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Emsian (Early Devonian) microvertebrates from the Buchan and Taemas areas of southeastern Australia

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Abstract – Microvertebrates obtained from measured stratigraphic sections near Buchan in northeastern Victoria and Taemas in southern New South Wales have been dated as *dehiscens* and *perbonus* conodont zones (early Emsian). The two microvertebrate faunas are similar; the areas are separated by only about 300 km and were both shallow marine environments during the Early Devonian. Thelodonts are a rare component in the otherwise abundant microvertebrate fauna recovered from four sections containing almost 450 samples; 18 turiniid scales have been found. It is considered likely that only one species of turiniid is represented. Trunk and transitional scales share similarites with scales of at least five species of turiniids from eastern Gondwana, recovered from the Aztec Siltstone in Antarctica, the Cravens Peak Beds in western Queensland, the Officer Basin in South Australia and the Silverband Formation in western Victoria. Some head scales show a previously undescribed crown morphology of sharply incised, parallel-sided notches separating wide radiating ribs. The scales are referred to *Turinia* sp. cf. *T. australiensis*.

GEOLOGICAL SETTING AND PREVIOUS WORK

Buchan Group

The Buchan Group in northeastern Victoria comprises three formations: the Buchan Caves Limestone (*dehiscens* Zone), overlain by the Taravale Formation (*dehiscens – serotinus* zones) and the Murrindal Limestone (*perbonus* Zone). An outline of the geology of the Buchan area is given by Mawson (1987). The conodont biostratigraphy is documented by Mawson (1987) and Mawson *et al.* (1988, 1992). The Buchan Caves Limestone contains abundant stromatoporoids and corals (Webby *et al.* 1993), associated with brachiopods, bivalves and ostracods (Talent 1995). The Taravale Formation contains more diverse faunas of brachiopods, corals, and trilobites (Teichert and Talent 1958), the oldest known ammonoids (Mawson 1987), dacryoconarids, ostracods, agglutinated foraminiferans, scolecodonts and 55 species of chitinozoans (Winchester-Seeto 1996).

Young (1979) discussed early discoveries of fossil fish from the Buchan area and the similar sequence from the Taemas/Wee Jasper region of NSW (see below). Placoderms are the most common element in the macrovertebrate fauna, and brachythoracid arthrodires are the most common placoderms. The arthrodire skull first described by Chapman (1916), prepared by Hills (1936a) and eventually assigned to *Buchanosteus confertituberculatus* by Stensiö (1945) came from the Buchan area, as did a mandible of the lungfish *Dipnorhynchus* (Hills 1936b). The only recent description is by Long (1984), who assigned various disarticulated plates from the McLarty Member of the Murrindal Limestone to *Buchanosteus confertituberculatus*, and described two new acanthothoracids: *Murrindalaspis wallacei* and *M. bairdi*. Also identified were several genera first described from the Taemas/Wee Jasper fauna: the brachythoracids *Arenipiscis westolli*, *Errolosteus* sp. cf. *E. goodradigbeensis*, and *Taemasosteus maclartiensis*, and the petalichthyid *Widjeaspis warrooensis*. Turner (1991, 1993) discussed elements of the Buchan microvertebrate fauna; faunal lists are given in Young (1993) and De Pomeroy (1995). Microvertebrates from Buchan have not previously been illustrated, except for the scales of *Dipnorhynchus* figured by Thomson and Campbell (1971, figures 86–88).

Murrumbidgee Group

The Murrumbidgee Group in southeastern New South Wales is of similar age and lithology to the Buchan Group (*pireneae – serotinus* zones), and occurs in two separate outcrops on the shores of Burrinjuck Dam. The stratigraphy of the eastern outcrop (Taemas area), as first outlined by Browne (1959), comprises, from oldest to youngest, the Cavan, Majurgong and Taemas Formations. The geology of the western outcrop, in the valley of the Goodradigbee River at Wee Jasper, was outlined by

Pedder *et al.* (1970). The same sequence is evident in the lower part of the Wee Jasper section, but the upper part contains more extensive and massive limestone horizons up to a total of approximately 450 m thick, and is overlain by the terrigenous Hatchery Creek Formation. Mawson *et al.* (1992) identified the Pragian-Emsian boundary within the Cavan formation at the base of the Wee Jasper succession.

The marine limestones in the Burrinjuck Dam area contain an abundant invertebrate fauna (e.g. Johnston 1993). The diverse fish fauna is dominated by placoderms (White 1952, 1978; White and Toombs 1972; Young 1979, 1980, 1981, 1985; Long and Young 1988; Findlay 1996), but also includes lungfishes (e.g. Campbell and Barwick 1982–85), other osteichthyans (e.g. Schultze 1968; Ørvig 1969; Giffin 1980), and acanthodians (Long 1986). Chondrichthyans are represented only by microremains (e.g. Giffin 1980). Turner (1991, 1993) discussed the microvertebrate faunas. The first thelodont scales from the Burrinjuck area are a result of the present study; the form "*Skamolepis*", previously assigned to this group by Giffin (1980), is now considered to be a shark scale, and is not the same as *Skamolepis* described by Karatajute-Talimaa (1978), and considered to be a thelodont (e.g. Turner 1991, 1993). The vertebrate fauna is apparently similar to, or the same as, that from the Buchan area (see faunal lists in Young 1993 and De Pomeroy 1995).

RESULTS

Residues of the seven stratigraphic sections sampled for conodonts near Buchan (see Mawson 1987) were investigated for microvertebrates. Only three sections – Slocombe's (SL/SLO; 42 samples), McLarty's (120 samples) and Gelantipy Road (80 samples) contained significant microvertebrate faunas, expecially placoderms and acanthodians, while all seven thelodont scales from Buchan were recovered from six samples in section SL/SLO.

The 11 thelodont scales from Taemas, the first recorded from the Burrinjuck limestone sequence, are from stratigraphic section YWJ (224 m), which spans the *pireneae* and *dehiscens* zones. It passes through the Cavan and Majurgong Formations along the road on the northern side of Taemas bridge, the type locality for the index conodont *Polygnathus dehiscens* (Philip and Jackson 1967). The scales were recovered from two of the 125 sampled horizons: YWJ117.5, uppermost Cavan Formation, and YWJ135.4, basal Majurgong Formation, both *dehiscens* Zone. The single scale recovered from the higher of these two samples, YWJ135.4, appears abraded and possibly reworked. Microvertebrate remains occur throughout the section, but are especially abundant around the Cavan-Majurgong boundary. The depositional environment of the Cavan Formation is interpreted as nearshore intertidal; higher horizons, comprising shales with limestone lenses, contain a fauna of brachiopods, bivalves and gastropods decreasing in abundance towards the boundary with the Majurgong Formation (Young 1969). The Majurgong Formation, consisting of siltstones, fine sandstones and shales with some thin limestone lenses, is fairly unfossiliferous, although spiriferids and rare lingulids occur in the lower horizons (Young 1969), suggesting brackish conditions during deposition. There is evidence from other areas that thelodonts preferred very shallow water or non-marine environments (Märss and Einasto 1978; Turner 1997).

Although some of the scale morphologies are previously undescribed, it is assumed for the present that only one species of turiniid thelodont is represented, since, although possible, it is unlikely that such a small number of specimens (18 scales from almost 450 samples) would have originated from several species.

SYSTEMATIC PALAEONTOLOGY

Figured material is lodged in the palaeontological collections of the Australian Museum (prefix AM F). Locality information is given by section code followed by metres above base of section of lowest and highest productive sample.

Figure 1 Thelodont scales *Turinia* sp. cf. *T. australiensis* from Buchan and Taemas. **A–C**, scale AM F101174 from SLO51–68m, Taravale Formation, *perbonus* Zone. **A**, crown view; **B**, base view; **C**, lateral view. **D–F**, scale AM F101203 from YWJ117.5, Cavan Formation, *dehiscens* Zone. **D**, crown view; **E**, base view; **F**, lateral view. **G–I**, scale AM F101175 from SLO213m, Taravale Formation, *perbonus* Zone. **G**, crown view; **H**, base view; **I**, lateral view. **J–L**, scale AM F103583 from SL46.5m, Buchan Caves Limestone, *dehiscens* Zone. **J**, crown view; **K**, base view; **L**, lateral view. **M–N**, scale AM F101176 from SL48.7m, Buchan Caves Limestone, *dehiscens* Zone. **M**, crown view; **N**, base view. **O**, scale AM F103584 from SLO28.5m, Taravale Formation, *dehiscens* Zone. Crown view. **P–Q**, scale AM F101204 from YWJ117.5, Cavan Formation, *dehiscens* Zone. **P**, crown view; **Q**, lateral view. **R–S**, scale AM F103585 from YWJ117.5, Cavan Formation, *dehiscens* Zone. **R**, crown view; **S**, lateral view. **T–V**, scale AM F101177 from SLO51m, Taravale Formation, *dehiscens* Zone. **T**, crown view; **U**, base view; **V**, detail of crown ornament. **W**, scale AM F101205 from YWJ117.5, Cavan Formation, *dehiscens* Zone. Crown view. **X**, scale AM F103586 from SL46.5m, Buchan Caves Limestone, *dehiscens* Zone. Crown view (specimen broken and crown misoriented by 180°). Scale bars = 100 μm.

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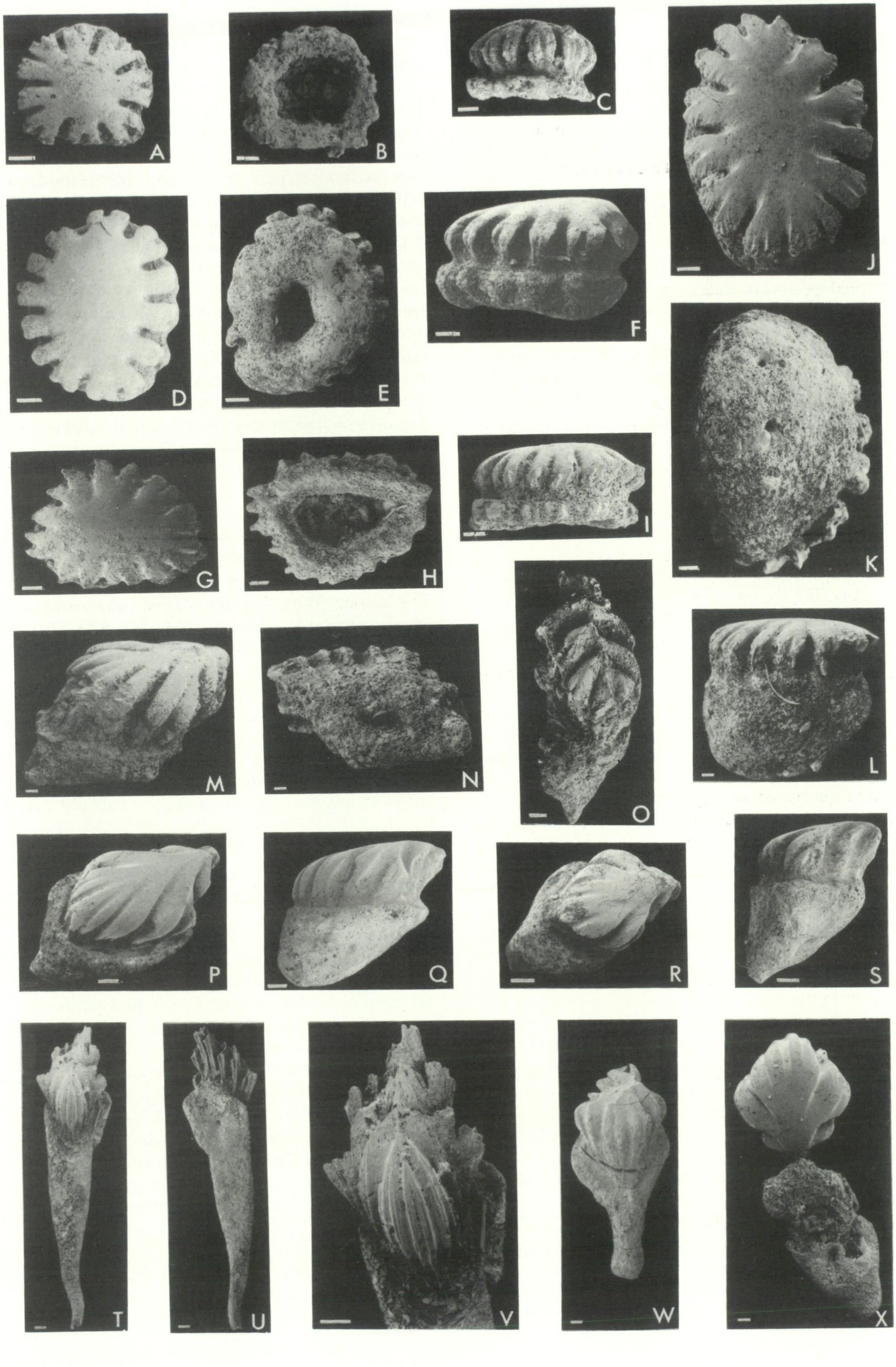
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Superclass Agnatha Haeckel, 1895

Subclass Thelodonti Kiaer, 1924

Order Thelodontida Stensiö, 1958

Family Turiniidae Obruchev, 1964

Genus *Turinia* Traquair, 1896

Turinia sp. cf. *T. australiensis* Gross, 1971

Material Examined

Eighteen scales: 10 head scales, four transitional (cephalopectoral) scales, four trunk (postpectoral) scales.

Localities

Slocombe's section at Buchan, samples SL 46.5m, SL 48.7m (Buchan Caves Limestone), SLO 28.5m, SLO 51m, SLO 51–68m, SLO 213m (Taravale Formation); Section YWJ at Taemas, samples 117.5m (Cavan Formation) and 135.4m (Majurgong Formation).

Stratigraphic Range

Early Devonian, Emsian: *dehiscens* – *perbonus* conodont zones at Buchan; *dehiscens* Zone at Taemas.

Description

Head Scales

The head scales (Figure 1A–L) are circular or subcircular. The central part of the crown is unornamented and, in the elongated scales (Figure 1D–L), flat. Approximately 14 main ribs around the rim of the crown are separated by deep troughs. In scale AM F101174 (Figure 1A–C), the troughs are deeply incised with parallel sides, and on parts of the margin long and short troughs alternate producing a bifurcation of some of the ribs. The troughs in scales AM F101175 (Figure 1G–I) and AM F103583 (Figure 1J–L) become narrower towards the centre of the crown and terminate in shallow elongated depressions. The ribs are subdivided by narrow vertical grooves; in scale AM F101174 (Figure 1A–C) these occur only on the sides of the scale and give the outline a serrated appearance, in scales AM F101175 (Figure 1G–I) and AM F103583 (Figure 1J–L) the grooves extend a short distance onto the crown, while in scale AM F101203 (Figure 1D–F) the vertical grooves on the distal ends of the ribs are not well developed (see Figure 1F).

In scales AM F101174 (Figure 1A–C), AM F101203 (Figure 1D–F) and AM F101175 (Figure 1G–I) the crown and base are separated by a constricted neck. The base is shallow and comprises a low rounded rim surrounding a central large, deep pulp cavity. In scale AM F103583 (Figure 1J–L) the neck is not constricted and is not clearly defined (Figure 1L). The base is deeply convex and contains one small central pulp cavity and a smaller cavity towards one side (Figure 1K).

Transitional Scales

Crown is elliptical (Figure 1O) or diamond-shaped (Figure 1M). Deep troughs aligned from the outer anterior margin posteriorly towards the centre of the crown produce coarse ribs covering virtually the entire crown surface. In scale AM F103584 (Figure 1O) these ribs are separated by a narrow central ridge running from anterior to posterior; the ribs alternating in their anterolateral direction from this central ridge to the lateral margin of the crown. A central ridge is less pronounced in scale AM F101176 (Figure 1M), where the ridges and troughs are all aligned from the anterior and lateral margins towards the posterior of the crown. Troughs on the crown of scales AM F101204 (Figure 1P) and AM F103585 (Figure 1R) terminate closer to the scale margin, leaving a smooth, flat central area on the crown.

The base is the same shape as the crown, but projects forward from the crown, while the crown overhangs the base posteriorly. The base contains a central pulp cavity surrounded by a rounded rim. The crown joins directly to the base without a constricted neck, although in scales AM F101204 (Figure 1P) and AM F103585 (Figure 1R) there is a shallow trough around the base of the crown, similar to that found on some body scales, e.g. Figure 1T.

Trunk Scales

There are two distinct morphological types of trunk scales. The more commonly occurring type is illustrated in Figure 1T–W. Scale AM F101177 (Figure 1T–V) is elongated horizontally with the base extending as a long anterior process approximately two-thirds the total length of the scale. The complex crown structure comprises several overlapping, deeply subdivided layers surrounding a central lanceolate platform. This central platform bears ridges and troughs subparallel to the margin. The central platform is successively underlain towards the posterior of the crown by three similar, larger, ridged layers. The posterior part of the crown has been broken; overall crown shape is difficult to determine. The posterior part of the crown substantially overhangs the base (Figure 1U), with 10 parallel ribs extending from the posterior crown-base interface to the posterior edge of the crown (Figure 1U). The anterior neck region is a wide, shallow trough. The base is shallow and flat with a small central pulp cavity, and the tapering anterior process extends smoothly from the base in the same horizontal plane. Other scales of this type, e.g. Figure 1W, have crown ornament of similar overlapping layers with less deeply incised troughs, and a shorter anterior process on the base.

The second scale type is represented by only one specimen (broken during electron micrography; Figure 1X). The flat diamond-shaped crown has a central, diamond-shaped, slightly raised portion with three wide, shallow anterior ridges separated by wide, shallow troughs. This central area is surrounded laterally and posteriorly by a larger, flat, diamond-shaped area with the lateral corners slightly stepped down, and the posterior corner extending slightly into a rounded point. On either side of this posterior point there is a lower, narrow, elliptical platform. There is no clearly-defined neck area. The base is extended into a short, stout, tapering anterior process approximately one-third the total length of the scale.

DISCUSSION

Some Buchan/Taemas thelodont scales share features with those of *Turinia australiensis* from western Queensland (Turner *et al.* 1981) and from the Jerula Formation of central NSW (*pesavis - sulcatus* zones) (Turner 1997, figures 3C, 3K, 3N, 4G, 4I, 4M); *T. antarctica* from southern Victoria Land, Antarctica (Turner and Young 1992); *T. gondwana* from Bolivia (Gagnier *et al.* 1988); *T. fuscina* from western Victoria (Turner 1986), and scales from western Queensland described as *Turinia gavinyoungi* by Turner (1995a) and from South Australia described as *Turinia* cf. *T. pagoda* by Long *et al.* (1988). Scales from the Cravens Peak Beds of western Queensland (Eifelian), and the Aztec Siltstone in Antarctica (Givetian), held in the collections of the Queensland Museum and the Australian National University, also show similarities with the Buchan/Taemas specimens.

Crown ornamentation of distinct, parallel-sided troughs between sometimes bifurcating ribs on head scale AM F101203 (Figure 1D) is seen in head scales of *T. australiensis* (Turner *et al.* 1981, figure 11A). The Buchan specimen lacks the deep rounded base of typical head scales of *T. australiensis* (Turner *et al.* 1981), although the depth of the base in thelodont scales is related to ontogenetic stage (S. Turner pers. comm. 1995). Similar crown ornament occurs in specimens from samples C654 from the Jerula Formation at Condobolin (see also Turner 1997, figure 3F) and C657 from the Trundle Group at Kadungle, held in the collections of the Queensland Museum.

The second type of head scale morphology, with tapering troughs terminating in shallow depressions (Figure 1G–L), can be found in specimens from the Officer Basin, South Australia (*Turinia* sp. aff. *T. australiensis* – Long *et al.* 1988, figure 5A), Cravens Peak Beds (*T. australiensis* – Turner *et al.* 1981, figure 10D), and in collections at the Australian National University from shot point and outcrop samples from the Cravens Peak Beds (*T. australiensis*, sample SP813, and *T. gavinyoungi*, sample GB77, respectively), and from the Aztec Siltstone (*T. antarctica*, sample V2616).

The crown of transitional scale AM F101176 (Figure 1M–N) also resembles that of *T. australiensis* (e.g. Turner *et al.* 1981, figure 11I), with crenulations deeply incising the crown almost to the centre, leaving only a narrow central smooth area (Figure 1M). Scales of *T. gavinyoungi* figured by Turner *et al.* (1981, figure 7A) have a similarly crenulated crown, but the crenulations here are more widely spaced and the central smooth ridge is wider than in the Buchan specimen. Subparallel troughs extending from the margin almost to the central antero-posterior axis of the crown are also found in scales of *Turinia* cf. *T. pagoda* from the eastern Officer Basin, South Australia, figured by Long *et al.* (1988, figure 2A,B). Although the number and orientation of the troughs is similar to those on the crown of Buchan specimen AM F101176 (Figure 1M–N), the crown of the South Australian scale is more shallowly incised. The base, too, of the Buchan scale (Figure 1N), which is shallow with a large central pulp cavity and small anterior process, resembles that of body scales of *Turinia* sp. cf. *T. pagoda* (Long *et al.* 1988, figure 2A–C,E). However, although the Buchan specimen shares these features with the *Turinia* sp. cf. *T. pagoda* material from South Australia, it differs from the original description of *T. pagoda* from western Yunnan, China (Wang *et al.* 1986) in lacking the lateral neck-spurs and by having more deeply incised grooves on the crown (see Wang *et al.* 1986, figure 4G–J). A specimen of *T. fuscina*, figured by Turner (1986, figure 2N), resembles the transitional scales from Buchan and Taemas in crown ornament.

The crown of trunk scale AM F101177 (Figure 1T,V) resembles scales of *T. australiensis* from the Jerula Limestone Member of the Gleninga Formation in western New South Wales (Turner 1997, figure 4M), *T. antarctica*, described from the Aztec Siltstone of southern Victoria Land, Antarctica by Turner and Young (1992, figure 5H), and *T. gondwana* from the Catavi Formation, Bolivia (Gagnier *et al.* 1988, figure 4D,E). Common features are the central raised elliptical section with subparallel ribs, lateral segments that converge with the posterior tip of the central platform in a thin ridge extending towards the posterior of the crown (e.g. Turner and Young 1992, figure 5h; Gagnier *et al.* 1988, figure 4D,E), parallel ribs on the ventral side of the crown (Turner and Young 1992, figure 6; Gagnier *et al.* 1988, figure 4), a smooth wide trough around the anterior edge of the crown (Turner and Young 1992, figure 5a, c–m), and a long anterior process on the base (Turner and Young, 1992, figure 5d–e, g–m; Gagnier *et al.* 1988, figure 5B). The same pattern of tiered subdivisions of the crown occurs in body scales from the Early Lochkovian Read Bay Formation of Cornwallis Island, Canadian Arctic (Turner and Burrow 1997), and in specimens from outcrop locality GB77 of the Cravens Peak Beds in western Queensland (Turner 1995a, figure 3V,W; Queensland Museum collection).

CONCLUSION

The turiniid scales described in this study show most morphological similarity to scales of *T. australiensis* (see Turner 1995b, 1997 for discussion of *T. australiensis* scale morphology, histology and significance of the taxon in biostratigraphic subdivision of the Early Devonian). However, because of slight differences from previously figured specimens of *T. australiensis*, similarities with other species of *Turinia*, and the unique morphology of scale AM F101174 (Figure 1A–C), the turiniid scales from the Buchan/Taemas fauna described herein are referred to *Tuninia* sp. cf. *T. australiensis*. The age of this fauna (*perbonus* - *dehiscens* zones) is the same as that of the *T.* sp. cf. *T. australiensis* Assemblage (Fauna 3) of Turner (1997).

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