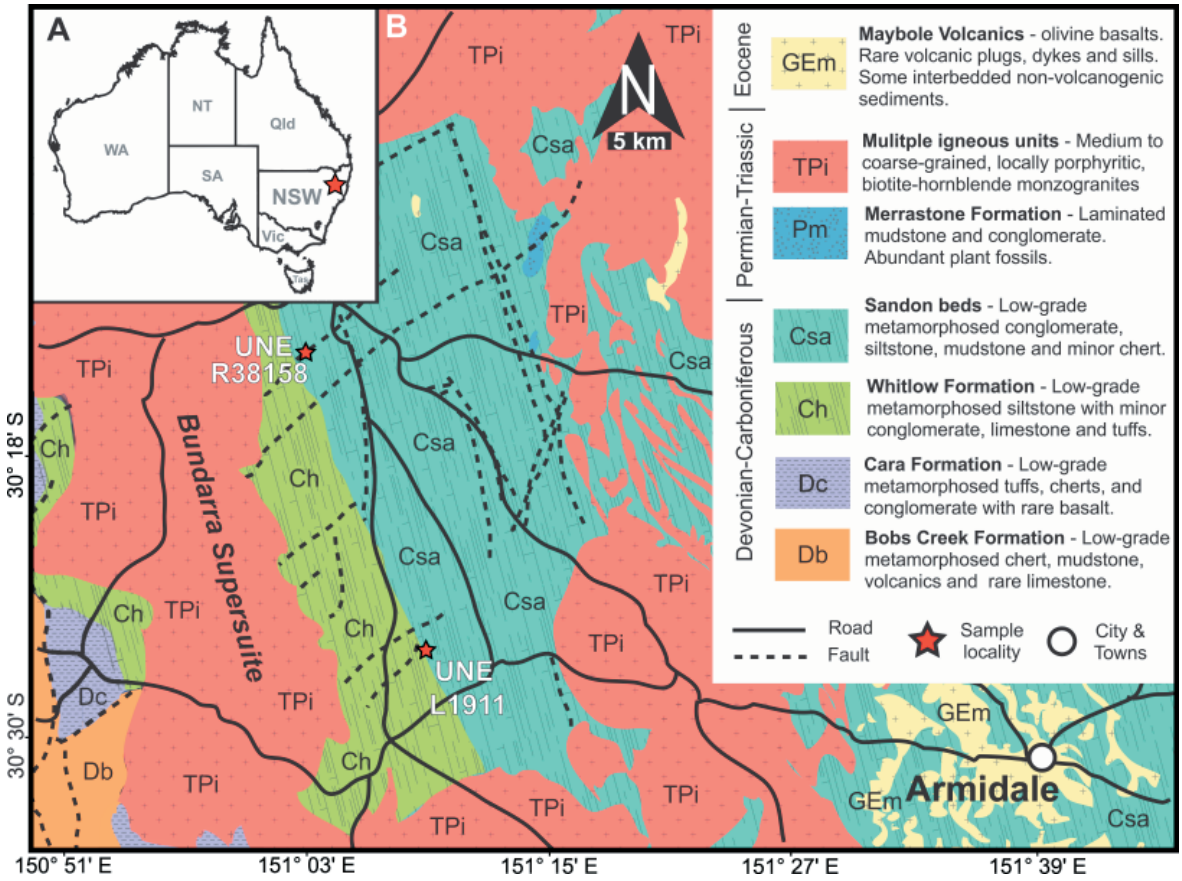

Figure 1: Geological, stratigraphical, and geographical information for specimen locations. (A) Map of Australia showing specimen location (red star) in north western New South Wales. (B) Geological map showing rocks proximal to Armidale. Red stars indicate specimen locations. UNE L1991 is the Ross Hill radiolarian site and UNE R38158 is the placoderm specimen location. Geology derived from Cuddy (1978).

GEOLOGICAL CONTEXT

The specimen reported herein comes from an interbedded chert and cherty argillite unit at approximately 30°14'53.3"S, 151°04'04.2"E; 60 km west-northwest of Armidale, northern New South Wales (Figure 1). The fossil bearing horizon dips steeply towards the southwest, with the strike being discontinuously traceable for ~1 km northward. Towards the south there is a lithologically distinct chert band ~600 m away. This may be a lateral equivalent. Bedding in the chert has prominent small-scale slump structures, although these are not apparent in the fossiliferous horizon itself. Abundant radiolarian tests are also known from most chert layers, and most tests obvious in cross section (Cuddy, 1978). A small collection of fossil plants is also known from nearby at the township of Torryburn, ~29 km south-east of the examined fossil site. Here they consist of *Sigillariophyllum* sp., *Lepidocarpon* sp. and *Cladaxylale* sp. (Cuddy 1978). Trace fossils assignable to *Zoophycos* spp. in the thin interbedded siltstone and mudstones of the unit are known. Given these records, the unit was deposited in a deeper marine condition, possibly an abyssal setting. Elsewhere, *Zoophycos* trace fossils and radiolarian cherts have were identified by Seilacher (1964, 1967) and Boucot (1975) as components of typical deep-water communities. The occurrence of plant fossils does not necessarily indicate a nearshore environment because similar plant remains are known from the Lower Devonian Hunsrück Slate, Germany, which is a formation thought to be deposited at a marked distance from shore and below (or at) the storm wave base (Poschmann et al. 2017, 2020). Likewise, several Devonian deposits in Alaska demonstrate plant macrofossils in graptolitic shales that formed at great depth (see Churkin Jr et al. 1969, p. 567).

The unit has been mapped locally by Cuddy (1978) and subsequent authors as part of the so-called Sandon

beds. This attribution was based on its proximity and similar lithology to the material documented in McKelvey and Gutsche (1969). However, this assignment is questionable as the stratigraphy in the Central Block of the New England Fold Belt is not mapped in great detail. This reflects the enormous degree of structural complexity, inadequate outcrop, and scarcity of fossils, as well as the proliferation of regional names in unpublished theses (Gilligan et al. 1992). The Sandon beds have been assigned a latest Devonian to earliest Carboniferous age based on a radiolarian association containing *Staurodruppa* ?*prolata* and *Entactinosphaera palimbola* (Blake and Murchey 1988). A slightly younger early Carboniferous (Tournaisian or Viséan) age was favoured for radiolarian material derived from a spot sample at Ross Hill (UNE L1911; Figure 1), which is ~35 km south of the locality reported herein (Blake and Murchey 1988). This Carboniferous age was further supported by Aitchison and Flood (1990), who resampled the Ross Hill locality and found a diverse radiolarian assemblage. In particular, Aitchison and Flood (1990) highlighted the presence of *Albaillella indensis* in association with *Albaillella furcata*, indicating a late Tournaisian to early Viséan age. This age estimate contradicts dates previously predicted from plant megafossils at proximal localities. The presence of a Cladoxylaceae taxon in the Sandon beds is comparable to those from the Kiah Limestone and in boulders of the Keepit Conglomerate, suggesting a latest Devonian age (i.e. Famennian) (Korsch 1977; Cuddy 1978). Based on this evidence, and a lack of any biostratigraphic sections through the entire Sandon beds, the unit could range through the latest Famennian into the Tournaisian, possibly even into the early Viséan.

An alternative interpretation for the geological unit at the placoderm fossil locality is that the locality was incorrectly assigned to the Sandon beds and is potentially from the stratigraphically lower Cara Formation. A slightly older radiolarian assemblage containing *Holoeciscus formanae*, *Ceratoikiscum* sp., *Archocyrtium* sp., *Cyrtentactina* spp., and ?*Palaeoscenidium cladophorum* suggests a late Famennian age for this latter formation (Aitchison 1988). If the specimen examined here is derived from the Cara Formation, rather than the Sandon beds, this would be the easternmost occurrence of the unit, as the Cara Formation is currently known only from the west of the Copeton Monzogranite (part of the Bundarra Supersuite). At present, we consider this option less likely. Nonetheless, more lithostratigraphic and biostratigraphic work needs to be conducted in the area, a much larger project that is beyond the scope of the current work.

MATERIALS AND METHODS

The examined specimen was collected by R. G. Cuddy and noted within their thesis (Cuddy, 1978). It was photographed both uncoated, and coated with ammonium chloride sublimate, under low angle LED light with a Canon EOS 5DS to highlight morphology. A latex cast of the specimen made at the University of New England (UNE), Armidale, NSW, Australia was coated and photographed under the same conditions. The specimen and the cast are housed within the UNE Geological collection (UNE R38158).

SYSTEMATIC PALAEONTOLOGY

PLACODERMI McCoy, 1848

ARTHRODIRA Woodward, 1891

?arthrodire indet.

Figure 2

Referred material:

Articulated plate, UNE R38158

Age and formation:

Sandon beds, Famennian, NSW.

Preservation:

Placoderm plate preserved as flattened, external impression in black, cherty argillite.

Description:

UNE R38158 is a fragmentary plate (374 mm long by 162 mm wide) adorned with round, smooth tubercular ornament (Figure 2A–D). Tubercles have two major groupings: those that are 2–4 mm diameter located over most of the dermal surface of the plate (Figure 2A, B), and those that are sub-millimetre that located on the left section of the plate (Figure 2A). Smaller tubercles are also noted in the middle of the specimen. The two groups of tubercles appear to define different sections of the plate. There is no evidence of the internal mould of the plate.

Remarks:

This specimen is not an actinopterygian as the dermal skeleton of these fishes comprises predominately of endochondral bones, and the dermal bone of the skull roof and shoulder girdle bones with more lineated ornamentation rather than rounded tubercles (e.g., Gardiner 1984, Long, 1988c, Choo, 2012). It is also not a sarcopterygian as they have either cosmine covered dermal bones (e.g., *Gogonasus,* Long et al. 1997) or a thinner, more reticulate ornamentation (e.g., *Mandageria,* Ahlberg and Johanson 1997), except in some basal forms that occasionally have fine tubercular ornamentation on thin bones (e.g., *Onychodus,* Andrews et al. 2006).

The bone form and rounded tubercular morphology ranging in diameter from sub-millimetre to millimetre are indicative of a placoderm (Burrow

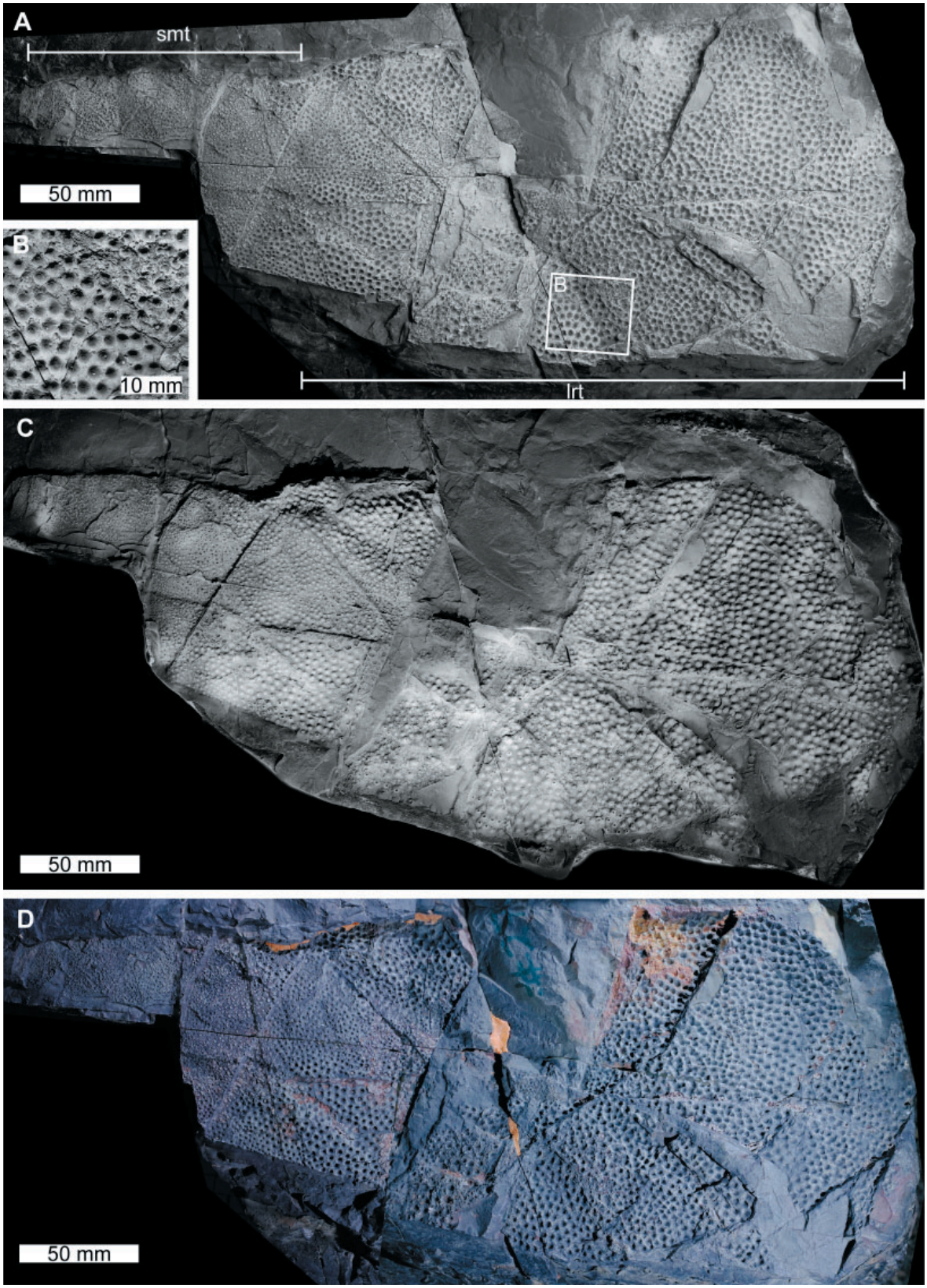

Figure 2: Placodermi indet. specimen the Sandon Beds. UNE R38158. (A) External impression of fossil showing two main divisions of tubercle size. (B) Close up of box in (A) showing tubercles in detail. (C) Latex cast of fossil. (D) Same as (A), original specimen colour. (A–C) Coated in ammonium chloride before photography. (A–C) converted to greyscale. (C) reflected to align with (A). Abbreviations: lrt: larger tubercles; smt: smaller tubercles.

and Turner 1998, 1999). Most arthrodires exhibit tubercular ornamentation, although, in some derived arthrodires dermal ornamentation was absent (e.g., *Dunkleosteus*, Carr and Hlavin 2010). Derived ptyctodontids (e.g., *Campbellodus,* Long 1997) and antiarchs (e.g., some Australian *Remigolepis* species, cf. Johanson 1997a, b; Young and Burrow 2020) have a more reticulate ornamentation, with the ptyctodonts showing very thin dermal bones (Long 1997; Trinajstic and Dennis-Bryan 2009; Trinajstic et al. 2012, 2019). Acanthothoracids and petalichthyids are not known from the Late Devonian in Australia, and while there are forms known to estuarine conditions, there are no known Famennian antiarchs in fully marine environments (Denison 1978), so UNE R38158 most likely represents a large marine arthrodire.

In Australia, the following arthodire families are known from the Famennian (Table 1): Dinichthyidae, Groenlandaspididae, Holonematidae, and Phyllolepididae. In Western Australia, broken dermal plates with a tubercular ornamentation identified as from brachythoracid arthrodires, are known from the Late Devonian Gumhole Formation (Druce and Radke 1979). However, the only articulated specimen, the dinichthyid *Westralichthys uwagedensis*, recorded from the middle Famennian, Virgin Hills Formation is unornamented (Long 1987). Groenlandaspidids are known from numerous sites across Australia ranging from Early to Late Devonian strata (Table 1; Long, 1983; Long and Trinajstic, 2000; Young and Goujet, 2003; Young, 2006). These forms show tubercular ornamentation and an as-of-yet unnamed taxon from the Dulcie Sandstone and Cravens Peak Beds has comparable tubercular structures to UNE R38158 (Young and Goujet, 2003). Holonematids are known exclusively from Late Devonian deposits in WA. Considering the youngest Australian holonematid from the Munabia Sandstone, WA, the ornamentation consists of bony ridges and small tubercles, distinct from UNE R38158 (Long, 1991). Furthermore, tubercular ornamentation is not considered a useful diagnostic structure of the family (Miles, 1971). Finally, *Cowralepis lachlani*, one of the youngest Australian phyllolepidids, lacks any tubercular ornamentation (Ritchie, 2005), very distinct from UNE R38158.

Globally, late Famennian marine deposits show that a range of placoderms existed in the oceans at this time. The Cleveland Shale in the USA (357–359 Mya) has over 30 species of arthrodires present (Carr and Hlavin 2010) including large dunkleosteids and titanichthyids in excess of eight metres long. The Famennian marine faunas of Morroco, Belgium and Poland are also dominated by dunkleosteids and titanichthyids (Rücklin, 2010). However, all of these forms lack prominent, coarse tubercular ornamentation. This is because most either have no ornament (e.g. *Dunkleosteus, Titanichthys, Heintzichthys*) or show a very fine meshwork or reticulated bone surface ornament (e.g. *Stenosteus,* see Carr 1996 and *Amazichthys*, see Jobbins et al. 2022). The selenosteid arthrodire *Gymnotrachelus* has very fine tubercular ornamentation (Carr 1994) but this is distinctly different from UNE R38158 in being larger and more pronounced across most of the plate.

DISCUSSION

The taxonomic placement of UNE R38158 required careful consideration. Although we have presented a very conservative perspective here, it is possible that the specimen is a dermal fragment from a large *Groenlandaspis* — an arthrodire common in Late Devonian deposits around the world (Young et al., 2010). These *Groenlandaspis* specimens are known almost exclusively from terrestrial Famennian deposits (Gess and Hiller 1995; Daeschler et al. 2003; Broussard et al. 2018), whereas the Sandon beds exhibit a much greater marine influence. One undescribed groenlandaspidid specimen from the marine Frasnian Gneudna Formation of Western Australia is known (Trinajstic and Long pers. obs.), so a groenlandaspidid affinity for UNE R38158 is possible (Denison 1978; Gess and Hiller 1995; Long 1997; Gess and Trinajstic 2017). If UNE R38158 is confirmed as a member of Groenlandaspididae, it would be the seventh such observation from Australian deposits (Table 1) and would extend the fossil record of the family in Australia from the late Early Devonian up to the end-Devonian boundary. However, due to the fragmentary nature of the specimen and lack of plate boundaries and sensory lines to identity the plate, the higher taxonomic placement of UNE R38158 remains uncertain. Additional fossils from temporally contiguous deposits will be needed to further elucidate the position of this material within the Arthrodira. Also note, a new, undescribed species of *Groenlandaspis* from the Canowindra mass kill fish site (late Famennian) is currently under study by some of the authors.

Placoderms went extinct at the end-Devonian (Denison 1978; Lelièvre and Goujet 1986; Young 2010 and references therein; Becker et al. 2020). Placoderms associated with a “Carboniferous-like” fish fauna have been reported from the lowest Köprülü Shales, southeastern Turkey (Janvier et al. 1984); however, these specimens are now confirmed to be

stratigraphically above the Hangenberg Biocrisis and are therefore very latest Famennian in age (Higgs et al. 2002). With effectively no evidence for Carboniferous placoderms, the presence of a placoderm within the Sandon beds supports the latest Devonian age of the deposit. This outcome is at odds with younger ages suggested for the deposit (Aitchison 1988; Blake and Murchey 1988; Aitchison and Flood 1990). As noted above, detailed geological re-evaluation of the region is needed. A likely outcome of such a project would be the formalisation of the "Sandon beds" and a more accurate age for the placoderm-bearing unit.

The almost global distribution of select placoderm genera indicates that members of the group are informative biostratigraphic markers (Lelièvre and Goujet 1986; Young and Turner 2000) and placoderm zonations are included in the Geological Timescale (Becker et al. 2020). One limitation of this approach is the notable endemism of select genera in regions such as Australia and China (Lelièvre and Goujet 1986; Long, 2011). This endemism has allowed placoderm remains to function as effective tools in differentiating and refining stratigraphic boundaries of Devonian-aged deposits within Australia (De Pomeroy 1995; Young 2005a). While bony plates and more complete body fossils have been used more commonly (Young 1999), microfossils, such as placoderm scales, have also been highlighted as informative indicators (Burrow 1996; Burrow and Turner 1998, 1999; Burrow et al. 2010) and may have a more global application (Burrow and Turner 1998). Although UNE R38158 shows few features that are useful for a confident taxonomic placement, such specimens do represent key tools for refining aspects of Australian biostratigraphy.

Considering the diversity of Australian placoderms throughout the Devonian (Table 1) a marked abundance of taxa from Early and Late Devonian deposits is noted. The Early Devonian diversity likely reflects the first placoderm diversification and radiation event, a pattern that is observed in other parts of the globe (e.g., Young 2004, 2010; Zhao and Zhu 2007; Vaškaninová and Ahlberg 2017; Jobbins et al. 2021). Given this early record of high diversity, it is therefore interesting that a decrease in observations and species is noted in Middle Devonian deposits (also see Turner et al. 2010). This likely reflects under-sampling of deposits from this time period and, as Young (2010) identified, a need for further examination of these under-documented fauna. Conversely, the Late Devonian placoderm diversity in Australian deposits is exceptional. This primarily reflects the incredible diversity recorded within the Gogo Formation (Miles and Young 1977a; Long and Trinajstic 2010, 2018). With over 50 species of fishes preserved, with occasional evidence for soft-bodied preservation (Trinajstic et al. 2022), the deposit presents a unique insight into Australia's first Great Barrier Reef (Long and Trinajstic 2010, 2018; Trinjastic et al. 2022). Beyond the Gogo Formation, there are a selection of Late Devonian deposits in NSW, Queensland, and Victoria that have placoderms preserved (Table 1). Given this situation, it stands to reason that re-examination of these other deposits will further expand the record of Australian placoderms and represent important future research directions (Young 2010).

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Table 1: Summary of Devonian placoderm taxa from Australia ordered by order, family, genus, and then species based. Abbreviations: NSW: New South Wales; NT: Northern Territory; QLD: Queensland; VIC: Victoria; WA: Western Australia.

Name	Order	Family	Age	Locality	See also
Romundina sp.	Acanthothoraci	Palaeacanthaspidae	Early Devonian (Lochkovian)	Connemarra Formation, NSW	Burrow et al. (2010)
Murrindalaspis bairdi Long, 1984b	Acanthothoraci	Weejasperaspididae	Early Devonian (Emsian)	Murrindal Limestone, VIC	-
Murrindalaspis wallacei Long, 1984b	Acanthothoraci	Weejasperaspididae	Early Devonian (Emsian)	Murrindal Limestone, VIC	-
Weejasperaspis gavini White, 1978	Acanthothoraci	Weejasperaspididae	Early Devonian (Emsian)	Taemas Limestone or Wee Jasper Formation, NSW	-
Brindabellaspis stensioi Young, 1980	Acanthothoraci	-	Early Devonian (Emsian)	Taemas Limestone or Wee Jasper Formation, NSW	-
Jerulalepis pickelli Burrow, 1996	Acanthothoraci	-	Early Devonian (Pragian)	Jerula Formation, NSW	-
Remigolepis redcliffensis Johanson, 1997a	Antiarchi	Asterolepidae	Late Devonian (Famennian)	Hunter Siltstone, NSW	-
Remigolepis walkeri Johanson, 1997b	Antiarchi	Asterolepidae	Late Devonian (Famennian)	Mandagery Sandstone, NSW	-
Remigolepis sp.	Antiarchi	Asterolepidae	Late Devonian (Frasnian)	Twofold Bay Formation, NSW	Johanson (1997b); Young (2007)
Remigolepis sp.	Antiarchi	Asterolepidae	Late Devonian (Frasnian–Famennian)	Worange Point Formation, NSW	Young (2007)
Remigolepis sp.	Antiarchi	Asterolepidae	Late Devonian (Famennian)	Gilberton Formation, QLD	Young and Burrow (2020)
Asterolepid indet.	Antiarchi	Asterolepidae	Late Devonian (Frasnian)	Twofold Bay Formation, NSW	Young (2007)
Bothriolepis bindareei Long, 1983	Antiarchi	Bothriolepididae	Late Devonian (Frasnian)	Bindaree Formation, VIC	-
Bothriolepis cullodenensis Long, 1983	Antiarchi	Bothriolepididae	Late Devonian (Frasnian)	Avon River Group, VIC Bindaree Formation, VIC Mount Kent Conglomerate or Wellington Rhyolites, VIC	-
Bothriolepis fergusoni Long, 1983	Antiarchi	Bothriolepididae	Late Devonian (Frasnian)	Avon River Group, VIC	-
Bothriolepis gippslandiensis Hills, 1929	Antiarchi	Bothriolepididae	Late Devonian (Frasnian)	Avon River Group, VIC Blue Range Formation, VIC	Long (1983)

Bothriolepis grenfellensis Johanson, 1997a	Antiarchi	Bothriolepididae	Late Devonian (Famennian)	Hunter Siltstone, NSW	-
Bothriolepis longi Johanson and Young 1999	Antiarchi	Bothriolepididae	Middle to Late Devonian (Frasnian)	Comerong Volcanics, NSW	-
Bothriolepis tatongensis Long and Werdelin 1986	Antiarchi	Bothriolepididae	Middle to Late Devonian (Givetian–Frasnian)	?Hollands Creek Ignimbrite, VIC	-
Bothriolepis yeungae Johanson, 1998	Antiarchi	Bothriolepididae	Late Devonian (Famennian)	Mandagery Sandstone, NSW	Johanson (2002)
Bothriolepis warreni Long, 1983	Antiarchi	Bothriolepididae	Late Devonian (Frasnian)	Mount Kent Conglomerate or Wellington Rhyolites, VIC	-
Bothriolepis sp.	Antiarchi	Bothriolepididae	Middle Devonian (Givetian)	Boyd Volcanic Complex, NSW	Young (2007)
Bothriolepis sp.	Antiarchi	Bothriolepididae	Middle to Late Devonian (Givetian–Famennian)	Pertnjara Group, NT	Young (1985)
Bothriolepis sp.	Antiarchi	Bothriolepididae	Late Devonian (Frasnian–Famennian)	Munabia Sandstone, WA	Long (1991)
Bothriolepis sp.	Antiarchi	Bothriolepididae	Late Devonian (Frasnian)	Mount Kent Conglomerate or Wellington Rhyolites, VIC Blue Range Formation, VIC Combyingbar Formation, VIC	Long (1983)
Bothriolepis sp.	Antiarchi	Bothriolepididae	Late Devonian (Frasnian)	Twofold Bay Formation, NSW	Young (2007)
Bothriolepis sp.	Antiarchi	Bothriolepididae	Late Devonian (Frasnian)	Mount Kent Conglomerate or Wellington Rhyolites, VIC Blue Range Formation, VIC Combyingbar Formation, VIC	Long (1983)
Bothriolepis sp.	Antiarchi	Bothriolepididae	Late Devonian (Frasnian)	Gogo Formation, WA	Young and Zhang (1992)
Monarolepis verrucose (Young and Gorter, 1981)	Antiarchi	Bothriolepididae	Middle Devonian (Eifelian)	Taemas Limestone, NSW	Young (1988)
Nawagiaspis wadeae Young, 1990	Antiarchi	Bothriolepididae	Middle Devonian (Givetian)	Broken River Formation, QLD	-
Pambulaspis cobandrahensis Young, 1983	Antiarchi	Pambulaspidae	Middle Devonian (Givetian)	Boyd Volcanic Complex, NSW	Young and Moody (2002)

Wurungulepis denisoni Young 1990	Antiarchi	Pterichthyodidae	Middle Devonian (Givetian)	Broken River Formation, QLD	-
Toombalepis tuberculata Young and Goujet, 2003	Arthrodira	Antarctaspidae	Early to Middle Devonian (Pragian–Givetian)	Dulcie Sandstone, NT Cravens Peak Beds, QLD	-
Cravenaspis trematosus Young and Goujet, 2003	Arthrodira	Arctaspididae	Early to Middle Devonian (Pragian–Givetian)	Dulcie Sandstone, NT Cravens Peak Beds, QLD	-
Arenipiscis westolli Young, 1981	Arthrodira	Buchanosteidae	Early Devonian (Emsian)	Taemas Limestone, NSW	-
Arenipiscis westolli	Arthrodira	Buchanosteidae	Early Devonian (Emsian)	Murrindal Limestone, VIC	Long (1984b)
Buchanosteus confertituberculatus (Chapman, 1916)	Arthrodira	Buchanosteidae	Early Devonian (Emsian)	Taemas Limestone, NSW	Young (1979)
Errolosteus goodradigbeensis Young, 1981	Arthrodira	Buchanosteidae	Early Devonian (Emsian)	Taemas Limestone or Wee Jasper Formation, NSW	-
Errolosteus goodradigbeensis	Arthrodira	Buchanosteidae	Early Devonian (Emsian)	Murrindal Limestone, VIC	Long (1984b)
Goodradigbeeon australianum White, 1978	Arthrodira	Buchanosteidae	Early Devonian (Emsian)	Taemas Limestone, NSW	-
Richardosteus barwickorum Long et al., 2014	Arthrodira	Buchanosteidae	Early Devonian (Emsian)	?Taemas Limestone, NSW	-
Taemasosteus maclartiensis Long, 1984b	Arthrodira	Buchanosteidae	Early Devonian (Emsian)	Murrindal Limestone, VIC	-
Taemasosteus novaustrocambricus White, 1952	Arthrodira	Buchanosteidae	Early Devonian (Emsian)	Taemas Limestone, NSW	-
Lurapullaspis johannseni Young and Goujet, 2003	Arthrodira	Bulbocanthidae	Early to Middle Devonian (Pragian–Givetian)	Dulcie Sandstone, NT Cravens Peak Beds, QLD	-
Burrinjucosteus asymmetricus White, 1978	Arthrodira	Burrinjucosteidae	Early Devonian (Emsian)	Taemas Limestone, NSW	-
Toombsosteus denisoni White, 1978	Arthrodira	Burrinjucosteidae	Early Devonian (Emsian)	Taemas Limestone, NSW	-
Camuropiscis concinnus Miles and Dennis, 1979	Arthrodira	Camuropiscidae	Late Devonian (Frasnian)	Gogo Formation, WA	-
Camuropiscis laidlawi Miles and Dennis, 1979	Arthrodira	Camuropiscidae	Late Devonian (Frasnian)	Gogo Formation, WA	-
Fallacosteus turnerae Long, 1990	Arthrodira	Camuropiscidae	Late Devonian (Frasnian)	Gogo Formation, WA	-

Latocamurus coulthardi Long, 1988b	Arthrodira	Camuropiscidae	Late Devonian (Frasnian)	Gogo Formation, WA	-
Rolfosteus canningensis Dennis and Miles, 1979	Arthrodira	Camuropiscidae	Late Devonian (Frasnian)	Gogo Formation, WA	-
Tubonasus lennardensis Dennis and Miles, 1979	Arthrodira	Camuropiscidae	Late Devonian (Frasnian)	Gogo Formation, WA	-
Westralichthys uwagedensis Long, 1987	Arthrodira	Dinichthyidae	Late Devonian (Famennian)	Virgin Hills Formation, WA	-
Eastmanosteus callispis Dennis–Bryan, 1987	Arthrodira	Dunkleosteidae	Late Devonian (Frasnian)	Gogo Formation, WA	-
Groenlandaspis sp.	Arthrodira	Groenlandaspididae	Early to Middle Devonian (Pragian–Givetian)	Dulcie Sandstone, NT Cravens Peak Beds, QLD	Young and Goujet (2003)
Groenlandaspis sp.	Arthrodira	Groenlandaspididae	Late Devonian (Frasnian)	Avon River Group, VIC Bindaree Formation, VIC Mount Kent Conglomerate or Wellington Rhyolites, VIC Blue Range Formation, VIC	Long (1983)
Groenlandaspis sp.	Arthrodira	Groenlandaspididae	Late Devonian (Frasnian)	Gneudna Formation, WA	Long and Trinajstic (2000)
Groenlandaspis sp.	Arthrodira	Groenlandaspididae	Late Devonian (Frasnian–Fammenian)	Worange Point Formation, NSW	Young (2006)
Mithakaspis lyentye Young and Goujet, 2003	Arthrodira	Groenlandaspididae	Middle Devonian (Givetian)	Dulcie Sandstone, NT	-
groenlandaspid indet.	Arthrodira	Groenlandaspididae	Early to Middle Devonian (Pragian–Givetian)	Dulcie Sandstone, NT Cravens Peak Beds, QLD	Young and Goujet (2003)
Holonema westolli Miles, 1971	Arthrodira	Holonematidae	Late Devonian (Frasnian)	Gogo Formation, WA	-
Holonema westolli	Arthrodira	Holonematidae	Late Devonian (Frasnian)	Gneudna Formation, WA	Trinajstic (1999)
Holonema sp.	Arthrodira	Holonematidae	Late Devonian (Frasnian–Famennian)	Munabia Sandstone, WA	Long (1991)
Incisoscutum ritchei Dennis and Miles, 1981	Arthrodira	Incisoscutidae	Late Devonian (Frasnian)	Gogo Formation, WA	-
Incisoscutum sarahae Long, 1994	Arthrodira	Incisoscutidae	Late Devonian (Frasnian)	Gogo Formation, WA	Trinajstic and Dennis-Bryan (2009)
Kendrickichthys cavemosus Dennis and Miles, 1980	Arthrodira	Mylostomatidae?	Late Devonian (Frasnian)	Gogo Formation, WA	-

Huginaspis australis Young and Goujet, 2003	Arthrodira	Phlyctaeniidae	Early to Middle Devonian (Pragian–Givetian)	Dulcie Sandstone, NT Cravens Peak Beds, QLD	-
Tokolepis ulpe Young and Goujet, 2003	Arthrodira	Phlyctaeniidae	Early to Middle Devonian (Pragian–Givetian)	Dulcie Sandstone, NT Cravens Peak Beds, QLD	-
Cobandrahlepis petyrwardi Young, 2005b	Arthrodira	Phyllolepididae	Middle Devonian (Givetian)	Boyd Volcanic Complex, NSW	Young (2007)
Yurammia browni Young, 2005b	Arthrodira	Phyllolepididae	Middle Devonian (Givetian)	Boyd Volcanic Complex, NSW	Young (2007)
Kimberleyichthys bispicatus Dennis-Byran and Miles, 1983	Arthrodira	Plourdosteidae	Late Devonian (Frasnian)	Gogo Formation, WA	-
Kimberleyichthys whybrowi Dennis-Bryan and Miles, 1983	Arthrodira	Plourdosteidae	Late Devonian (Frasnian)	Gogo Formation, WA	-
Mcnamaraspis kaprios Long, 1995	Arthrodira	Plourdosteidae	Late Devonian (Frasnian)	Gogo Formation, WA	-
Torosteus tuberculatus Gardiner and Miles, 1990	Arthrodira	Plourdosteidae	Late Devonian (Frasnian)	Gogo Formation, WA	-
Torosteus pulchellus Gardiner and Miles, 1990	Arthrodira	Plourdosteidae	Late Devonian (Frasnian)	Gogo Formation, WA	-
Elvaspis tuberculata Young, 2009	Arthrodira	Williamsaspididae	Early Devonian (Emsian)	Taemas Limestone, NSW	-
Elvaspis whitei Young, 2009	Arthrodira	Williamsaspididae	Early Devonian (Emsian)	Taemas Limestone, NSW	-
Williamsaspis bedfordi White, 1952	Arthrodira	Williamsaspididae	Early Devonian (Emsian)	Taemas Limestone, NSW	-
brachythoracid indet.	Arthrodira	-	Early Devonian (Emsian)	Taemas Limestone, NSW	Young et al. (2001)
Bruntonichthys multidens Dennis and Miles, 1980	Arthrodira	-	Late Devonian (Frasnian)	Gogo Formation, WA	-
Bullerichthys fascidens Dennis and Miles, 1980	Arthrodira	-	Late Devonian (Frasnian)	Gogo Formation, WA	-
Compagopiscus croucheri Gardiner and Miles, 1994	Arthrodira	-	Late Devonian (Frasnian)	Gogo Formation, WA	Trinajstic and Hazelton (2007)
Connemarraspis youngi Burrow, 2006	Arthrodira	-	Early Devonian (Lochkovian)	Connemarra Formation, NSW	-
Edgellaspis gorteri Hunt and Young, 2011	Arthrodira	-	Early Devonian (Emsian)	Corradigbee Formation NSW	-
Ethabukaspis leios Young and Goujet, 2003	Arthrodira	-	Early to Middle Devonian (Pragian–Eifelian)	Cravens Peak Beds, QLD	-

indet.	Arthrodira	-	Early Devonian (Emsian)	Murrindal Limestone, VIC	Long (1984b)
Euarthrodira indet.	Arthrodira	-	Late Devonian (Frasnian)	Gneudna Formation, WA	Long and Trinajstic (2000)
Harrytoombsia elegans Miles and Dennis, 1979	Arthrodira	-	Late Devonian (Frasnian)	Gogo Formation, WA	-
Narrominaspis longi Burrow, 2006	Arthrodira	-	Early Devonian (Lochkovian)	Connemarra Formation, NSW	-
phlyctaenioid indet.	Arthrodira	-	Early to Middle Devonian (Pragian–Givetian)	Dulcie Sandstone, NT Cravens Peak Beds, QLD	Young and Goujet (2003)
Pinguosteus thulborni Long 1990	Arthrodira	-	Late Devonian (Frasnian)	Gogo Formation, WA	-
Simosteus tuberculatus Dennis and Miles, 1982	Arthrodira	-	Late Devonian (Frasnian)	Gogo Formation, WA	-
Tnoralaspis petercooki Young and Goujet, 2003	Arthrodira	-	Early to Late Devonian (Pragian–Famennian)	Pertnjara Group, NT Cravens Peak Beds, QLD	Young (1985)
Lunaspis sp.	Petalichthyida	Macropetalichthyidae	Early Devonian (Emsian)	Taemas Limestone, NSW	-
Notopetalichthys hillsi Woodward 1941	Petalichthyida	Macropetalichthyidae	Early Devonian (Pragian–Emsian)	Cavan Formation, NSW	Turner and Long, 2016
Shearsbyaspis oepiki Young, 1985	Petalichthyida	Macropetalichthyidae	Early Devonian (Emsian)	Taemas Limestone, NSW	-
Petalichthyid indet.	Petalichthyida	-	Early to Middle Devonian (Pragian–Givetian)	Dulcie Sandstone, NT Cravens Peak Beds, QLD	Young and Goujet (2003)
Wijdeaspis warrooensis Young, 1978	Petalichthyida	-	Early Devonian (Emsian)	Taemas Limestone or Wee Jasper Formation, NSW	-
Austrophyllolepis dulciensis Young 2005a	Phyllolepidida	Phyllolepididae	Middle Devonian (Givetian)	Dulcie Sandstone, NT	-
Austrophyllolepis ritchiei Long 1984a	Phyllolepidida	Phyllolepididae	Middle to Late Devonian (Givetian–Frasnian)	Avon River Group, VIC	Young and Long (2005); Long et al. (2009)
Cowralepis mclachlani Ritchie, 2005	Phyllolepidida	Phyllolepididae	Late Devonian (Famennian)	Merriganowry Shale Member, NSW	-
Placolepis budawangensis Ritchie, 1984	Phyllolepidida	Phyllolepididae	Late Devonian (Frasnian-Famennian)	?Comerong Volcanics, NSW	-

Phyllolepis sp.	Phyllolepidida	Phyllolepididae	Late Devonian (Frasnian)	Avon River Group, VIC Bindaree Formation, VIC Mount Kent Conglomerate or Wellington Rhyolites, VIC Blue Range Formation, VIC	Hills (1936) Long (1983)
Wuttagoonaspis fletcheri Ritchie, 1973	Phyllolepidida	Wuttagoonaspidae	Early to Late Devonian (Pragian–Fransian)	Mulga Downs Group, NSW	Young and Lu (2020)
Wuttagoonaspis milligani Young and Goujet, 2003	Phyllolepidida	Wuttagoonaspidae	Early to Middle Devonian (Pragian–Givetian)	Dulcie Sandstone, NT Cravens Peak Beds, QLD	-
Austroptyctodus gardineri Miles and Young, 1977b	Ptyctodontida	Ptyctodontidae	Late Devonian (Frasnian)	Gogo Formation, WA	Long (1997) Trinajstic et al. (2012)
Campbellodus decipiens Miles and Young, 1977b	Ptyctodontida	Ptyctodontidae	Late Devonian (Frasnian)	Gogo Formation, WA	Long (1997)
Campbellodus decipiens	Ptyctodontida	Ptyctodontidae	Late Devonian (Frasnian)	Napier Formation, WA	Long (1988a)
Kimbryanodus williamburyensis Trinajstic and Long, 2009	Ptyctodontida	Ptyctodontidae	Late Devonian (Frasnian)	Gneudna Formation, WA	-
Materpiscis attenboroughi Long et al., 2008	Ptyctodontida	Ptyctodontidae	Late Devonian (Frasnian)	Gogo Formation, WA	Trinajstic et al. (2012)