



TELEPHINA AND OTHER TRILOBITES FROM THE PRATT FERRY BEDS, ORDOVICIAN OF ALABAMA, U.S.A.

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ABSTRACT—The Pratt Ferry beds are a three meter thick bioclastic carbonate unit containing the *Pygodus serrus*–*P. anserinus* conodont zone boundary and lying just below the *Nemagraptus gracilis* graptolite zone at a single locality in Alabama. *Telephina* Marek at Pratt Ferry and other eastern North American localities is represented by at least six species. These are judged widespread and in part conspecific with Scandinavian or Asian forms of similar age. Most of the fifteen Appalachian telephinid species proposed by Ulrich (1930) are reviewed and some synonymized. *Bevanopsis* Cooper is present, extending its stratigraphic range via *B. buttsi* (Cooper). The original description of *Ceraurina buttsi* Cooper is augmented. Other recorded but poorly represented genera include *Ampyxina*, *Arthrorhachis*, *Calyptaulax*, *Hibbertia*, *Lonchodomas*, *Mesotaphraspis*, *Porterfieldia*, and *Sphaerexochus*. The entire faunule represents a mixture of ‘inshore’ and ‘offshore’ or planktonic faunal elements rarely seen elsewhere in the latest Middle Ordovician (Darriwilian) of eastern North America.

INTRODUCTION

THE PRATT Ferry beds are a late Darriwilian bioclastic carbonate facies between two deeper water shale facies. These beds display some of the expected mix of planktonic, ‘deep water’ and ‘inshore’ trilobite genera. The Pratt Ferry unit is the same age as parts of the Copenhagen Formation of Nevada, some units from the Northwest Territories, the Simpson Group of Oklahoma, the Lenoir Formation of the southern Appalachians, the Chazy Group of New York and the Mingan and Table Head units of eastern Canada. Unlike most of the above units, the Pratt Ferry and Table Head contain a few distinctive, pelagic elements (principally *Telephina*). Thus, the trilobites and conodonts show some ‘North Atlantic’ and some interior North American affinities. By analogy to the slightly younger trilobite biofacies outlined from farther north in Virginia (Carlucci and Westrop, 2012) the ‘outer ramp’ non-pelagic genera in the Pratt Ferry beds are *Arthrorhachis*, *Calyptaulax*, *Porterfieldia* and raphiophorids. Shallower water elements would then be *Bevanopsis*, *Hibbertia* and *Ceraurina*. The shallower water genera reflect Laurentian provinciality, while the ‘offshore’ genera represent more widely distributed deep and/or planktonic genera (Fortey and Cocks, 2003, fig. 2).

This paper is based on new collections from Pratt Ferry and review of earlier collections. Several visits to Ulrich’s other Appalachian telephinid localities were unproductive. His published photos and descriptions, however, closely match his specimens in the United States National Museum (USNM).

Ulrich (1930) described four species of *Telephina* from the Pratt Ferry beds (*T. gelasinosa*, *T. bipunctata*, *T. impunctata*, and *T. prattensis*) and eleven more from other Appalachian rocks of about the same age and facies. North along the Appalachian trend, Whittington (1965) redescribed *Telephina americana* (Billings, 1865) from abundant well-preserved material in the Darriwilian Table Head Group of Newfoundland (Maletz et al., 2011).

Some Appalachian *Telephina* species are here judged synonymous with *T. bicuspis* (Angelin, 1854) and *T. granulata* (Angelin, 1854) from Scandinavia. The Appalachian species *T.*

gelasinosa (Ulrich, 1930) is very similar to several Asian species. *Telephina prattensis* (Ulrich, 1930) closely resembles some Scandinavian and Asian forms, particularly *T. mobergi* (Hadding, 1913). *Telephina americana* (Billings, 1865), originally described from Newfoundland, resembles species from the southern Appalachians and Argentina. This wide distribution reflects the assumed planktonic lifestyle of *Telephina* (Fortey, 1985).

Many *Telephina* species show variable cephalic characters, lack well assigned free cheeks and pygidia, or are defined by a very few deformed specimens. Although several species or species groups are geographically widespread, particularly those of *T. bicuspis*-type, no one *Telephina* species reached the worldwide distribution of the telephinid *Carolinites genacinaca* Ross (McCormick and Fortey, 2002).

AGE, PALEOECOLOGY, AND BIOGEOGRAPHY

The Middle Ordovician Pratt Ferry beds are an unsubdivided three-meter thick bioclastic limestone unit known from one locality in central Alabama (Fig. 1). Located between the Lenoir and Athens formations, the upper part of these beds contains the stratigraphically important *Pygodus serrus*–*Pygodus anserinus* conodont zonal boundary (late Darriwilian) (Sweet and Bergström, 1962; Bergström, 1990). Finney (1984) and Bergström (1990) showed that the base of the *Nemagraptus gracilis* Zone (early Sandbian) lies in the Athens Formation just above the Pratt Ferry beds. This graptolite zone and the accompanying conodonts closely correlate in time the American, European and Asian telephinids and other trilobites considered here (Bergström et al., 2008).

The only depositional interpretation for this locality (Benson and Stock, 1986) assigned the bioclastic Pratt Ferry beds to a “temporary return to above wave-base deposition” in a persistent deepening trend. This trend culminates in the calcareous, graptolitic shales of the overlying Athens Formation. Structurally, the Pratt Ferry area is east of the Helena fault (Chowns, 1986), which separates the ‘Blount’ offshore (‘deeper’) facies from the onshore ‘Tazewell’ and ‘Lee’ facies. This facies concept, here redrawn and modified (Fig. 1) after

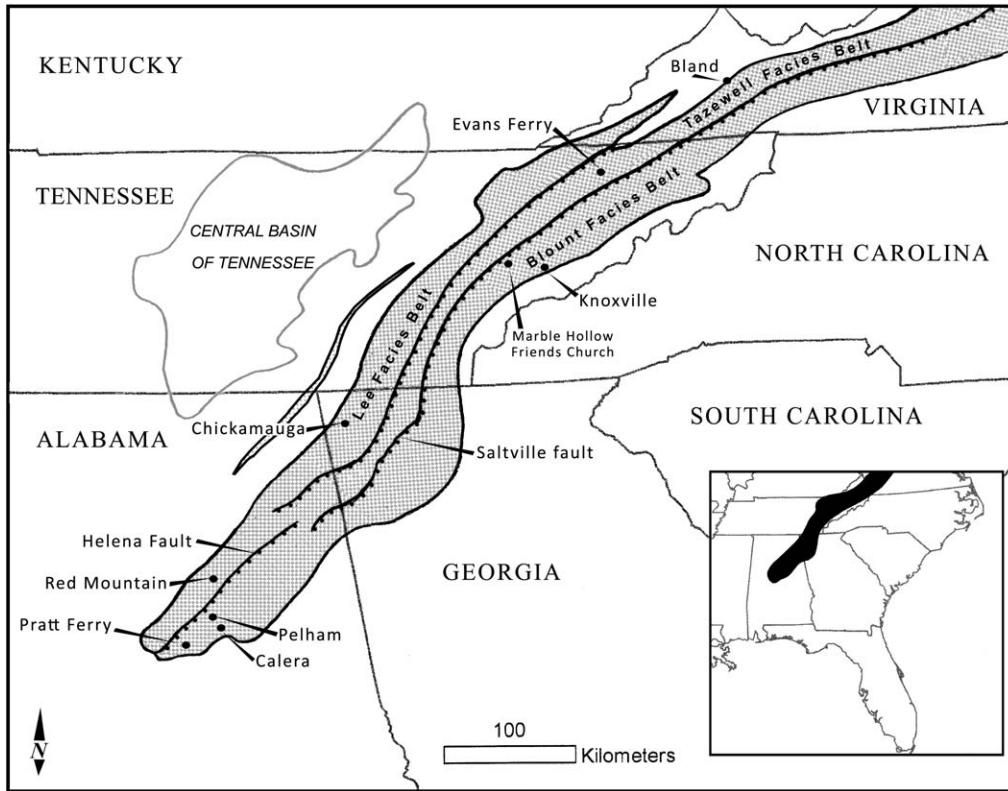


FIGURE 1—Locality map, Pratt Ferry and related localities, southeastern U.S.A., modified and redrawn after Grahn and Bergström (1984). Shaded area is the Appalachian Valley and Ridge Province, with major faults and facies belts as labeled. The exact Pratt Ferry locality is 11.6 km N35°E of the Cahaba River Bridge at Centreville, Alabama, and 300 m SE of the Cahaba River on Route 27. Outcrop trends NE/SW across Route 27 for about 0.6 km.

		International Conodont & Graptolite(g) Zones	North American Series	Balto-Scandian Series	
UPPER ORDOVICIAN	Katian	<i>P. linearis</i> (g)	CINCINNATIAN	HARJU	Sweden Alabama Sweden Alabama Sweden Alabama Sweden Alabama
		<i>D. caudatus</i> (g)			
	Sandbian	<i>C. bicornis</i> (g)	MOHAWKIAN	VIRU	
		<i>N. gracilis</i> (g)			
MIDDLE ORDOVICIAN	Darrwillian	<i>P. anserinus</i>	WHITEROCKIAN	OELAND	Telephina bicuspsis Telephina mobergi Telephina prattensis Telephina granulata Sweden Alabama
		<i>P. serra</i>			
		<i>D. artus</i> (g)			
		<i>U. austrodentatus</i> (g)			

FIGURE 2—Some Swedish and southern Appalachian *Telephina* ranges compared to graptolite and conodont zones. Swedish data from Ahlberg (1995).

Jaanusson and Bergström (1980) and Grahn and Bergström (1984), originated in the Baltic and was extended to eastern North America. Brachiopods from the Pratt Ferry (Cooper, 1956) fit the same pattern (Jaanusson and Bergström, 1980). Pålsson et al. (2002) placed *Telephina* in the deepest or farthest offshore of these Baltic litho- and biofacies patterns. Pope and Read (1997), using a sequence stratigraphic framework, presented a similar bathymetric picture for the shelf along strike about 1000 km to the (present day) northeast in Virginia. The Middle–Upper Ordovician boundary there also shows a sea level rise. Carlucci and Westrop (2012) proposed trilobite biofacies in the Sandbian of this Virginia section, listing *Telephina* in their outermost, ‘deep water’ facies. Bayona and Thomas (2003) confirmed the same Appalachian paleogeography.

With their typical occurrence in outermost ‘deep water’ facies, and wide distribution, telephinids have been repeatedly interpreted as planktonic and little influenced by bottom conditions (Fortey, 1985; McCormick and Fortey, 2002; Bruton and Høyberget, 2006). Baltica and Laurentia were about 2000 km apart with connecting equatorial surface currents (Herrmann and Haupt, 2010, fig. 2). The observed telephinid similarities between the Appalachians and Scandinavia (Fig. 2) are thus expected. Using a slightly different paleogeography, Harper et al. (2009) also characterized *Telephina* as epipelagic—occurring widely over their Celtic Province. Given an Arenig species in Argentina (Chatterton et al., 1999) Harper et al. (2009) suggested that the genus was a late migrant into Scandinavia and the Appalachians. *Telephina* is also known from Tasmania (Burrett et al., 1983); Kazakhstan (Koroleva, 1982; Ghobadi Pour et al., 2011); Thailand (Fortey, 1997); China (Peng et al., 2001; Zhou and Dean, 1986) and Argentina (Chatterton et al., 1999). The similarity of these specimens to Balto-American forms supports the concept of *Telephina* as epipelagic.

Given this nearly world-wide distribution it is not clear why *Telephina* is unknown from western North America. The Late Ordovician equator ran (present day) north-south through the continent (Fortey and Cocks, 2003; Harper et al., 2009; Jin et al., 2013), guaranteeing little climatic or current separation between (present day) eastern and western North America. In contrast, *Bevanopsis*, a shallow water encrinurid, occurs at Pratt Ferry and in western North America as well as Europe.

SYSTEMATIC PALEONTOLOGY

Family TELEPHINIDAE Marek, 1952

Genus TELEPHINA Marek, 1952

Type species.—*Telephus fractus* Barrande, 1852 from the Ashgillian Králův Dvůr Formation (upper part), Králův Dvůr, Prague Basin, Czech Republic (see Shaw, 2000).

Remarks.—Shaw (2000) refigured the type species, which is known only from the original three Barrande specimens. Hammann and Leone (1997) assigned the type pygidium to *Symphysops armata* (Barrande, 1852). Reliably assignable hypostomes, free cheeks, pygidia and segments are rare in most *Telephina* collections.

Unique lenses and paired vertical anterior border spines are synapomorphies which unite the genus. As Fortey (1997) and Han (2001) noted, the eye lenses are sub-square. Han (2001) claimed that the major lenses were octagonal, with intervening smaller lenses, giving a schizochroal/holochroal eye with the appearance of square lenses. Bruton and Høyberget (2006) suggested that these square lenses were an adaptation to pelagic life as seen in macruran crustaceans.

Well shown by Whittington (1965) and the present paper, the anterior medial border is distinctive, consisting of four ventrally

directed tubular spines. The distal pair is partly formed by the anterior proximal margin of the free cheek. This is the ancestral condition seen in *Oopsites* Fortey (1975, pl. 35, fig. 4). The proximally added spine pair is a ventral extension of the cranial border. This generates a slot between the margin of the free cheek and the central arched opening of the cephalon.

Species determination rests largely on details of the glabella and fixed cheeks. Several authors (Whittington, 1965; Ahlberg, 1995a, 1995b; Hammann and Leone, 1997; Chatterton et al., 1999; Yin et al., 2000; Shaw, 2000) have commented on changes in these characters during growth and their potential confusing effect on taxonomy of the genus. Ahlberg (1995a, 1995b) in particular worked with larger collections (up to 100 in at least one case) and described cephalic variability within single species. Whittington's (1965) figures show this variability well (pl. 37, fig. 1 vs. fig. 8). Hansen (2009) analyzed latest Middle Ordovician Norwegian *Telephina* species, disagreeing with two species assigned to Ahlberg's synonymy of *Telephina bicuspis* (Angelin, 1854), but again noting variability within the species. Hansen (2009) also suggested that differential compaction can alter cephalic dimensions. This is shown in specimens figured by Ahlberg, (1995, pl. 4, figs. 1–7) and Ulrich, (1930, pl. 3, fig. 11, pl. 7, fig. 1).

Nikolaisen (1963) divided *Telephina* into three species groups and one new subgenus *Telephops*. Ahlberg (1995) largely concurred, although delimiting only three major species groups. Reviewing works by Ulrich (1930), Nikolaisen (1963), Whittington (1965), Koroleva (1982), Ahlberg (1995a), Månsson (1995), Fortey (1997), Chatterton et al. (1999), Yin et al. (2000), Peng et al. (2001), and Hansen (2009), as well as examining new Pratt Ferry material and that in United States Geological Survey, Museum of Comparative Zoology and USNM collections, I concur with Ahlberg (1995) that three principal types of *Telephina* exist, even in single collections.

Group one includes species like *T. bicuspis* (Angelin, 1854), which have the glabellar outline rounded in dorsal view, without pronounced glabellar furrows or pits in the adult. The glabella shows smooth areas interpreted as muscle scars. Cephalic ornament is predominantly pustular, although some forms (including *T. bicuspis* itself) show the ‘wrinkled’ networks (lirae) more common in group two below. The fixed cheek is expanded anterolaterally in dorsal view, but this is less true in species such as *Telephina americana* (Billings, 1865) and *T. chingolo* Chatterton et al. (1999). The type species for the genus, *T. fracta* (Barrande, 1852), belongs in this group, although known only by its cranium. Bruton and Høyberget (2006) showed a distinctive vertically oriented genal spine rising off the free cheek for at least some members of this group. This feature is not well shown in poorer Swedish and Appalachian specimens, although Ulrich (1930, pl. 3, figs. 7, 8) shows such a spine in *Telephina pustulatus* (Ulrich, 1930).

Group two is exemplified by *Telephina mobergi* (Hadding, 1913), showing a more anteriorly tapered glabella which retains pronounced glabellar furrows or pits in the adult. The fixed cheek is more expanded anterolaterally than in the preceding group. Many members of this group show a distinctive ‘wrinkled’ or ridged cephalic ornament (lirae), and the smooth muscle scars of group one are less developed this second group. The glabellar furrows do not closely match the smooth muscle scar positions of group one.

Group three is related closely to group one, and includes forms such as *Telephina granulata* (Angelin, 1854) with two prominent spines developed from glabellar tubercles. Nikolaisen (1963) set this group aside as the subgenus *Telephops*, but subsequent workers (with the exception of Romano and Owen, 1993;

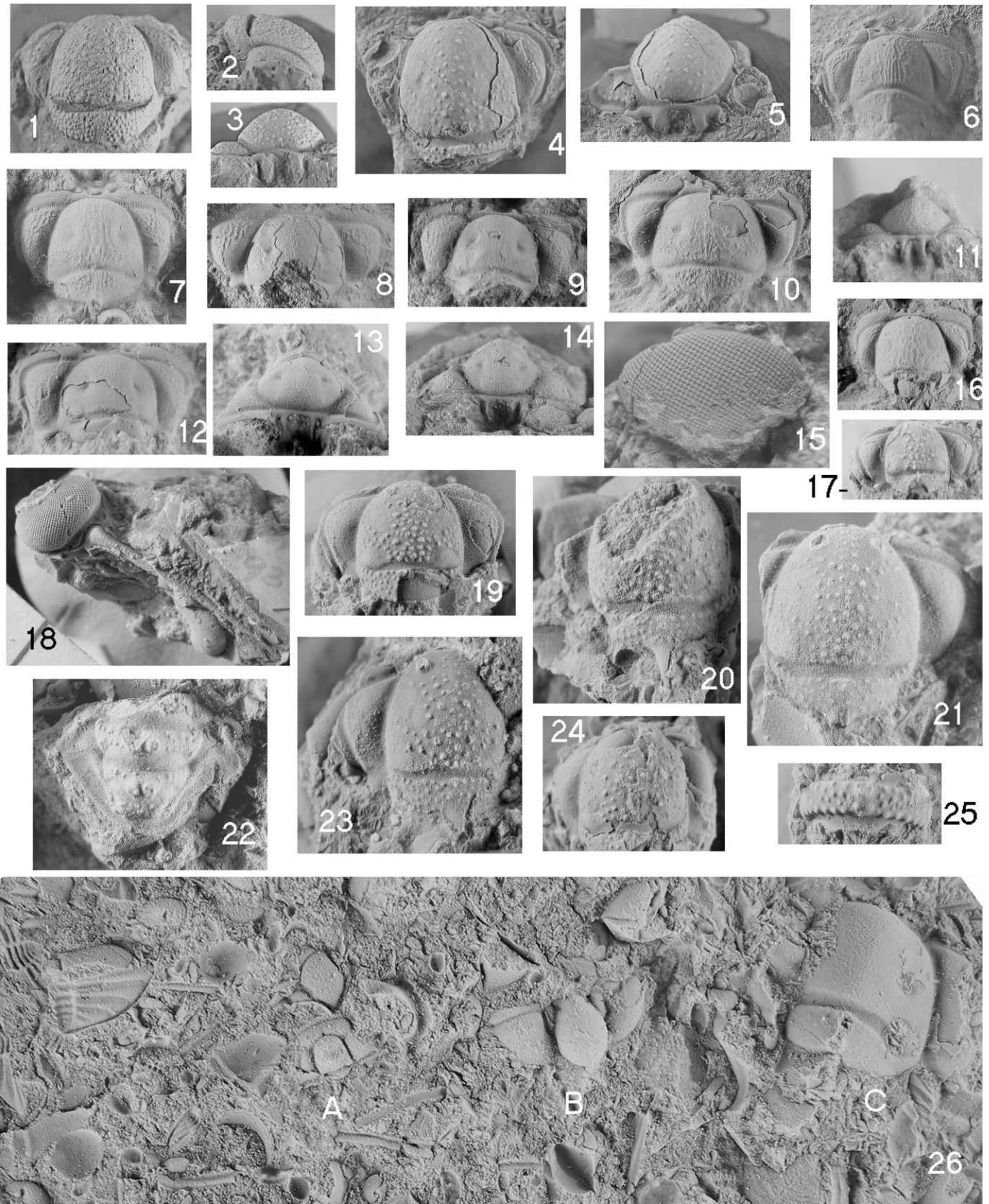


FIGURE 3—1–5, *Telephina gelasinosa* (Ulrich): 1–3, partial cranium dorsal ($\times 2.6$), lateral ($\times 2.2$), anterior ($\times 2.2$) views, type of *Telephus gelasinus* Ulrich, USNM 71468; 4, 5, partial cranium, dorsal view ($\times 3.5$), anterior view ($\times 3.4$), USNM 528280; 6–14, 16, 26, *Telephina prattensis* (Ulrich): 6, 11, cranium, dorsal and anterior views, $\times 4.4$, USNM 528281; 7, cranium, dorsal view, $\times 7.8$, USNM 528285; 8, cranium, dorsal view, $\times 5.2$, USNM 528283; 9, 14, cranium, dorsal and anterior views, $\times 6$, USNM 528287; 10, cranium, dorsal view, $\times 7.8$, USNM 528282; 12, 13, cranium, dorsal and anterior views, $\times 4.4$, USNM 528284; 16, cranium, dorsal view, $\times 5$, lectotype of *Telephus prattensis* Ulrich, USNM 80541; 15, eye, lateral view, species uncertain, $\times 6$, USNM

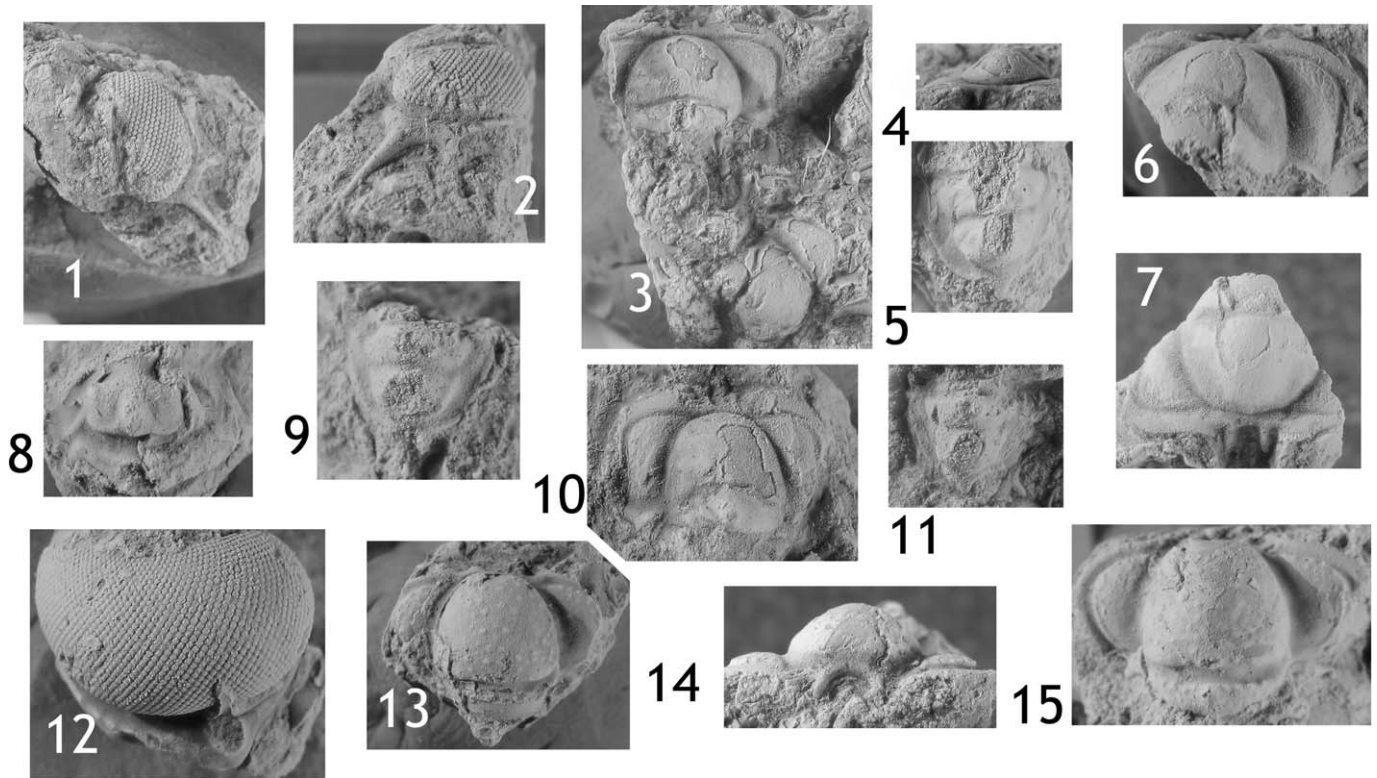


FIGURE 4—1–7, 9–11, *Telephina tellicoensis* (Ulrich, 1930): 1, 2, free cheek, dorsal and right lateral views, $\times 3.2$, USNM 80531; 3, 4, lectotype cranium (herein), dorsal (upper specimen) and anterior views, $\times 3.2$, USNM 80532A; 6, 7, cranium, dorsal and anterior views, $\times 5.5$, USNM 80532B; 5, pygidium, dorsal view, $\times 5.5$, USNM 80533B; 9, pygidium, dorsal view, $\times 5.5$, USNM 80533A; 10, cranium, dorsal view, $\times 3.2$, USNM 80532C; 11, pygidium, dorsal view, $\times 5.5$, USNM 80533C, all from “Tellico formation”, Knoxville, Tennessee; 8, 12–15, *Telephina bicuspis* (Angelin): 8, pygidium, dorsal view, $\times 5.5$, USNM 80536C; 12, eye and partial free cheek, $\times 6.5$, USNM 80536B; 13, cranium, dorsal view, $\times 3.2$, USNM 80536A; 14, 15, cranium anterior and dorsal views, $\times 3.2$, USNM 80536, holotype of *Telephus pustulatus* Ulrich. All from “Whitesburg limestone, Lexington, Virginia”.

Hammann and Leone, 1997; and Pärnaste and Popp, 2011) have not continued the usage (Tripp, 1976; Ahlberg, 1995; 1995a; Hansen, 2009). The spines are the only distinctive feature. Otherwise, these forms are very similar to group one (centered on *T. bicuspis* [Angelin, 1854]).

The above three species groups are also present in telephinid collections from the Americas (Ulrich, 1930; Chatterton et al., 1999; Whittington, 1965). In the Asian region, almost all specimens are of *T. bicuspis/fracta* type, carrying no or poorly incised glabellar furrows and showing considerable variation in glabellar length and fixed cheek width as seen in the following: Fortey (1997), Thailand; Burrett et al. (1983), Tasmania; Lu (1975), Zhou and Dean (1986), Peng et al. (2001), Tripp et al. (1989), Yin et al. (2000), Zhou et al. (1984), Zhou et al. (2001), China; Koroleva (1982), Ghobadi Pour et al. (2011), Kazakhstan. Peng et al. (2001) reduced the number of Chinese species and proposed sexual dimorphs with variably developed glabellar tubercles for *T. longicephala* Lu (1975). Zhou et al. (2001) figured a form similar to *T. granulata*.

North American species of Telephina.—Given the small

collection size of southern Appalachian telephinids (a few hundred specimens total), it is probable that Ulrich’s (1930) fifteen *Telephina* species are oversplit. Ulrich (1930) himself repeatedly noted how close his species were to European forms: “Under the circumstances, I am persuaded that the apparent difference between the American and European species rests on imperfect observation” (Ulrich, 1930, p. 3).

Many of the named North American telephinids are indistinguishable from each other or from foreign species of similar age. Age, morphologic similarity and probable pelagic habit suggest that the three defined species ‘groups’ (Ahlberg, 1995) have merit and are distributed widely. Most North American species of *Telephina* are assigned below to the above three groups and discussed in the following systematic section.

Group one forms in North America strongly resembling *Telephina bicuspis* (Angelin, 1854): *Telephina pustulatus* (Ulrich, 1930) (probably conspecific, with a free cheek spine and expanded fixed cheek identical to *T. bicuspis*), *T. gelasinosa* (Ulrich, 1930) and *T. americana* (Billings, 1865). *Telephina gelasinosa* and *T. americana* have narrower fixed cheeks and the

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528286; 17–25, *Telephina granulata* (Angelin) originally described as *Telephus bicornis* Ulrich from the “Whitesburg formation near Bland, Virginia”: 17, cranium, dorsal view, $\times 3$, USNM 80535-f, original of Ulrich (1930, pl. 4, fig. 7); 18, free cheek and eye, lateral view, $\times 3.5$, USNM 80535-a, original of Ulrich (1930, pl. 4, fig. 1); 19, cranium, dorsal view, $\times 4$, USNM 80535-b, original of Ulrich (1930, pl. 4, fig. 3); 20, cranium, dorsal view, $\times 4.5$, USNM 80535-d, original of Ulrich (1930, pl. 4, fig. 5); 21, cranium, dorsal view, $\times 4.4$, USNM 80535-g, original of Ulrich (1930, pl. 4, fig. 8); 22, pygidium, dorsal view, $\times 5$, USNM 80535-j, original of Ulrich (1930, pl. 4, fig. 12); 23, cranium, dorsal view, $\times 5$, USNM 80535-h, original of Ulrich (1930, pl. 4, fig. 9), here designated lectotype of *Telephina bicornis* (Ulrich); 24, cranium, dorsal view, $\times 3.5$, USNM 80535-i, original of Ulrich (1930, pl. 4, fig. 11); 25, segment, dorsal view, $\times 5$, USNM 80535-k, original of Ulrich (1930, pl. 4, fig. 14); 26, bedding plane with several species: A, *Mesotaphraspis* sp.; B, *Ampyxina* sp.; C, *Telephina prattensis*, $\times 7$, USNM 528288. All specimens from Pratt Ferry except for USNM 80535 a-k, which were collected from the “Whitesburg formation near Bland, Virginia” by Ulrich.

former has thicker anterior cephalic spines as well as pustular glabellar ornament. Owen and Bruton (2012) describe a poorly preserved *Telephina* of this type from the middle Katian of Maine, which may be the youngest occurrence in North America.

Group two forms in North America strongly resembling *Telephina mobergi* (Hadding, 1913): *Telephina prattensis* and *T. tellicoensis*, (both Ulrich, 1930).

Group three forms in North America strongly resembling *Telephina granulata* (Angelin, 1854): *Telephina bicornis* (Ulrich, 1930).

TELEPHINA GELASINOSA (Ulrich in Butts, 1926)

Figure 3.1–3.5

- 1926 *Telephus gelasinus* ULRICH in Butts, 1926, pl. 19, figs. 1, 2.
 1930 *Telephus gelasinus* ULRICH, p. 26, pl. 7, figs. 12–14.
 1930 ?*Telephus impunctatus* ULRICH, p. 33, pl. 5, fig. 10–15.
 1986 *Telephina convexa* LU ZHOU AND DEAN, p. 752, pl. 58, fig. 11, pl. 59, figs. 1, 4.
 1997 ?*Telephina convexa* LU FORTEY, p. 42, pl. 5, figs. 16, 17.

Description.—Only cranidia certainly known. Cranidial appearance similar to *T. bicuspis* (Angelin, 1854) but with thicker anterior cranidial border spines and narrower fixed cheeks (glabellar width at maximum fixed cheek width a ratio of 4:1 compared to *T. bicuspis* (at 2:1). Smooth ‘muscle attachment areas’ easily seen on the glabella, glabella relatively parallel sided with no clear ‘glabellar depressions’ (usage of Ahlberg, 1995). Remaining glabellar surface tuberculate, with no evidence of extended spines or lirae. Anterior border spines large and ventrally directed. Thorax, hypostome, free cheek and pygidium not known in the Pratt Ferry material.

Material.—Three cranidia, two in the USNM collections (holotype cranidium is USNM 71468) and one newly collected, are all from the Pratt Ferry beds.

Remarks.—One of the USNM specimens, contrary to Ulrich’s statement, shows most of the occipital ring, but no occipital spine. However, the case could be as in Ahlberg’s figure (1995, pl. 2, fig. 8) where the spine base is poorly developed on the internal mold. Cranidia have been described from eastern Asia (*T. convexa* Lu, 1975; Zhou et al., 1984; Yin et al., 2000; Zhou et al., 2001; Zhou and Dean, 1986; Fortey, 1997) and the British Isles by Rushton et al. (1996). Some of these specimens are assignable to *Telephina gelasinosa*, particularly the Zhou and Dean material, which shows thick anterior cranidial spines and an almost identical age to the Appalachian specimens.

Telephina impunctata (Ulrich, 1930) has narrowed fixed cheeks but thinner anterior spines and an occipital spine which prevent definite assignment here.

Telephina americana (Billings, 1865) (Whittington, 1965) also has relatively narrow fixed cheeks, a *gelasinosa*-type glabellar outline and lacks an occipital spine. However, it possesses glabellar ornament of lirae, thinner anterior spines and the genal spines are unlike any found in the Pratt Ferry beds. *Telephina mysticensis* (Ulrich, 1930) is probably a synonym of *T. americana* as its only specific character is a slight difference in glabellar ornament.

TELEPHINA PRATTENSIS (Ulrich, 1930)

Figure 3.6–3.14, 3.16, 3.26

- 1930 *Telephus prattensis* ULRICH, p. 34, pl. 3, figs. 16–19.
 1930 *Telephus bilunatus* ULRICH, p. 39, pl. 6, figs. 8, 9.
 1930 *Telephus transversus* ULRICH, p. 37, pl. 6, figs. 20, 21.
 1930 *Telephus buttsi* ULRICH, p. 40, pl. 5, fig. 16.
 1930 ?*Telephus bipunctatus* ULRICH, p. 31, pl. 5, figs. 1–9.

Lectotype.—Here selected as the best of Ulrich’s syntypes; partial cranidium figured by Ulrich (1930, pl. 3, fig. 16), USNM 80541.

Description.—Glabellar length (excluding occipital ring) two-thirds maximum glabellar width. Glabellar outline smoothly rounded anteriorly, unlike ‘pear shape’ or sub-triangular glabella of *T. mobergi* (Hadding, 1913). Fixed cheek sub-triangular, expanded anteriorly, maximum width about one-third of maximum glabellar width. Many specimens with cranidial ornament of raised wrinkles, rather than the granular or pustulose surface in many specimens of *T. bicuspis* (Angelin, 1854) and *T. gelasinosa* (Ulrich, 1930). These are the ‘lirae’ described by Bruton and Høyberget (2006) for a range of species, including some Scandinavian specimens of *T. bicuspis*. Lirae thus are not a species character. One pair of glabellar furrows or ‘dents’ at about one-half glabellar length, depth of impression variable but always visible. Anterior border spines well developed but thinner than in *T. gelasinosa*. Occipital spine present at posteriormost edge of occipital ring, full length not visible. Associated free cheek spines present, but disarticulated, oriented horizontally, and at least twice as long as eye surface. Spine surface ornament of distinctive chevron pattern. Associated eye size and granular free cheek ornament (Fig. 3.18) suggests assignment to this species rather than to *T. gelasinosa* (Ulrich, 1930). Eye lens arrangement in ‘squares’ as remarked upon by Fortey (1997). No well-preserved telephinid pygidia have been recorded from the Pratt Ferry beds. Ulrich did assign pygidia from other localities to various telephinid species. However, with the possible exception of *Telephus bicornis* Ulrich (1930) from the Whitesburg Formation none of these are definitely assignable to a particular species.

Material.—About 10 cranidia are present in the various collections from Pratt Ferry, together with three fragments of eyes and free cheeks. The above synonymized species bring the total to about 70 specimens

Remarks.—The relatively short sub-trapezoidal glabella and ornament type are strongly reminiscent of *T. mobergi* (Hadding, 1913), which is described widely from Scandinavia. However, the present species has a more evenly rounded glabella and lacks the posterolateral bulge or expansion of the *T. mobergi* glabella. The two species appear closely related. Compared to *T. bicuspis* (Angelin, 1854), the glabella tapers more anteriorly, and the anterolateral corners of the fixed cheek are relatively expanded. ‘Glabellar depressions’ (presumably S1) are well marked on all individuals. Chatterton et al. (1999) and Ahlberg (1995) both commented that the glabellar depressions (S1), although distinctive, are variably developed and less impressed in large specimens of *Telephina*.

The Ulrich species in the synonymy are included for the following reasons: *Telephina bipunctata* has an identical glabellar shape and furrow position. It has deeper glabellar furrows and was described primarily from the Whitesburg Formation, not the Pratt Ferry beds. *Telephina bilunatus* is fragmentary and crushed but shows somewhat similar glabellar details, except that the glabellar furrows are distorted. *Telephina transversus* and *T. buttsi* are both crushed, the former so badly that the anterior glabellar spines stick straight forward. Their glabellar details and occipital spine, however, look close to *T. prattensis*.

All the Ulrich species and the newly collected material have a glabellar length/width ratio of about 0.6, within the range (0.5–0.7) for *T. mobergi* given by Ahlberg (1995). They also show identically developed S1 (‘glabellar depressions’). Maximum glabellar width to maximum fixed cheek width ratio of 2 (Wg/Wf of Ahlberg, 1995) is similar to Ahlberg’s Swedish *T. mobergi* material. Overall glabellar shape is thus the main distinction between *T. mobergi* and *T. prattensis*.

Telephina norvegica, *T. intermedia*, and *T. sulcata* as described by Hansen (2009, pl. 24) have slightly less anterior taper to the glabella than *T. mobergi* and strongly resemble the Pratt Ferry specimens. The Appalachian species may belong to one of these other Scandinavian species. It also is possible that the Scandinavian species are oversplit, as they are very difficult to differentiate using the descriptions and photos currently available. *Telephina troedssoni* (Raymond, 1925), as Ulrich noted, is too poorly preserved to assign.

Telephina convexa Lu (1975), originally and as later described by Zhou and Dean (1986); Peng et al. (2001), and Yin et al. (2000) shows expanded anterolateral free cheeks. None of the figures, however, show the degree of glabellar taper or S1 impression typical of *T. mobergi* (Hadding, 1913).

TELEPHINA GRANULATA (Angelin, 1854)

Figure 3.17–3.25

- 1854 *Telephus granulatus* ANGELIN, p. 91, pl. 41, fig. 21.
 1930 *Telephus bicornis* ULRICH, p. 23, pl. 4, figs. 1–14.
 1995 *Telephina granulata* (Angelin), AHLBERG, p. 273, pls. 4, 5, 6 (pars.) (See for additional synonymy.)
 1995a *Telephina granulata* (Angelin), AHLBERG, p. 51, fig. 2C–2H.

Neotype.—A cranidium (PMO 72698) from the Vollen Formation (Ampyx limestone), Oslo, Norway. Selected from material of *Telephina (Telephops) bos* Nikolaisen by Ahlberg (1995).

Other material.—From North America, *Telephus bicornis* Ulrich (1930) is represented by about 10 cotypes in the USNM collections. Partial cranidium USNM 80535h (the best of Ulrich's cotypes, 1930, pl. 4, fig. 9) is here selected as lectotype (Fig. 3.23). *Telephina granulata* (Angelin, 1854) has not been identified in the Pratt Ferry trilobite fauna, but comments and figures are included here to complete the discussion of *Telephina* in the southern Appalachians. The known material consists of Ulrich's (1930) cotypes from "the Whitesburg limestone 5 miles southwest of Bland, Virginia". This locality is about ten miles northeast along strike from the well-known Porterfield Quarry section (Harris et al., 1979; Ruppel and Walker, 1977). Much of the succession in this area is slightly younger than the Pratt Ferry beds (Bergström, 1990; Carlucci and Westrop, 2012). *Telephina granulata* is also slightly younger than most other species in the Baltic region (Ahlberg, 1995).

Remarks.—Ulrich (1930, p. 24) compared his new species *T. bicornis* to *T. granulata* (Angelin, 1854), noting close similarities. Although commenting that deformation might be a factor, he erected a new species on the basis of fixed cheek outline, glabellar convexity, and tubercle arrangement. His figures, although slightly retouched, are accurate. Most notable is the presence of the impressive genal spine, and an attributed pygidium. Both of these features correlate closely to the new figures by Ahlberg (1995a, 1995b) for *T. granulata*. The morphology and even stratigraphic position suggest strongly that the two species are synonymous.

Pärnaste and Popp (2011) revived the subgenus *Telephops* Nikolaisen, based on new material from Estonia. They note that several varieties of this form can be distinguished by variation in the glabellar spine position. The Appalachian form most closely mirrors the *T. granulata* spine position. It is also closest to *T. granulata* in age. *Telephina* cf. *longicephala* Lu (1975) (Zhou et al., 2001) and *Telephina (Telephops)* cf. *bicornis* (Ulrich, 1930) (Romano and Owen, 1993) possess distinctive paired glabellar spines and are close to *Telephina granulata* (Angelin, 1854). Peng et al (2001) proposed sexual dimorphism for *T. longicephala* Lu in collections where only some individuals show large glabellar

tubercles. Zhou et al. (2001) figured *T. aff. biseriata* (Asklund, 1936) with very large spine bases in the center of the glabella. However, the figured specimen shows no glabellar furrows and the spine base is in a different position from *T. biseriata*.

TELEPHINA BICUSPIS (Angelin, 1854)

Figure 4.8, 4.12–4.15

- 1854 *Telephus bicuspis* ANGELIN p. 91, pl. 41, fig. 22, 22a.
 1930 *Telephus pustulatus* ULRICH, p. 28, pl. 3, figs. 1–10.
 1930 ?*Telephus latus* ULRICH, p. 26, pl. 3, figs. 13, 14.
 1930 ?*Telephus spiniferus* ULRICH, p. 29, pl. 3, fig. 11.
 1930 ?*Telephus sinuatus* ULRICH, p. 30, pl. 3, fig. 15.
 1995 *Telephina bicuspis* (Angelin) AHLBERG, p. 264, pl. 1, figs. 1–13; pl. 2, figs. 1–12 (see for additional older synonymy).
 2006 *Telephina bicuspis* (Angelin) BRUTON AND HØYBERGET, p. 359.
 2009 *Telephina bicuspis* (Angelin) HANSEN, p.132.

Neotype.—A partial cranidium figured and selected by Thorslund (1935) as a probable Angelin (1854) cotype from Oslo. Horizon and locality not certain, but probably from the *Ogygiocaris* Shale (see Ahlberg, 1995, p. 265).

Other material.—From North America, approximately 5 cranidia from the Whitesburg Formation of Virginia (Ulrich, 1930).

Remarks.—The glabellar outline is rounded in dorsal view, without pronounced glabellar furrows or pits in the adult. The glabellar surface shows smooth areas interpreted as muscle scars. Cephalic ornament is predominantly pustular, although some specimens show 'wrinkled' networks (lirae). The fixed cheek is expanded anterolaterally in dorsal view, maximum width one-half glabellar width. The free cheek spine figured by Ulrich for *Telephus pustulatus* (1930, pl. 3, fig. 8, not from Pratt Ferry) is directed dorsally (Fig. 4.12) as is characteristic for *T. bicuspis* (Bruton and Høyberget, 2006). This peculiar spine is here taken as the principal species characteristic for *T. bicuspis*. Spine details are not known for the other three Ulrich species in the synonymy but the available cephalic details match closely.

Emphasis on this striking genal spine also raises important taxonomic problems for European species in which genal spines are not well described. For instance, Hansen (2009) did not give genal spine details in his descriptions, and Ahlberg (1995) included very few spine descriptions. Thus, many of the European forms assigned to *T. bicuspis* may be other closely related species with non-vertical genal spines (e.g., Ahlberg, 1995, pl. 1, fig. 13). Ahlberg (1995) analyzed over 100 specimens of this species and described considerable variation in glabellar width, fixed cheek width, and degree of tuberculation. Glabellar depressions were described from smaller specimens, becoming effaced in larger individuals.

Given this variability and the closely similar age of the American and Scandinavian collections, Ulrich's (1930) various Appalachian species listed above are judged to be junior synonyms of *Telephina bicuspis* (Angelin, 1854). The glabellar length width ratio for *T. bicuspis* ranges from 0.7–0.9. The fixed cheek width (0.5) is similar. All of Ulrich's above-synonymized species fall in this range and have no other distinguishing characters. The Ulrich species listed above were described from fewer than ten specimens. Nearly all were described as from the Whitesburg Formation or close equivalents in Virginia and Alabama at or near the base of the Athens shale. None is known from the Pratt Ferry beds. Bergström (1973, p. 276) noted that, in the type Whitesburg section, the *Pygodus serrus*–*Pygodus anserinus* zonal boundary is somewhere in the upper half of the

Whitesburg Formation if not higher. This puts the Whitesburg telephiniids close in time to the Pratt Ferry fauna.

Chatterton et al. (1999) described *Telephina calandria* and *T. chingolo* from, respectively, the Arenig and Llanvirn of western Argentina. Both species show some variation in impression of S1 (glabellar depression of Ahlberg, 1995) and width of the fixed cheek. None show the distinctive vertical librigenal spine but are otherwise quite similar to the *T. bicuspis* group. A further puzzle is the Arenig age of *T. calandria*, which makes it about the same age as *Oopsites* Fortey (1975), the presumed ancestral genus of *Telephina*.

Telephina twelvetreesi Burrett et al. (1983) from Tasmania, and *T. convexa* Lu from Thailand (Fortey, 1997), and multiple Chinese localities (Lu, 1975; Peng et al., 2001; Zhou and Dean, 1986; Tripp et al., 1989; Yin et al. 2000) are similar to *T. bicuspis*. Likewise, *T. omega* and *T. stepnjakensis* Koroleva, 1982 are very like *T. bicuspis* (Ghobadi Pour et al., 2011). Koroleva also listed a number of additional specimens. From her figures, some belong to the *Telephina mobergi* group. In sum, there seems to be a relatively conservative, widespread lineage of *T. bicuspis*-type forms from *T. calandria* Chatterton et al. (1999) (Arenig) to *T. fracta* (Barrande, 1852) (Ashgill).

TELEPHINA TELLICOENSIS (Ulrich, 1930)

Figure 4.1–4.7, 4.9–4.11

1930 *Telephus tellicoensis* ULRICH, p. 35, pl. 6, figs. 10–19, pl. 7, figs. 10, 11.

1930 *Telephus hircinus* ULRICH, p. 38, pl. 7, figs. 1–9.

Material.—About 10 specimens and fragments, all from the lower part of the “Tellico formation” near Knoxville, Tennessee. Lectotype here selected as the best of Ulrich’s syntypes (Fig. 5.3, 5.4), USNM 80532A, original of Ulrich (1930; pl. 6, fig. 13).

Remarks.—*Telephina tellicoensis* (Ulrich, 1930) shares most of the cranial details of *T. prattensis* (Ulrich, 1930) except that the glabellar furrows are not present or faint. In addition, there are two posterolaterally projecting genal spines on each free cheek which are not present in other Appalachian *Telephina*.

Some of the Norwegian cranidia figured by Hansen (2009) approach *T. tellicoensis* and *T. prattensis* in having a rounded glabella and anterolaterally expanded fixed cheeks (i.e., *T. bicuspis*, pl. 24, fig. 2, fig. 15; *T. viriosa*, pl. 24, fig. 17) but lack of genal spines renders exact comparison impossible.

Telephina hircinus (Ulrich, 1930) is badly crushed, with the anterior spines distorted to project anteriorly. However, it shares all characteristics (including the genal spines) with *T. tellicoensis* and is from the same formation and locality.

FAMILY ENCRINURIDAE Angelin, 1854

Genus BEVANOPSIS Cooper, 1953

Type species.—*Bevanopsis ulrichi* Cooper, 1953, from the Edinburg Formation of Virginia.

Remarks.—The genus occurs over a wide geographic range. Beyond the detailed descriptions of silicified Virginia material by Evitt and Tripp (1977), there are a few specimens noted from Girvan (Tripp, 1993) and western Canada (Ludvigsen, 1979). Cooper (1953) noted that *Bevanopsis* is similar to *Cybeloides* Slocum, but lacks the longitudinal trilobation of the glabella, and possesses narrower interpleural regions on the pygidium.

BEVANOPSIS BUTTSI (Cooper, 1953)

Figure 5.1–5.4, 5.6–5.9

1953 *Cybeloides buttsi* COOPER, p. 32, pl. 13, figs. 15–17.

Holotype.—Crushed cranidium with partial attached thorax (USNM 116483c) from “just below Athens shale, near Pratt’s Ferry”. However, the plate description lists the locality of the

holotype as “Little Oak limestone, Pelham, Alabama”. Also, the same species is called *Bevanopsis buttsi* (Cooper, 1953, table 1, p. 44).

Description.—The cranidia are internal molds but show four pairs of tubercles sagittally along the glabella, the posteriormost pair about opposite the inner end of S2. The typical glabellar pit is located between the anterior two pairs of tubercles. On one specimen there is a diamond-shaped cluster of smaller pustules anterior to the pit, similar to those of *B. thor* (Ludvigsen, 1979). Fixed cheek details unclear, except that part of the typical strong eye ridge is present.

Visual surface of free cheek not seen, remainder of cheek lightly and uniformly pitted, rolled border with sparse tubercles (5–7). Hypostome as described by Evitt and Tripp (1977), including a central area of tubercles and wrinkles on the median body.

Pygidium also as earlier described by Evitt and Tripp (1977), with four posterior pleural bands well-developed (cybelinid usage of the Treatise; Whittington, 1997, fig. 54, not that of Evitt and Tripp, 1977, fig. 15 which is mislabeled). However, the anterior bands are very broad and flat (about four times wider than posterior bands) divided by a low median ridge.

Other material.—From Pratt Ferry, six partial cranidia, three free cheeks, three hypostomes, five pygidia.

Remarks.—The new Pratt Ferry specimens lack the complex tuberculation of *Bevanopsis ulrichi* Cooper (1953) from Virginia (Evitt and Tripp, 1977) but fall within the range of variation described for the Virginia material. However, the anterior bands on the pygidium are wider on the Pratt Ferry specimens, approaching the arrangement in *Stiktocybele* Ingham and Tripp (1991). In contrast, the anterior bands in that genus are broad and smooth, having no central ridge as in the present specimens. *Stiktocybele* also lacks the paired glabellar tubercles of *Bevanopsis*. The Pratt Ferry beds are older than the Edinburg Formation (Bergström, 1990, fig. 8). Thus *B. buttsi* is probably the oldest *Bevanopsis*, with a distinctive pygidium.

Two other species have been described, *B. phyllisae* Tripp (1993) and *B. thor* (Ludvigsen, 1979). The first lacks the anterior glabellar pit, and the last shows a tuberculate knob on the occipital ring, setting both forms well apart from the type species.

FAMILY CHEIRURIDAE Hawle and Corda, 1847

Subfamily CHEIRURINAE Hawle and Corda, 1847

Genus CERAURINELLA Cooper, 1953

Type species.—*Ceraurinella typha* Cooper, 1953, Edinburg Formation, Virginia.

Remarks.—Edgecombe et al. (1999) most recently discussed the genus, describing a new species found in *Nemagraptus gracilis* age rocks in Argentina. Pygidia assigned to *Ceraurinella* show variable development of the second and third pleural spines, variation in pleural furrow impression and variation in first pleural spine curvature in dorsal view. In addition, in some but not all species, the first pleural spines are upturned from the base in lateral view, while the other lesser spines are not.

CERAURINELLA BUTTSI Cooper, 1953

Figure 5.12–5.15, 5.17, 5.18

1953 *Ceraurinella buttsi* COOPER, p. 330, pl. 11, fig. 14, ?pl. 12, fig. 9.

1926 *Ceraurina glabra* BUTTS, p. 79, pl. 39, fig. 16.9, non *Chirus glaber* ANGELIN (fide Cooper, 1953).

Holotype.—Partial cranidium, USNM 116474a, Pratt Ferry beds, Pratt Ferry, Alabama.

Material.—Seven fragmentary cranidia, two pygidia, five hypostomes.

Remarks.—The principal difference from *C. typha* Cooper (1953) and *C. chondra* Whittington and Evitt (1954) lies in S2,

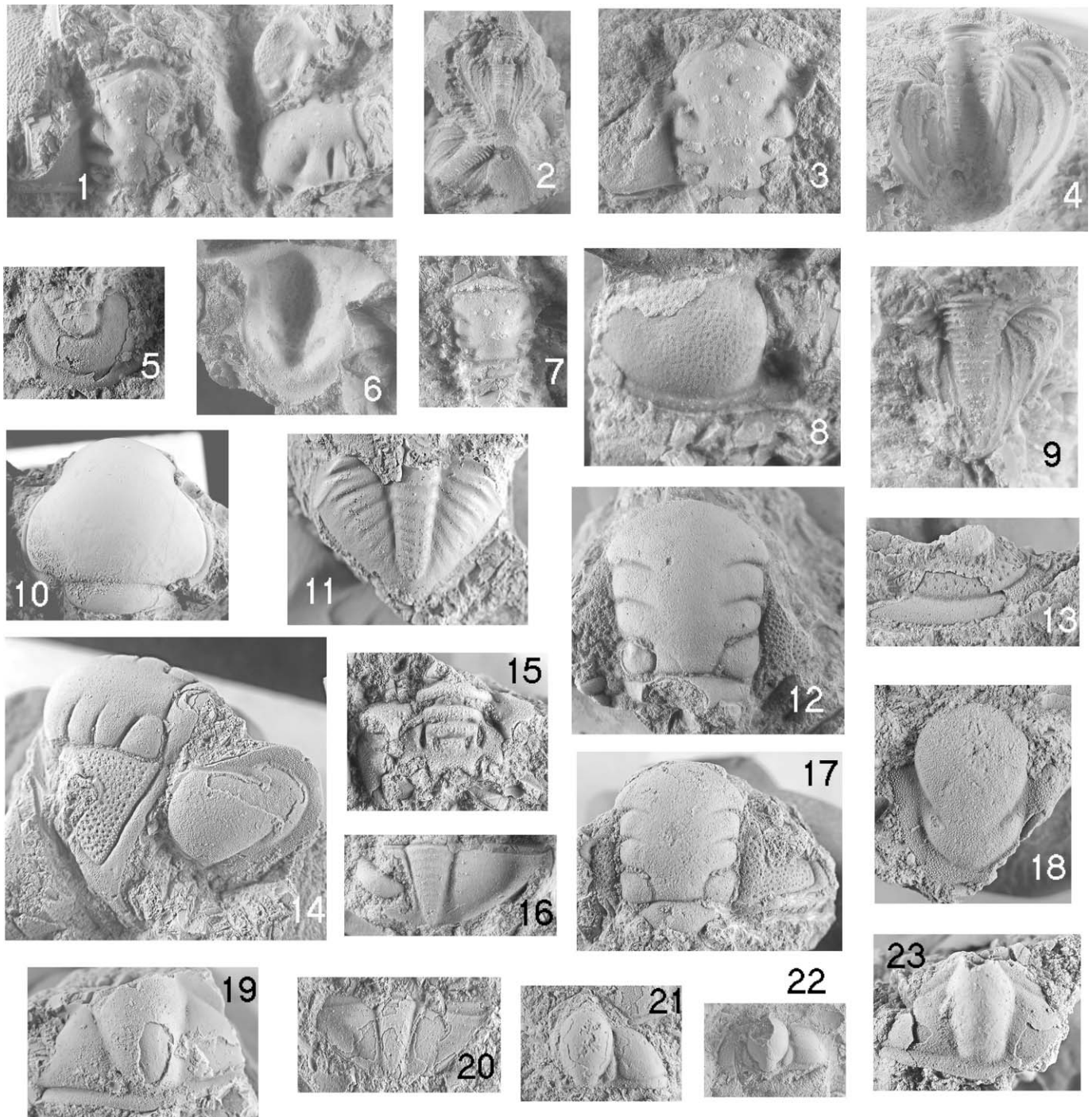


FIGURE 5—1–4, 6–9, *Bevanopsis buttsi* (Cooper): 1, cranidia, dorsal and left lateral views, hypostome, ventral view, $\times 2.8$, USNM 528290; 2, two pygidia, dorsal and anterodorsal views, $\times 2.8$, USNM 528291; 3, cranidium, dorsal view, $\times 2.8$, USNM 528292; 4, pygidium, internal mold, ventral view, $\times 3.7$, USNM 528295; 6, hypostome, dorsal view, $\times 4.6$, USNM 528297; 7, cranidium, dorsal view, $\times 5.5$, USNM 528293; 8, free cheek, left lateral view, $\times 4.6$, USNM 528294; 9, pygidium, internal mold, dorsal view, $\times 6.4$, USNM 528296; 5, *Arthrorhachis* sp., pygidium dorsal view, $\times 7$, USNM 528303; 10, *Remopleurides* sp., cranidium, dorsal view, $\times 2$, USNM 71472; 11, *Calyptaulax* sp. pygidium, dorsal view, $\times 4$, USNM 528522; 12–15, 17, 18, *Ceraurina buttsi* Cooper: 12, cranidium, dorsal view, $\times 3.7$, USNM 71471a; 13, free cheek, right lateral view, $\times 4$, USNM 528300; 14, cranidium and hypostome, left elevated and ventral views, $\times 2.8$, holotype, USNM 71471b; 15, pygidium, dorsal view, $\times 4$, USNM 528302; 17, cranidium, dorsal view, $\times 2.8$, USNM 528299; 18, hypostome, ventral view, $\times 4$, USNM 528298; 16, 19, 20, 23, *Lonchodomas politus* Raymond: 16, pygidium, dorsal view, $\times 4$, USNM 528520; 19, cranidium, dorsal view, $\times 2.8$, USNM 528289; 20, pygidium, dorsal view, $\times 5.5$, USNM 528306b; 23, cranidium, dorsal view, $\times 4.6$, USNM 528521; 21, 22, *Ampyxina* sp.: 21, cranidium, dorsal view, $\times 4$, USNM 528305; 22, cranidium, dorsal view, $\times 4$, USNM 528304.

which is longer (tr.) and more parallel to S1 in *C. buttsi*. However, the Pratt Ferry material is not silicified and largely exfoliated. *Ceraurus* in the Chazy Group and the Mingan Formation shows precisely these preservational influences on S1 and S2 within a

single species (Shaw, 1968, pl. 15, figs. 16, 23 vs. figs. 12, 13; Shaw and Bolton, 2011). The pygidia of *C. tupa* and *C. chondra* differ in the arc of the primary spines in dorsal view. The spines are more strongly bent in *C. chondra* and appear similar to *C.*

latipyga Shaw (1968) from the Chazy Group of New York. However, spine arc is not preserved in the Pratt Ferry specimens.

ADDITIONAL PRATT FERRY TRILOBITES

Cooper (1953) noted other rare trilobite fragments from Pratt Ferry. Additional fragments were also collected during this study. Insufficient material is available for a systematic treatment, but it is listed here to support the paleoecologic generalizations above. Some specimens are figured here as noted.

Additional Pratt Ferry trilobites noted by Cooper (1953).—Porterfieldia caecigenus (Raymond). Cooper (1953, pl. 2, fig. 8). A single cranidium.

Lonchodomas politus Raymond. Cooper (1953, p. 19; Fig. 5.16, 5.19, 5.20, 5.23).

Calliops declivis Ulrich and Delo. Cooper (1953, p. 35. pl. 15, figs. 8, 9). Cranidium and pygidium.

Newly collected Pratt Ferry material.—Hibbertia sp. Abundant fringe fragments.

Ampyxina sp. Two fragmentary cranidia, abundant pygidia. (Figs. 3.26, 5.21, 5.22). Cranidium similar to *Ampyxina elegans* Cooper, 1953, having a short glabella and small basal lobes.

Calyptaulax sp. One partial cranidium and a pygidium. Probably the same as *C. declivis* above (Fig. 5.11).

Arthrorhachis sp. One pygidium. Also mentioned by Cooper (1956) (Fig. 5.5).

Sphaerexochus sp. One fragmentary glabella.

Mesotaphraspis sp. One cranidium. (Fig. 3.26). Unidentifiable rare illaenid, asaphid and remopleurid (Fig. 5.10) fragments.

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