TELEPHINID TRILOBITES FROM THE ORDOVICIAN OF SWEDEN

by PER AHLBERG

ABSTRACT. Twelve telephinid trilobite species, all assigned to the genus *Telephina*, from the Middle and Upper Ordovician of Sweden are described or discussed. In Sweden, the genus appears in equivalents of the uppermost *Didymograptus murchisoni* Biozone and ranges into the late Ashgill or Harjuan (Jerrestadian Stage), where only one species, *T. wegelini*, is present. The others are restricted largely to strata belonging to the *Hustedograptus teretiusculus* and *Nemagraptus gracilis* biozones. In Baltoscandia, telephinid trilobites are commonest in fine-grained rocks west of the Central Baltoscandian Confacies Belt, and they seem to have occupied relatively peripheral sites on the continental plate of Baltica.

THE Telephinidae Marek, 1952 includes small- to medium-sized, micropygous trilobites with large eyes and short (tr.) pleurae. They are characteristic elements of many Ordovician faunas, and range upwards into the pre-Hirnantian Ashgill. It is generally agreed that they were adapted to a pelagic mode of life (e.g. Fortey 1975, 1981, 1985).

The earliest reference to telephinid trilobites from the Ordovician of Sweden is by Angelin (1854), who described *Telephina wegelini* from the Upper Ordovician of the Siljan district in Dalarna, central Sweden. Subsequently, additional material of this species was described from the Upper Ordovician Fjäcka Shale at various localities in this area (Linnarsson 1871, p. 350; Törnquist 1884, p. 89). During the latter half of the nineteenth century, telephinids were also reported from the island of Öland, southern Sweden, and Jämtland, central Sweden (Linnarsson 1872; Tullberg 1882; Moberg 1890; Wiman 1893; Holm 1897). Later Hadding (1913*a*) gave a valuable review of *Telephus* Barrande, 1852 (= *Telephina* Marek, 1952) and described all species known at the time, including four from Scandinavia. Subsequently further collecting resulted in an increased number of specimens from various horizons and localities in Sweden (e.g. Funkquist 1919; Warburg 1925; Thorslund 1935, 1948; Asklund 1936; Nilsson 1951; Nikolaisen 1963; Jaanusson 1960, p. 226; 1964, table 3; 1982*b*, p. 177). This paper focuses on the taxonomy and distribution of telephinids of Sweden, and includes an examination of all available museum material.

GEOLOGICAL SETTING

Ordovician sedimentary rocks are widely distributed in Baltoscandia (see Jaanusson 1976, p. 300, and Bruton *et al.* 1985 for brief reviews). The deposits belong to two distinct tectonic settings: the thick and largely siliciclastic sequences of the allochthonous Caledonides, and the generally much thinner autochthonous platform successions south and south-east of the Caledonides. The platform deposits accumulated in extensive belts, which maintained fairly constant litho- and biofacies characteristics throughout most of the post-Tremadoc Ordovician (Männil 1966; Jaanusson 1973). These distinct, composite belts were termed confacies belts by Jaanusson (1976, p. 308), and their approximate boundaries are shown in Text-figure 1.

The Central Baltoscandian, North Estonian and Lithuanian confacies belts consist predominantly of a variety of limestones with rich shelly faunas, whereas the western belts are developed mainly in graptolitic shale facies (Scanian Confacies Belt) or as mudstone with lenses or beds of limestone and some shale (Oslo belts and Lower Allochthon of Jämtland). Opinions differ as to the depth of deposition within the confacies belts. It is generally agreed, however, that the arrangement of the

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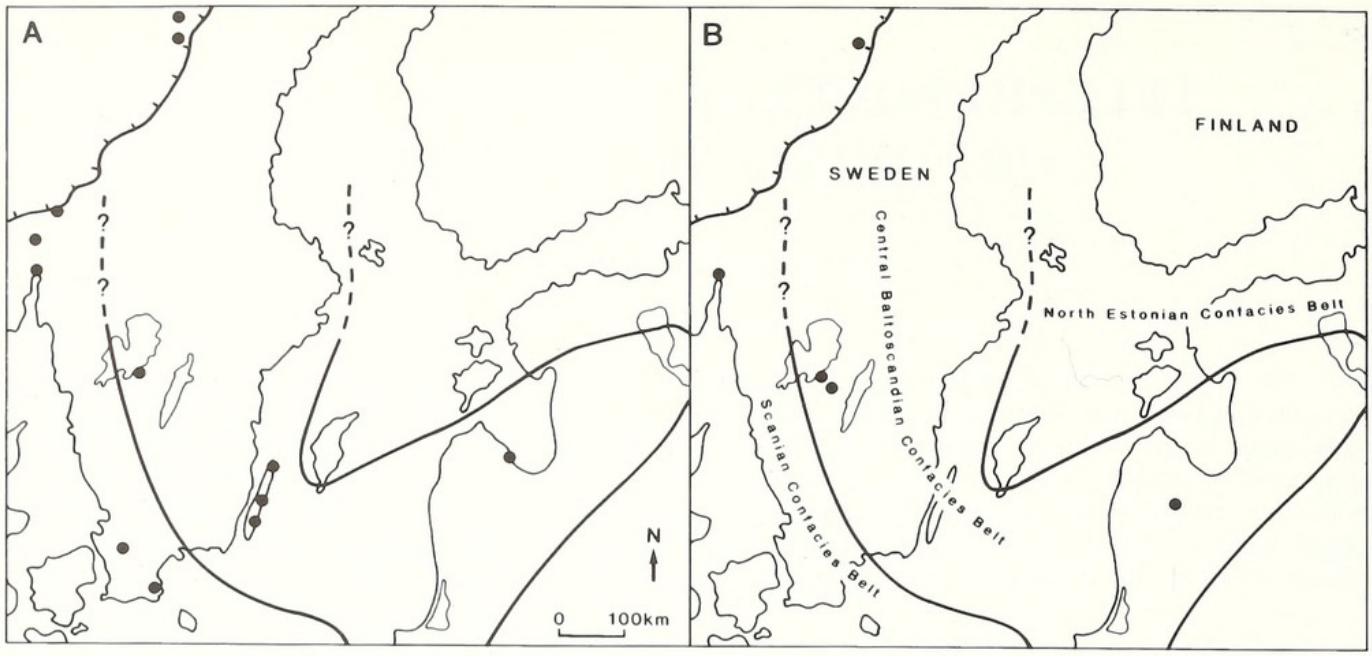


TEXT-FIG. 1. Maps of confacies belts in Baltoscandia (after Jaanusson 1976, text-fig. 7; 1982*a*, fig. 2), and the distribution of telephinid trilobites (black dots) in the uppermost *Didymograptus murchisoni* and *Hustedograptus teretiusculus* biozones (A) and the *Nemagraptus gracilis* Biozone (B). The boundaries between the confacies belts fluctuated to some extent, and the development of calcareous mudstones on Kinnekulle in Västergötland, south-central Sweden, can be regarded as an influence from the prevailing facies in the Oslo Region, Norway. The ticked line indicates the Caledonian Front.

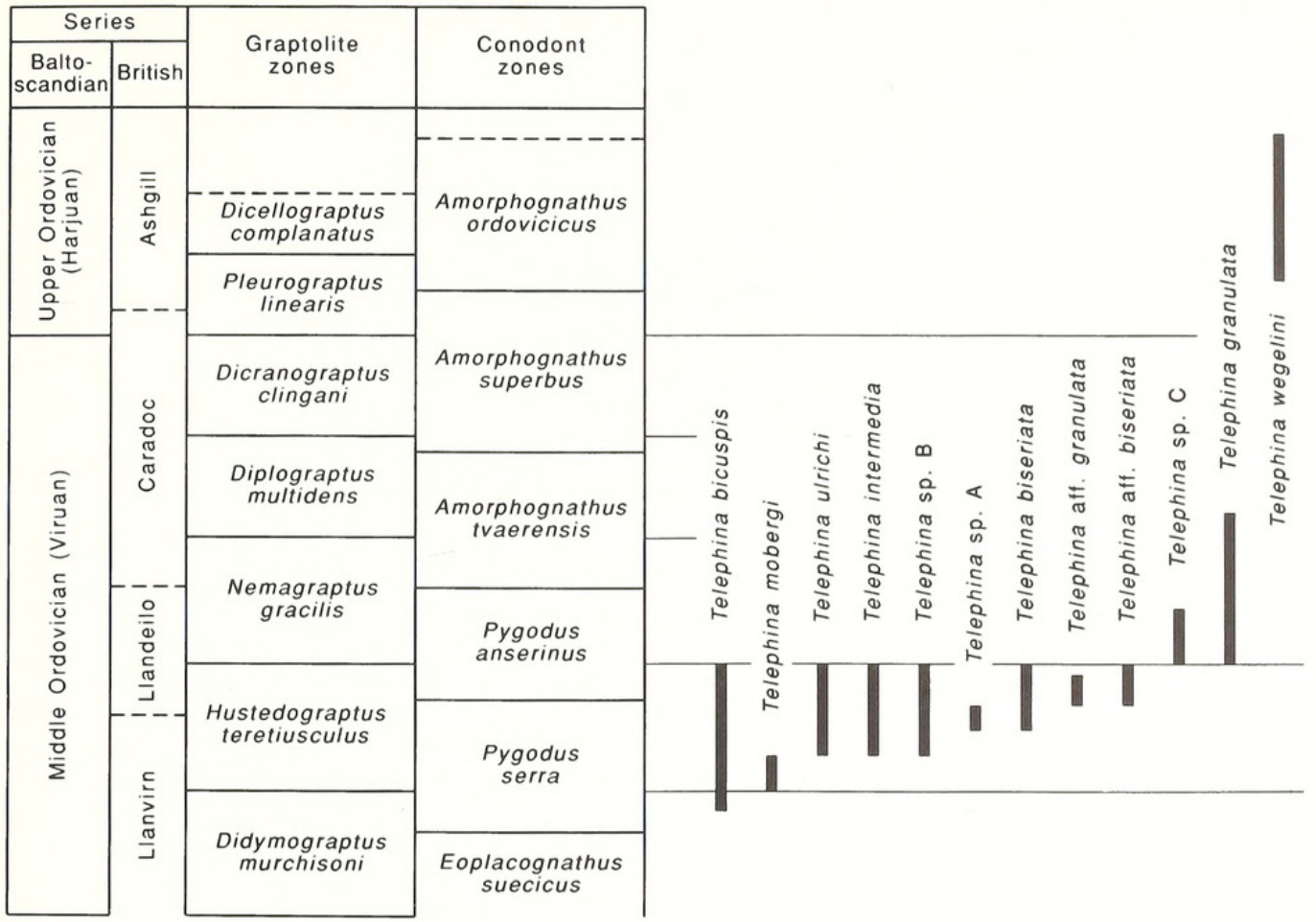
belts reflects an overall westward deepening (Jaanusson 1976, p. 309; Bruton *et al.* 1985, p. 274), but, as noted by Jaanusson (1976), this was not constant.

DISTRIBUTION

The *Telephina* species described herein range from equivalents of the uppermost *Didymograptus murchisoni* Biozone to the late Ashgill or Harjuan (Jerrestadian Stage), where only one, *T. wegelini* (Angelin, 1854), is present. The remainder are restricted largely to strata corresponding to the biozones of *Hustedograptus teretiusculus* or *Nemagraptus gracilis* (Text-fig. 2). These trilobites are confined largely to shales, mudstones, or fine-grained limestones, and they are frequently associated with graptolites. With respect to the distribution in relation to the confacies belts, it is worth noting that they are most common in those west of the Central Baltoscandian Confacies Belt (Text-fig. 1). Thus, telephinid trilobites are also characteristic elements in many Middle Ordovician faunas from the Oslo Region, Norway (see Nikolaisen 1963), and the Lower Allochthon in Jämtland, central Sweden. With respect to biofacies, the Ordovician of the Oslo Region shares several features with the Lower Allochthon in Jämtland, and several species are common to the two areas. These include *Telephina bicuspis* (Angelin, 1854), *T. intermedia* (Thorslund, 1935), *T. mobergi* (Hadding, 1913*a*), and *T. granulata* (Angelin, 1854).

Rare specimens are also known from Scania (Skåne), southern Sweden, which include an indeterminate specimen (*Telephina* sp. A), from the graptolitic shales (*Hustedograptus teretiusculus* Biozone) at Röstånga in western Scania, and *Telephina* aff. *granulata*, from the Killeröd Formation of southeastern Scania.

Telephinids are generally very rare in the Central Baltoscandian Confacies Belt. A notable exception is the occurrence of *T. bicuspis* in the Middle Ordovician Folkeslunda Limestone of Öland. This unit consists largely of grey calcarenites and is mostly rich in macrofossils (Jaanusson 1960). Telephinids have also been recorded from the Gullhögen, Ryd and Dalby formations in Västergötland in this confacies belt (Jaanusson 1964), where they are restricted largely to fine-



TEXT-FIG. 2. Approximate ranges of telephinid trilobites in the Middle and Upper Ordovician of Sweden. Many specimens in older collections are only vaguely localized with respect to the stratigraphy, and for most species the ranges shown are tentative. Stratigraphy slightly modified after Jaanusson (1982*a*, fig. 2).

grained limestones or mudstones. The appearance of telephinids in the Middle Ordovician of Västergötland seems to be related to brief eastward shifts of the general facies of the Oslo Region (Jaanusson 1964, p. 53; 1973, p. 21; 1982*b*, p. 168). Within the Central Baltoscandian Confacies Belt, rare specimens of *Telephina* are also known from drill cores in western Latvia (Männil 1963), and the Pskov district of western Russia. No telephinids are known from the North Estonian and Lithuanian confacies belts.

In North America, *Telephina* species have been recorded only from the Appalachian orogenic belt. The oldest forms are from the Llanvirn of the northern part (western Newfoundland and southern Quebec). In the southern and central Appalachians of the USA, *Telephina* is widely distributed in beds equivalent to the *Hustedograptus teretiusculus* and *Nemagraptus gracilis* biozones. Analysis of the distribution of shelly faunas and conodonts in this area has revealed a differentiation into three Middle Ordovician confacies belts (Jaanusson and Bergström 1980). Ulrich (1930, p. 47) noted that 'in the Appalachian Valley remains of *Telephus* are confined to areas in the eastern half of the valley', that is, to the Blount Confacies Belt of Jaanusson and Bergström (1980), and this is confirmed by the available evidence (V. Jaanusson, pers. comm. June 1993). The faunas of the Blount Belt are closely similar to those of northeastern Ireland and the Girvan district of southwestern Scotland (Jaanusson and Bergström 1980, p. 102). The latter area has also yielded telephinids, such as *Telephina girvanensis* (Reed, 1935) and *T. subsecuta* (Reed, 1944). These species were redescribed by Tripp (1976). In Baltoscandia, the closest equivalent to the Blount Belt is the Central Baltoscandian Confacies Belt, but the Blount Belt also includes analogues of the Oslo belts and the Scanian Confacies Belt (Jaanusson and Bergström 1980, p. 100).

In conclusion, most species of *Telephina* appear to be restricted to sequences situated fairly peripherally on the continental plates, at least in Baltica and in Laurentia. The lack of *Telephina* on the Siberian Platform supports this view.

SYSTEMATIC PALAEONTOLOGY

The terminology used herein in general follows that of Harrington *et al. in* Moore (1959), except that the terms rachis and dorsal furrow are preferred to axis and axial furrow. The glabella is taken to exclude the occipital ring and furrow. The palpebral area of the fixigena is between the palpebral furrow and the dorsal furrow.

Illustrated and cited specimens are deposited in the type collections of the Geological Survey of Sweden, Uppsala (SGU), the Department of Historical Geology and Palaeontology, University of Lund (LO or LR), the Palaeontological Museum, Oslo (PMO), the Palaeontological Museum, University of Uppsala (PMU), and the Swedish Museum of Natural History, Stockholm (RM). All specimens were painted with matt black opaque and then lightly coated with a sublimate of ammonium chloride prior to being photographed. Dorsal views are shown unless stated otherwise in the captions.

Measurements were made with a micrometer eyepiece fitted in a binocular microscope. All dimensions were measured as straight-line distances. The accuracy of all measurements is to 0·05 mm. Estimated values and transverse measurements arrived at by doubling the width from the sagittal line are indicated with a question mark. The following symbols are used for measured parameters: Lc, length (sag.) of cephalon (excl. occipital spine and anterior pair of spines); G, length (sag.) of glabella; Lo, length (sag.) of occipital spine; Wc, maximum width (tr.) of cranidium; Wg, maximum width (tr.) of glabella; Wf, maximum width (tr.) of fixigena (incl. palpebral lobe).

Family TELEPHINIDAE Marek, 1952

Diagnosis. See Fortey 1975, p. 94.

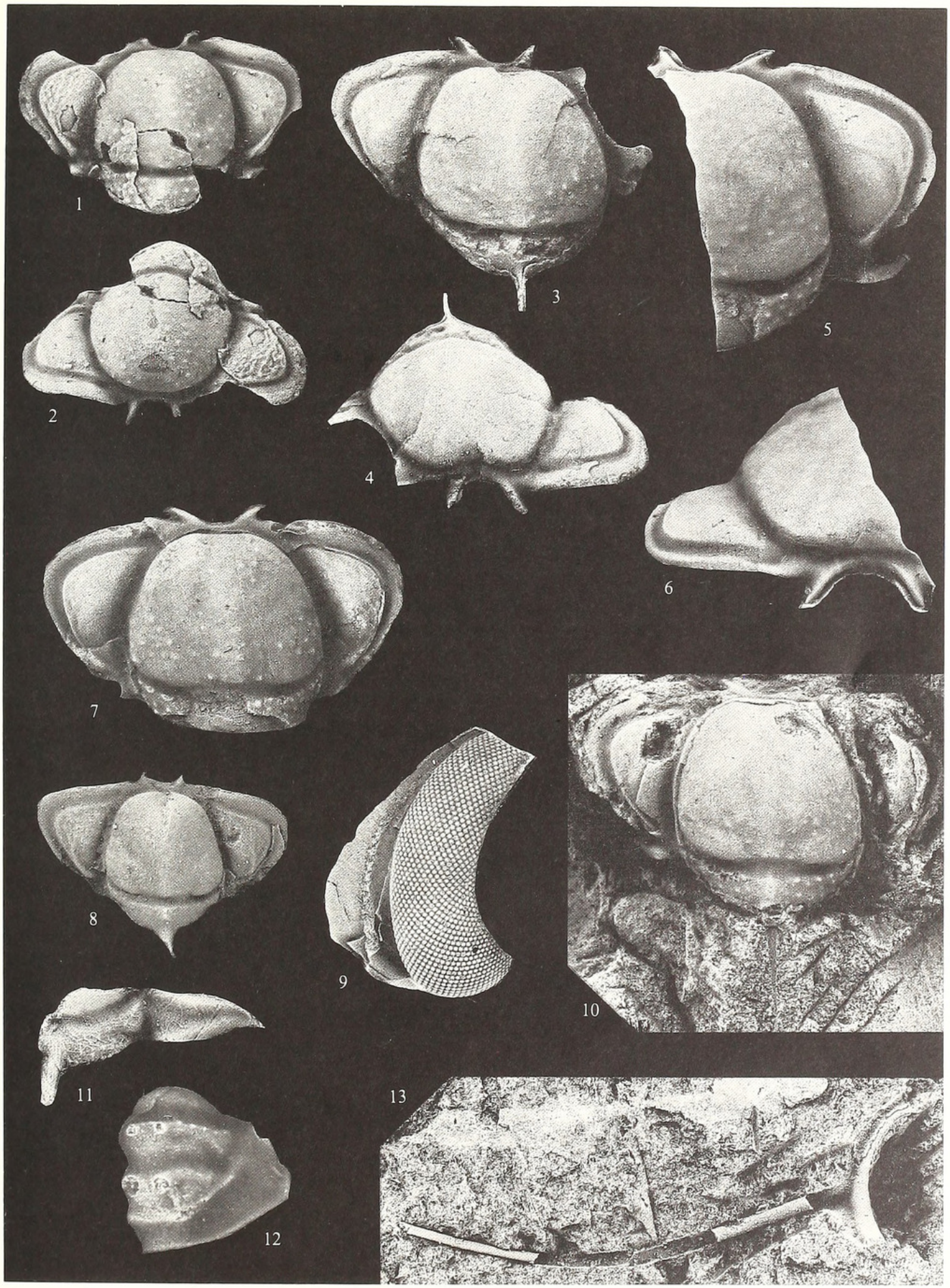
Remarks. The concept of the family Telephinidae was discussed comprehensively by Fortey (1975), and his definition and discussion cover all important aspects.

Genus TELEPHINA Marek, 1952

Type species. Telephus fractus Barrande, 1852 (p. 890, pl. 18, figs 30–34), from the Králův Dvůr Formation (Ashgill) at Králův Dvůr, Bohemia; by original designation.

EXPLANATION OF PLATE 1

Figs 1–13. *Telephina bicuspis* (Angelin, 1854). All specimens except 1–2 and 13 are from the lower Andersö Shale (*Hustedograptus teretiusculus* Biozone) on the northwestern shore of Andersön, Jämtland (locality 1 of Hadding 1912, pl. 7A, 1913*b*, fig. 12). 1–2, neotype, RM Ar 37315; dorsal and anterodorsal views; Oslo, Norway; original of Thorslund (1935, pl. 2, figs 1–2); ×8. 3–4, LO 2566t; cranidium in dorsal and anterior views; original of Hadding (1913*a*, pl. 1, fig. 4); coll. A. Hadding 1912; ×7. 5–6, LO 2544t; cranidium in dorsal and anterior views; original of Hadding (1913*a*, pl. 1, fig. 1*a–d*); coll. A. Hadding 1912; ×6. 7, LO 2565t; cranidium; original of Hadding (1913*a*, pl. 1, fig. 3*a–b*); coll. A. Hadding 1912; ×7·5. 8, SGU 8637; cranidium; coll. P. Thorslund 1949; ×7. 9, LO 6701t; incomplete librigena; coll. A. Hadding 1912; ×5. 10, LO 2564t; cranidium; original of Hadding (1913*a*, pl. 1, fig. 2); coll. A. Hadding 1912; ×7·5. 11, LO 2546t; incomplete thoracic tergite; original of Hadding (1913*a*, pl. 1, fig. 6); coll. A. Hadding 1912; ×7. 12, LO 2547t; incomplete pygidium, latex cast from external mould; original of Hadding (1913*a*, pl. 1, fig. 7); coll. A. Hadding 1912; ×13. 13, SGU 6687; incomplete librigena in ventral view; Ö. Ottsjön, Föllinge area, Jämtland; original of Thorslund (1935, pl. 2, fig. 6); coll. P. Thorslund 1934; ×5.



AHLBERG, *Telephina bicuspis*

Diagnosis. Telephinid trilobites with wide (tr.) glabella, tapering forward and broadly rounded to truncate in front. Cranidial anterior border narrow (tr.), distally turned downward to form a pair of spines; width of anterior border (between lateral extremities of spines) less than half the width (tr.) of occipital ring. Posterior border short (tr.). Librigenae with very large crescentic eyes and generally long genal spines. In addition to genal spines, one or two pairs of marginal librigenal spines may be present. Pygidial rachis with two rings, that may bear paired spines or tubercles, and short (sag.) terminal piece. Dorsal surface generally tuberculate, especially on glabella and occipital ring, and commonly with a pattern of fine, raised lines on the external exoskeletal surface. Glabella with three or four pairs of smooth muscle attachment areas.

Remarks. The earliest representatives of *Telephina* appear near the base of the Llanvirn. The genus underwent prolific radiation during the Middle Ordovician and ranges upwards into the pre-Hirnantian Ashgill. The origin of the genus was discussed by Fortey (1975), who showed that it was probably derived from a species of the early Ordovician genus *Oopsites* Fortey, 1975.

Species attributed to *Telephina* appear to have a distinctive arrangement of the glabellar muscle attachment areas. The posterior pair is generally prominent, transversely elongate, and situated immediately in front of the outer ends of the occipital furrow. The second area is larger, composite, and situated generally at about half the length of the glabella. The anterior sets are generally indistinct, small, and situated fairly close to the dorsal furrows. The inner, posterior part of the fixigena is commonly smooth, kidney-shaped, and slightly vaulted, and this area may also be a muscle attachment area (cf. Whittington 1965, p. 369; Fortey 1975, p. 100).

Nikolaisen (1963) proposed the subgenus *Telephina* (*Telephops*), with *T. granulata* (Angelin, 1854) as type species, for those species with a pair of spines or horns on the glabella. In most other characters, the type species of this subgenus is like the type and other species of *Telephina* (*Telephina*), and I am inclined to the view that the presence or absence of glabellar spines is not of subgeneric significance, because in many evolving trilobite lineages spines can be ephemeral characters. A metalibrigenal spine appears to be present in most species referable to *Telephina* (*Telephops*). A corresponding spine may, however, also be present in species attributed to *Telephina* (*Telephina*). Thus, I follow Tripp (1976, p. 376) and regard *Telephina* (*Telephops*) as a synonym of *Telephina* (*Telephina*).

Telephina bicuspis (Angelin, 1854)

Plate 1, figures 1–13; Plate 2, figures 1–12

*1854	*Telephus bicuspis* Angelin, p. 91, pl. 41, figs 22 and 22*a*.
v.*1882*	*Telephus* sp.; Tullberg, p. 233.
v.*1890*	*Telephus bicuspis* Ang,; Moberg, p. 16.
v.1897	*Telephus bicuspis* Ang.; Holm, p. 463 [*partim*].
v.1913*a*	*Telephus bicuspis* Ang.; Hadding, pp. 33–35, pl. 1, figs 1–7.
v.1913*b*	*Telephus bicuspis* Ang.; Hadding, pp. 75–76, pl. 8, figs 1–4 [copies of Hadding's (1913*a*, pl. 1, figs 1*a–c*, 5*b*–7) original figures].
v.1930	*Telephus haddingi* Ulrich, pp. 12–13, pl. 1, figs 11–18 [copies of Hadding's (1913*a*, pl. 1, figs 2–7) original figures].
v.1930	*Telephus jamtlandicus* Ulrich, p. 13, pl. 1, figs 8–10 [copies of Hadding's (1913*a*, pl. 1, fig. 1*a–d*) original figures].
.1930	*Telephus bicuspis* Angelin; Ulrich, p. 12, pl. 2, figs 20–21 [copies of Angelin's (1854) original figures].
v.1935	*Telephus bicuspis* Ang.; Thorslund, pp. 20–21, 60, pl. 2, figs 1–6.
v.1954	*Telephus bicuspis* Angelin; Kobayashi, pl. 6, fig. 1*a–c* [drawings of Hadding's (1913*a*, pl. 1, figs 1, 5–7) specimens].
.1963	*Telephina* (*Telephina*) *bicuspis* (Angelin, 1854); Nikolaisen, pp. 364–367, pl. 1, figs 1? and 2–10.
.1963	*Telephina* (*Telephina*) *furnesensis* Nikolaisen, pp. 367–368, pl. 1, fig. 11.
.1963	*Telephina* (*Telephina*) aff. *furnesensis* Nikolaisen, p. 360, fig. 4.

.1963 *Telephina* (*Telephina*) *norvegica* Nikolaisen, pp. 373–375, pl. 3, figs 1–2.
1975 *Telephina bicuspis* Hadding; Fortey, p. 95.

Neotype. A nearly complete cranidium (RM Ar37315; Pl. 1, figs 1–2), figured and selected by Thorslund (1935, pl. 2, figs 1–2). The specimen is from Oslo, Norway, and it may be Angelin's (1854) original (cf. Holm 1897, p. 463; Thorslund 1935, p. 21; Nikolaisen 1963, p. 365). The horizon is not precisely known, but it comes probably from the Engervik Member of the Elnes Formation (Ogygiocaris Shale or $4a\alpha_3$ of earlier usage).

Additional material. About one hundred cranidia, four eyes, three librigenae, one thoracic tergite, and one pygidium from Jämtland, and fifteen cranidia from Öland.

Emended diagnosis. Cranidium wide (length/width ratio 1·0:1·6–1·8). Glabella and occipital ring distinctly tuberculate. Anterior end of glabella broadly rounded to truncate with a slight backward curvature medially. Fixigenae wide (tr.) and subtriangular. Palpebral area with narrow, raised rim along postero-lateral margin. Anterior border relatively wide (width between lateral extremities of spines 0·4–0·5 times that of occipital ring). Pygidium wide with broadly rounded posterior margin.

Description. Length of cranidium (sag.; excl. occipital spine) 0·55 to 0·65 times the width, and widest along a transverse line passing through the anterior half of the glabella. Glabella highly convex (tr.), tapering forward, broadly rounded to truncate anteriorly (or curved slightly backwards medially), and generally 0·80–0·85 times as long (sag.) as its maximum width. Anterior part of glabella steeply down-sloping to preglabellar furrow, which is tucked beneath the frontal convexity of the glabella. Occipital furrow deep, widest medially, and curved forward abaxially. Occipital ring with moderately long, posteriorly directed spine, and a prominent tubercle antero-medially. Fixigenae wide (tr.) and subtriangular. Palpebral area convex, strongly down-sloping laterally and antero-laterally, and with a narrow, raised rim or ridge postero-laterally. This rim extends parallel to the posterior part of the palpebral furrow. Palpebral lobe anteriorly slightly wider than posteriorly, depressed below the level of the palpebral area and separated from it by a well-defined palpebral furrow. Facial suture running forwards and outwards at about 30° to sagittal line from posterior border furrow, then curving strongly around lateral extremity of palpebral lobe to run inwards and slightly forwards. Anterior border distally turned downward to form a pair of spines, which is generally seen in dorsal view. Width (tr.) of anterior border (between lateral extremities of spines) 0·4 to 0·5 times that of occipital ring.

TABLE 1. Dimensions (in mm) of cranidia of *Telephina bicuspis*.

	Lc	G	Lo	Wc	Wg	Wf
LO 6703t	2·00	1·60	1·00?	3·20	1·55	0·95
RM Ar 37315	3·30	2·35	—	5·55	2·80	1·45
LO 2565t	4·10	3·00	—	7·15	3·90	2·15
LO 2564t	4·35	3·15	3·30?	7·35?	3·75	2·15
SGU 8641	4·50	3·30	—	7·30	3·75	2·15
LO 2566t	4·80	3·55	—	8·65?	4·45	2·55
SGU 8657	5·35	4·00	—	8·70	4·75	2·50
SGU 8658	6·20	4·45	—	11·25	5·55	3·35
SGU 8659	6·65?	4·70	—	10·65	5·60	2·85
LO 2544t	7·30	5·50	—	—	—	3·00
SGU 8642	8·00	5·75	—	13·25	6·60	3·60

Librigena with approximately semi-elliptical outer margin, and with long, slender and gently curved genal spine. Extraocular cheeks narrow, widest (tr.) at genal spine. Eye bounded on outer side by a deep furrow, outside which is a convex border.

Thoracic tergite with pointed pleura. Rachial ring nearly twice as wide (tr.) as the pleura, and with a posteriorly directed spine at posterior margin. Pleural furrows transverse and widest (exsag.) adaxially. Articulating furrow deep and curved backwards medially.

Pygidium semicircular to subtriangular in outline and about 1·6 times wider (tr.) than long (sag.; incl. articulating half-ring). Rachis highly convex (tr.), tapering backwards, and truncate to bluntly rounded posteriorly. Articulating furrow wide (sag.) and deepest laterally. Two rachial rings well defined by a wide and deep ring furrow. Rachial rings bear a prominent pair of tubercles or spines at mid-line. Terminal piece short (sag.) and steeply downsloping to short (sag.) postrachial field. Pleural region with narrow (tr.) horizontal area adaxially, steeply downsloping and concave laterally. Pleural furrows absent. Border very narrow.

The external exoskeletal sculpture consists of relatively widely spaced tubercles on the glabella and on the occipital ring, and a reticulate pattern of raised lines anteriorly and laterally on the palpebral area. Furthermore, well-preserved specimens show a pattern of fine, raised lines on the palpebral lobe and on the glabella. Four pairs of smooth muscle attachment areas are present on the glabella. The posteror pair is transversely elongate and situated immediately in front of the outer ends of the occipital furrow. A second area is considerably larger, composite, diagonally directed, and situated at about half-way along the length of the glabella. The two anterior sets are small and situated close to the dorsal furrows. A smooth, kidney-shaped, and vaulted area is present adaxially on the posterior part of the fixigena, and it may also represent a muscle attachment area.

Remarks. In the wide, arched anterior border and the wide fixigenae, *Telephina bicuspis* closely resembles the early Ordovician genus *Oopsites* Fortey, 1975 (cf. Fortey 1975, p. 95). On the other hand, the short (tr.) posterior border, the presence of an occipital spine and spines or prominent tubercles on the pygidial rachial rings, and the arrangement of the muscle insertion areas, suggest that it is best classified as a species of *Telephina.*

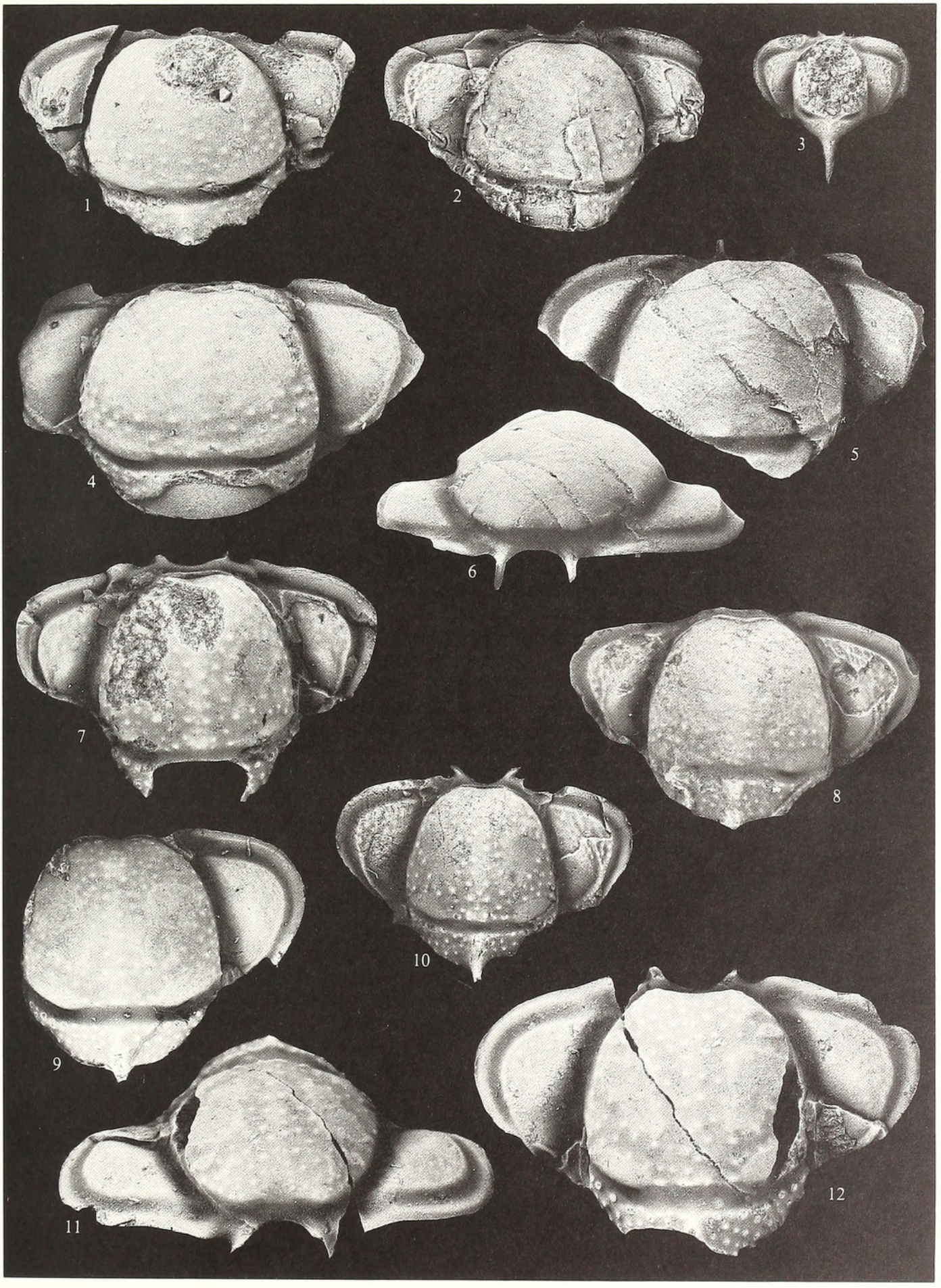
There is considerable variation exhibited by the material. Much of this variation, such as the expression of the tubercles, is due to varying degrees of flattening and to the mode of preservation. The width of the fixigenae and the shape of the glabella can, however, be shown to vary intraspecifically. The fixigena is 0·50 to 0·65 times as wide as the maximum width of the glabella. In dorsal view, the anterior end of the glabella ranges from broadly rounded to truncate with a slight backward curvature medially. In general, the front of the glabella is broadly rounded in juvenile specimens, whereas it tends to be truncate in mature ones. Small specimens also have a pair of shallow lateral depressions on the glabella that disappear during ontogeny, and they are generally effaced in cranidia longer (sag.) than 3·5 mm (cf. Nikolaisen 1963, p. 366). Well-preserved specimens exhibit cephalic muscle insertion areas (Pl. 2, figs 9, 11–12); their arrangement is similar to that of *T. americana* (Billings, 1865) (see Whittington 1965, p. 369, pl. 37, figs 5 and 18).

T. furnesensis Nikolaisen, 1963 and *T. norvegica* Nikolaisen, 1963, both from the middle Elnes Formation in the Mjösa area of Norway, agree in all essential features with *T. bicuspis* as described herein. Therefore, I regard them as subjective junior synonyms of *T. bicuspis.*

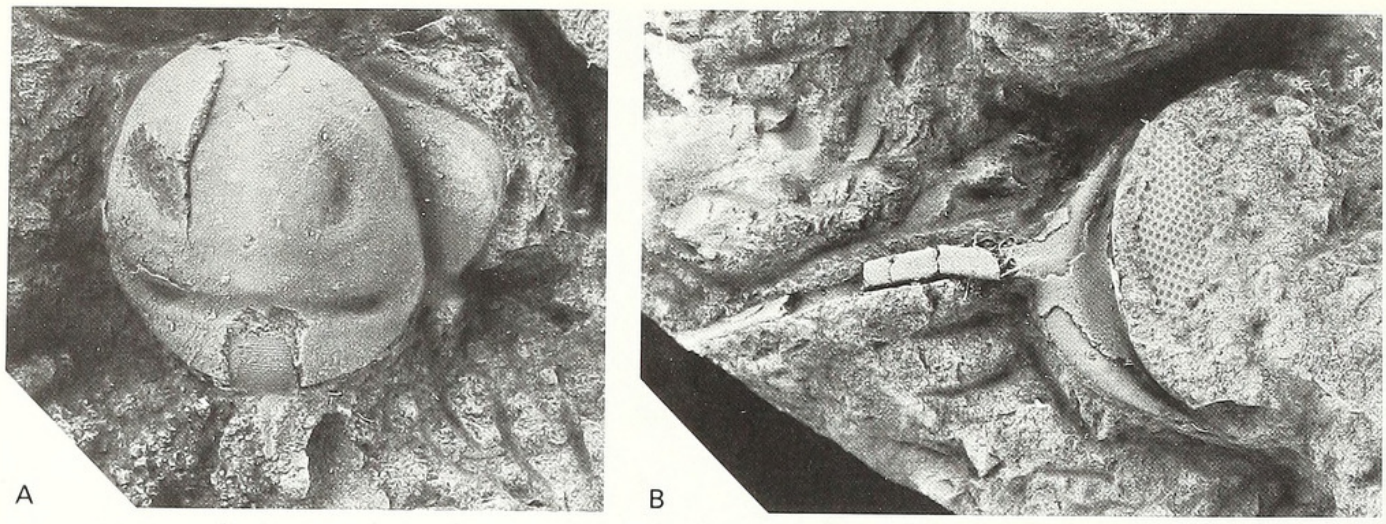
Occurrence. In Scandinavia, this species is known from the middle Elnes Formation ($4a\alpha_{1-2}$ and $4a\alpha_3$ of earlier usage; Owen *et al.* 1990) in the Oslo Region (Nikolaisen 1963, p. 366; Wandås 1984, p. 217), the lower Andersö Shale (Uhakuan Stage) in Jämtland, and the Folkeslunda Limestone (Lasnamaegian Stage) on Öland.

EXPLANATION OF PLATE 2

Figs 1–12. *Telephina bicuspis* (Angelin, 1854). Lower Andersö Shale, section in Raftan rivulet, Föllinge area, Jämtland (1, 5–6), lower Andersö Shale on the northwestern shore of Andersön, Jämtland (2–4), and the Folkeslunda Limestone of Öland (7–12). 1, SGU 6684; cranidium; original of Thorslund (1935, pl. 2, fig. 3); coll. P. Thorslund 1934; ×7. 2, LO 6702t; cranidium, latex cast from external mould; coll. A. Hadding 1912; ×7. 3, LO 6703t; small cranidium; coll. A. Hadding 1912; ×7·5. 4, LO 6704t; cranidium; ×7·5. 5–6, SGU 8638; cranidium in dorsal and anterior views; coll. P. Thorslund 1937; ×6. 7, SGU 8639; cranidium; Lerkaka, central Öland; coll. G. C. von Schmalensee 1881; ×6. 8, SGU 8640; cranidium; Slagerstad, southern Öland; coll. J. C. Moberg 1887; ×6. 9, RM Ar 23864; cranidium; Slagerstad, southern Öland; coll. J. G. Andersson 1892; ×5. 10, SGU 8641; cranidium; Lerkaka, central Öland; coll. G. C. von Schmalensee 1881; ×6·5. 11–12, SGU 8642; cranidium in dorsal and anterior views; Slagerstad, southern Öland; coll. J. C. Moberg 1887; ×5·5.



AHLBERG, *Telephina bicuspis*



TEXT-FIG. 3. *Telephina intermedia* (Thorslund, 1935). Lower Andersö Shale; *Hustedograptus teretiusculus* Biozone; Raftan rivulet, Föllinge area, Jämtland; coll. P. Thorslund 1934. A, holotype, an incomplete cranidium; original of Thorslund (1935, pl. 2, fig. 7) and Nikolaisen (1963, pl . 2, fig. 1); SGU 6688. B, nearly complete librigena; original of Thorslund (1935, pl. 2, fig. 8); SGU 6689. Both ×7·5.

In Jämtland, it is widely distributed in the lower Andersö Shale (*Hustedograptus teretiusculus* Biozone) and it has been collected from a large number of localities. These include, among others: (1) Ö. Ottsjön and a stream section of the Raftan rivulet in the Föllinge area (sections described by Thorslund 1935, pp. 6–9); (2) Andersön in the central Storsjön area (locality 1 of Hadding 1912, pl. 7A; 1913*b*, fig. 12); (3) the northern shore of Norderön in the central Storsjön area (see Thorslund and Jaanusson 1960, fig. 22); (4) Mellersta Utön in the central Storsjön area; (5) east of Övre Måläng, about 11 km SE of Sunne; (6) a road section (temporary exposure) at Borgen, 2–3 km NW of Oviken; and (7) a stream section 600 m NW of Abbåsen, about 4 km NNW of Oviken.

On Öland, the species is known from the Folkeslunda Limestone ('Centaurus limestone'; Moberg 1890) at: (1) Skärlöv, south of Hulterstad, southern Öland; (2) Slagerstad, south of Stenåsa, southern Öland; (3) Brunneby (drainage ditch east of the main road), north of Stenåsa, southern Öland; (4) Lerkaka, north of Runsten, central Öland; and (5) from a loose boulder at Stora Mossen, NNW of Böda, northern Öland.

A nearly complete cephalon of *T. bicuspis* is known from the lowermost Uhaku Stage in the Engure drill core (depth: 966·00 m) of western Latvia.

Telephina ulrichi (Thorslund, 1935)

Plate 3, figures 1–2

v*1935 *Telephus ulrichi* Thorslund, pp. 21–22, 60–61, pl. 2, figs 9–10.

Holotype. An internal mould of a nearly complete cranidium (SGU 6691; Pl. 3, fig. 1), illustrated by Thorslund (1935, pl. 2, fig. 10), from the lower Andersö ('Ogygiocaris') Shale, *Hustedograptus teretiusculus* Biozone, associated with *Botrioides efflorescens* (Hadding, 1913*b*), Ö. Ottsjön, Föllinge area, Jämtland (see Thorslund 1935, p. 6 for locality data).

Additional material. A largely exfoliated cranidium (SGU 6690; Pl. 3, fig. 2), illustrated by Thorslund (1935, pl. 2, fig. 9).

Dimensions of holotype (mm). Lc = 3·85; G = 2·75; Lo = 3·00; Wc = 5·00; Wg = 2·85; Wf = 1·35.

Diagnosis. See Thorslund (1935, pp. 21–22 and 60–61).

Remarks. Telephina ulrichi is closely comparable with *T. bicuspis* but differs in having a proportionately narrower and longer glabella, and narrower (tr.) fixigenae. Although the width of

TABLE 2. Dimensions (in mm) of cranidia of *Telephina mobergi*.

	Lc	G	Lo	Wc	Wg	Wf
LR 1	1·95	1·35	—	3·25	1·70	1·15
SGU 8643	2·60	1·85	1·35	4·90?	2·75	1·40
LO 2569t	3·20	2·25	—	5·10	3·05	1·45
LO 6705t	3·40	2·35	—	5·70?	3·50	1·50
SGU 8645	4·15	2·80	—	8·35	4·85	2·35
LO 2549t	5·40	3·85	—	—	5·15	—
LO 2568T	6·10	4·20	—	10·50?	6·75	2·80

the fixigenae is a variable feature in most species of *Telephina*, their width in *T. ulrichi* seems to fall outside the range of variation seen in *T. biscuspis*, and I regard them as two separate species. The glabella of *T. ulrichi* is subequal in length and width, whereas it is considerably wider than long in *T. bicuspis*. The occipital ring of *T. ulrichi* is comparatively long (sag.) with a long occipital spine. Tubercles are faintly indicated on the occipital ring and along the sagittal line of the glabella.

Occurrence. In addition to the type locality, known from the lower Andersö Shale in a section in the Raftan rivulet, Föllinge area, Jämtland (see Thorslund 1935, p. 7 for a locality description).

Telephina intermedia (Thorslund, 1935)

Text-figure 3

v*1935 *Telephus intermedius* Thorslund, pp. 22 and 61, pl. 2, figs 7–8.
1963 *Telephina* (*Telephina*) *intermedia* (Thorslund, 1935); Nikolaisen, pp. 369–370, pl. 2, figs 1–5.

Holotype. An incomplete cranidium (SGU 6688; Text-fig. 3A), illustrated by Thorslund (1935, pl. 2, fig. 7) and Nikolaisen (1963, pl. 2, fig. 1), lower Andersö ('Ogygiocaris') Shale, *Hustedograptus teretiusculus* Biozone, section in Raftan rivulet, Föllinge area, Jämtland (see Thorslund 1935, p. 7 for locality data).

Additional material. An incomplete librigena (SGU 6689; Text-fig. 3B), illustrated by Thorslund (1935, pl. 2, fig. 8).

Dimensions of holotype (mm). Lc = 5·10; G = 3·65; Wg = 4·70; Wf = 1·70?.

Diagnosis. See Thorslund (1935, pp. 22 and 61).

Remarks. In the outline and proportions of the individual parts of the cranidium, *Telephina intermedia* bears a strong similarity to *T. bicuspis*. The only difference observed is that *T. intermedia* has a pair of distinct depressions on the glabella. It is doubtful whether this is of specific significance, because such depressions are present in juvenile specimens of *T. bicuspis*, and may also be faintly indicated in adult specimens. Hence, *T. intermedia* may eventually prove to be a junior subjective synonym of *T. bicuspis*. For the time being, however, I treat it as a distinct species.

Occurrence. Outside the type locality, this species has been described from the middle–upper Elnes Formation in the Oslo Region of Norway (Nikolaisen 1963, p. 369).

Telephina mobergi (Hadding, 1913*a*)

Plate 3, figures 3–14

v*1913*a* *Telephus mobergi* Hadding, pp. 37–38, pl. 2, figs 12–17.

v.1913*b* *Telephus mobergi* Hadding; Hadding, p. 76, pl. 8, figs 6–8 [copies of Hadding's (1913*a*) original figures].
v.1917 *Telephus mobergi* Hdg; Isberg, pp. 593–596, pl. 6, figs 1–3.
v.1930 *Telephus mobergi* Hadding; Ulrich, pp. 14–15, pl. 2, figs 1–9 [copies of Hadding's (1913*a*) original figures].
.1963 *Telephina* (*Telephina*) *mobergi* (Hadding, 1913); Nikolaisen, pp. 371–373, pl. 2, figs 6–12.

Lectotype. An incomplete cranidium (LO 2568T; Pl. 3, fig. 7) figured by Hadding (1913*a*, pl. 2, fig. 13), selected and refigured by Nikolaisen (1963, pl. 2, fig. 6), lowermost Andersö ('Ogygiocaris') Shale, lower *Hustedograptus teretiusculus* Biozone, Andersön, Jämtland (locality 1 of Hadding 1912, pl. 7A, 1913*b*, fig. 12).

Additional material. Thirty-three cranidia, seven librigenae, ten fragmentary eyes, and five thoracic tergites. The specimens are preserved in a dark grey limestone or calcareous siltstone, and in general they are slightly compressed.

Emended diagnosis. Cranidium subrectangular in outline and wide (length/width ratio 1·0:1·6–2·0). Glabella strongly tapered forward, slightly pear-shaped in dorsal view, and with a pair of distinct, longitudinally elongated depressions. Glabella smooth. Anterior part of palpebral lobe wide, and directed along a nearly transverse line passing just in front of the glabella.

Description. Cranidium subrectangular in outline, about three-fifths as long as it is wide, and widest along a transverse line passing through the anterior part of the glabella. Glabella moderately convex, strongly tapered forward, broadly rounded anteriorly, slightly pear-shaped in dorsal view, and 0·6–0·8 times as long (sag.) as its maximum width (Table 2). Slightly posterior to the mid-length of glabella there is a pair of distinct, longitudinally elongated depesssions. Occipital furrow moderately deep and wide, curved forward abaxially. Occipital ring bears a moderately long, slender spine, posteriorly directed and with circular cross section. Fixigenae subtriangular and wide (tr.). Palpebral area convex and strongly downsloping anteriorly and laterally. It is widest (tr.) anteriorly, gradually narrowing backwards. Palpebral lobe widest anteriorly and directed forward and slightly outward from the posterior border furrow, then curved abruptly inward along a transverse line passing just in front of the glabella.

Librigena fairly wide with semicircular outer margin and very long spine, directed laterally. Extraocular cheeks and border widest at librigenal spine. Border convex (tr.).

Thoracic tergites with short (tr.), pointed pleurae. Pleural furrows transverse and widest (exsag.) adaxially. Rachial ring nearly twice as wide (tr.) as the pleura, and with a posteriorly directed spine at posterior margin.

Surface sculpture poorly known but appears to be smooth except for granules on the occipital ring and the thoracic rachial rings. In addition, a reticulate pattern of raised lines is present laterally and antero-laterally

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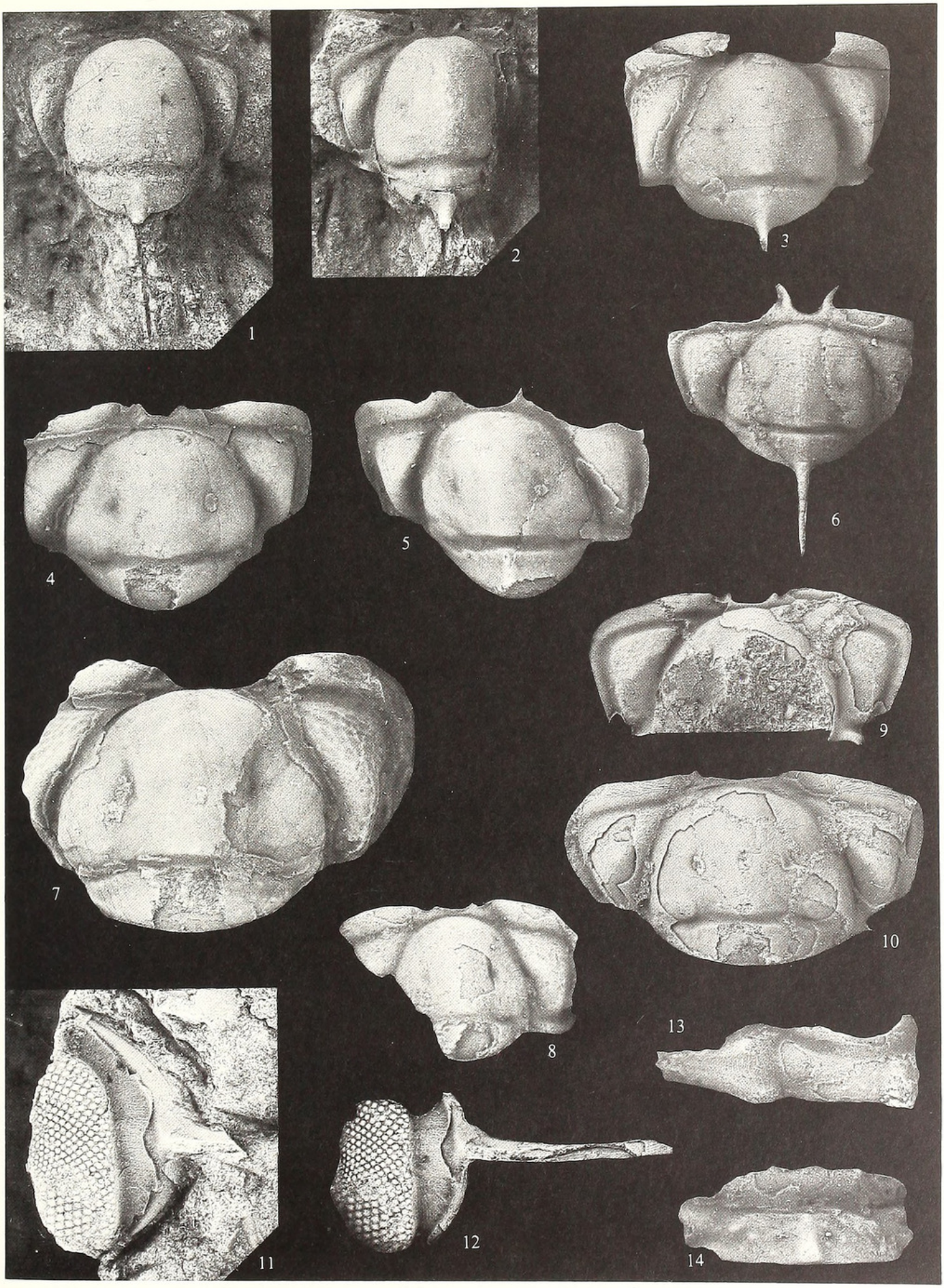
EXPLANATION OF PLATE 3

Figs 1–2. *Telephina ulrichi* (Thorslund, 1935); lower Andersö Shale; *Hustedograptus teretiusculus* Biozone; Jämtland; coll. P. Thorslund 1934. 1, holotype, SGU 6691; a nearly complete cranidium; original of Thorslund (1935, pl. 2, fig. 10); Ö. Ottsjön, Föllinge area; 2, SGU 6690; cranidium, internal mould; original of Thorslund (1935, pl. 2, fig. 9); Raftan rivulet, Föllinge area. Both ×7.

Figs 3–14. *Telephina mobergi* (Hadding, 1913*a*); lowermost Andersö Shale; lower *Hustedograptus teretiusculus* Biozone; northwestern shore of Andersön, Jämtland (3–5, 7–8, 11–14; coll. A. Hadding 1912), and Fagerdal, Jämtland (6, 9–10; coll. P. Thorslund and R. Skoglund 1961). 3, LO 2569t; cranidium; original of Hadding (1913*a*, pl. 2, fig. 14); ×8. 4, LO 6705t; cranidium; ×8. 5, LO 6706t; cranidium; ×8. 6, SGU 8643; cranidium; ×9. 7, lectotype, LO 2568T; an incomplete cranidium; original of Hadding (1913*a*, pl. 2, fig. 13) and Nikolaisen (1963, pl. 2, fig. 6); ×6. 8, LO 6707t; cranidium; ×8. 9, SGU 8644; cranidium; ×7. 10, SGU 8645; cranidium; ×7. 11, LO 2570t; incomplete librigena; original of Hadding (1913*a*, pl. 2, fig. 16), Isberg (1917, pl. 6, figs 2–3), and Nikolaisen (1963, pl. 2, fig. 8); ×6. 12, same librigena, latex cast from external mould; ×6. 13, LO 2550t; incomplete thoracic tergite; original of Hadding (1913*a*, pl. 2, fig. 17); ×8. 14, LO 6708t; incomplete thoracic tergite; ×8.



AHLBERG, *Telephina*

on the palpebral area, and transversely arranged terrace lines occur on the doublure of the occipital ring. Rare specimens exhibit a pattern of fine raised lines on the external exoskeletal surface and transversely elongate muscle attachment areas immediately in front of the outer part of the occipital furrow.

Pygidium not known.

Remarks. Telephina mobergi most closely resembles *T. sulcata* Nikolaisen, 1963, from the basal Elnes Formation (Helskjer Member; Owen *et al.* 1990, p. 17) in the Mjösa area, Norway, but *T. sulcata* has a considerably less tapered and nearly subrectangular glabella, and shorter (exsag.) lateral glabellar depressions (furrows).

T. bipunctata (Ulrich, 1930), from the Botetourt Formation (Caradoc; *Baltoniodus gerdae* Subzone; S. M. Bergström, pers. comm. 1992) of the southern Appalachians (Virginia), also invites comparison. In the proportions of the individual parts of the cranidium it is closely comparable with *T. mobergi*, but has deeper and more distinct lateral glabellar depressions, a strongly curved genal spine, and the external surface has a distinct pattern of raised lines and a more conspicuous muscle attachment area immediately in front of the occipital furrow. It must be emphasized, however, that the majority of the specimens ascribed to *T. mobergi* are largely exfoliated and the surface sculpture is poorly known.

Isberg (1917) described damaged and irregularly regenerated lenses in the eyes of *T. mobergi*.

Occurrence. In Sweden this species is known with certainty only from the type stratum and type locality, and from the lower Andersö Shale at Fagerdal (temporary exposure in the northern part of the village), about 8 km north of Hammerdal, Jämtland. Outside Sweden, the species has been described from the upper Elnes Formation (formerly Ogygiocaris Shale or $4a\alpha_3$) in the Oslo Region of Norway (Nikolaisen 1963, p. 371).

Telephina wegelini (Angelin, 1854)

Plate 4, figures 1–9

*1854	*Telephus wegelini* Angelin, p. 91, pl. 41, fig. 23.
v.*1884*	*Telephus fractus* Barr.; Törnquist, pp. 89–90 [remarks].
v.1913*a*	*Telephus wegelini* Ang.; Hadding, pp. 40–41, pl. 2, figs 18–19.
v.1925	*Telephus wegelini* Angelin; Warburg, pp. 90–92, pl. 1, figs 16–18.
.1930	*Telephus wegelini* Angelin; Ulrich, pp. 13–14, pl. 2, figs 10–12 [copies of Angelin's (1854, pl. 41, fig. 23) and Hadding's (1913*a*, pl. 2, figs 18–19) original figures].
v.1930	*Telephus linnarssoni* Ulrich, pp. 15–17, pl. 2, figs 15–17 [copies of Warburg's (1925, pl. 1, figs 16–18) original figures].
?1963	*Telephina* (*Telephina*) *wegelini* (Angelin, 1854); Nikolaisen, pp. 383–384.
non 1971	*Telephina* cf. *linnarssoni* (Ulrich); Dean, pp. 46–48, pl. 22, figs 1–2, 11.
?*1979*	*Telephina* sp.; Bruton and Owen, fig. 6.
?1980	*Telephina* sp.; Owen and Bruton, p. 11, pl. 1, fig. 9.

Type data. The holotype by monotypy (Angelin 1854, pl. 41, fig. 23) cannot be traced, and is considered lost. A nearly complete but flattened cranidium (LO 2571T; Pl. 4, fig. 5), figured by Hadding (1913*a*, pl. 2, fig. 18), is here selected as neotype. It was collected by S. L. Törnquist from the Fjäcka Shale (formerly black Tretaspis or Trinucleus shale; lower Ashgill) at Vikarbyn in the Siljan district, Dalarna (see Törnquist 1883, p. 58 for locality data).

Material. Fourteen cranidia from the Fjäcka Shale, and one cranidium from the Boda Limestone.

Remarks. Only cranidia of this species are known, and they show considerable variation due to varying degrees of flattening. For instance, the anterior border is clearly visible in dorsal view in strongly flattened specimens (Pl. 4, fig. 7), whereas it is tucked beneath the frontal lobe of the glabella in specimens retaining more of their original convexity (Pl. 4, fig. 8).

To the detailed description given by Warburg (1925, p. 90) it can be added that the occipital spine is long with a circular cross section (Pl. 4, fig. 2), and the posterior part of the palpebral area has

a distinct, kidney-shaped muscle insertion area. Furthermore, there is a narrow, raised ridge or rim along the postero-lateral margin of the palpebral area.

TABLE 3. Dimensions (in mm) of cranidia of *Telephina wegelini*. An asterisk indicates that the specimen is strongly flattened.

	Lc	G	Lo	Wc	Wg	Wf
LO 6709t	3·40	2·65	—	5·25	2·80	1·50
LR 2*	3·40?	2·65?	—	5·95	3·50	1·30
SGU 8646*	4·15	3·15	—	6·50	4·35	1·35
LO 6710t*	4·35	3·20	—	5·75	3·75	1·30
SGU 4106	4·55	3·35	—	7·00?	4·20	1·50
LO 2571T	4·60	3·70	2·40	6·60	4·25	1·80
LO 2572t*	4·70	3·70	2·75	7·25	4·70	1·80

Warburg's (1925) description of *T. wegelini* is based on a fairly well-preserved cranidium (SGU 4106; Pl. 4, figs 8–9) from the Boda Limestone in the Siljan district. It differs in some minor respects from the neotype and other specimens from the Fjäcka Shale, and Ulrich (1930, p. 15) assigned it to a new species, *T. linnarssoni*. This specimen is, however, uncompressed, and the differences pointed out by Ulrich (1930) can largely be attributed to the flattening of the specimens from the Fjäcka Shale. Hence, I concur with Nikolaisen (1963, p. 383) and regard *T. linnarssoni* as a junior subjective synonym of *T. wegelini*.

A fragmentary cranidium from the Chair of Kildare Limestone (Ashgill) of eastern Ireland was described by Dean (1971, p. 46) as *T.* cf. *linnarssoni* (Ulrich). The poor preservation makes evaluation difficult, but it differs from *T. wegelini* in having a proportionately wider (tr.) glabella, which is strongly tapered forwards and less broadly rounded in front.

T. wegelini is closely comparable with the type species, *T. fracta* from the Ashgill of Bohemia, and the two species are distinguishable only on the basis of minor characters. I have examined the type specimen of *T. fracta* (see Horný and Bastl 1970, pl. 4, fig. 11), and it differs from *T. wegelini* mainly in that the anterior part of the palpebral lobe is narrower, and the palpebral area lacks a raised rim along the postero-lateral margin. Moreover, there is no indication of muscle insertion areas on the palpebral areas, but this may be due to the mode of preservation.

Occurrence. Upper Ordovician (Harjuan Series) in the Siljan district, Dalarna. One specimen (SGU 4106; Pl. 4, figs 8–9) is from the Boda Limestone at Boda; the remaining ones are from the Fjäcka Shale (*Pleurograptus linearis* Biozone) at Vikarbyn, Amtjärn, Enån, and Skattungbyn. In addition, specimens questionably assigned to the species are known from the upper Solvang Formation (lowermost Ashgill) in the Oslo Region of Norway (Nikolaisen 1963, p. 383; Owen and Bruton 1980, p. 11).

Telephina granulata (Angelin, 1854)

Plate 4, figures 13–14; Plate 5, figures 1–11; Plate 6, figures 1–3

*1854	*Telephus granulatus* Angelin, p. 91, pl. 41, fig. 21.
v.1875	*Bohemilla*(?) *denticulata* Linnarsson, pp. 495–497, pl. 22, figs 4–5.
.1897	*Aeglina denticulata* (Linrs.); Holm, p. 461.
v.1897	*Telephus bicuspis* Ang.; Holm, p. 463 [*partim*].
v.1913*a*	*Telephus granulatus* Ang.; Hadding, pp. 35–37, pl. 1, figs 8–10.
v.1913*b*	*Telephus granulatus* Ang.; Hadding, p. 76, pl. 8, figs 9–10 [copies of Hadding's (1913*a*, pl. 1, figs 8, 10) original figures].
v.1930	*Telephus granulatus* Angelin; Ulrich, p. 11, pl. 1, figs 19–23 [copies of Hadding's (1913*a*, pl. 1, figs 8–10) original figures].

v.1936 *Telephus granulatus* Ang.; Asklund, pp. 9–10, pl. 2, figs 1–7.
non 1963 *Telephina* (*Telephops*) *granulata* (Angelin, 1854); Nikolaisen, pp. 386–387, text-fig. 5, pl. 4, fig. 13.
v.1963 *Telephina* (*Telephops*) *bos* Nikolaisen, pp. 389–391, pl. 4, figs 4–9.
v.*1982b* *Telephina* sp.; Jaanusson, p. 177.

Type data. The specimen figured by Angelin (1854, locality given as 'Norvegiæ') cannot be located and is considered lost. No other possible syntypes can be traced, and as neotype I select a cranidium (PMO 72698; Pl. 5, fig. 1) from the Vollen Formation (formerly Ampyx Limestone or 4aβ; Owen *et al.* 1990) on the western side of Bygdøy in Oslo, Norway. It was illustrated by Nikolaisen (1963, pl. 4, fig. 8), who assigned it to a new species, *T. bos*.

Angelin's illustration (1854, pl. 41, fig. 21) is of a tuberculate cranidium with fairly narrow (tr.) fixigenae and a pair of spines (broken) at the anterior end of the glabella. For a long time, however, the concept of *T. granulata* has been based on Hadding's (1913*a*) fairly detailed description, which is based on material from Jämtland. It would have been preferable to choose one of Hadding's (1913*a*) specimens as neotype, but this is not possible because Angelin's missing specimen was from Norway (precise locality not known). *T. bos* Nikolaisen, 1963 from Norway agrees in all essential features with *T. granulata sensu* Hadding, 1913*a*, and I regard them as conspecific. To retain stability, a neotype was therefore chosen among specimens described as *T. bos* by Nikolaisen (1963). In this context, it is worth noting that the specimens described as *T. granulata* by Nikolaisen (1963, p. 386) differ in some respects from *T. granulata sensu* Hadding, 1913*a*, and seem to represent a different species.

Material. Fourteen nearly complete cranidia, six fragmentary cranidia, four librigenae, two incomplete thoracic tergites, and two pygidia (SGU 3954 and 6721). The specimens are generally preserved as internal moulds.

Description. Length of cranidium (sag.; excl. occipital spine) about 0·7 times the width. Glabella highly convex (tr.), widest adjacent to or slightly in front of the occipital furrow, tapering forward (more rapidly in the anterior part), broadly rounded anteriorly, and generally about 0·9 times as long (sag.) as its maximum width. Preglabellar furrow tucked beneath the frontal convexity of the glabella. A pair of horns or spines is present at the top of the frontal slope of the glabella. These spines are situated far apart from each other and project obliquely forward, outward, and upward from the antero-lateral parts of the glabella. Occipital ring with a moderately long and slender spine, posteriorly directed and with circular cross section. Palpebral area

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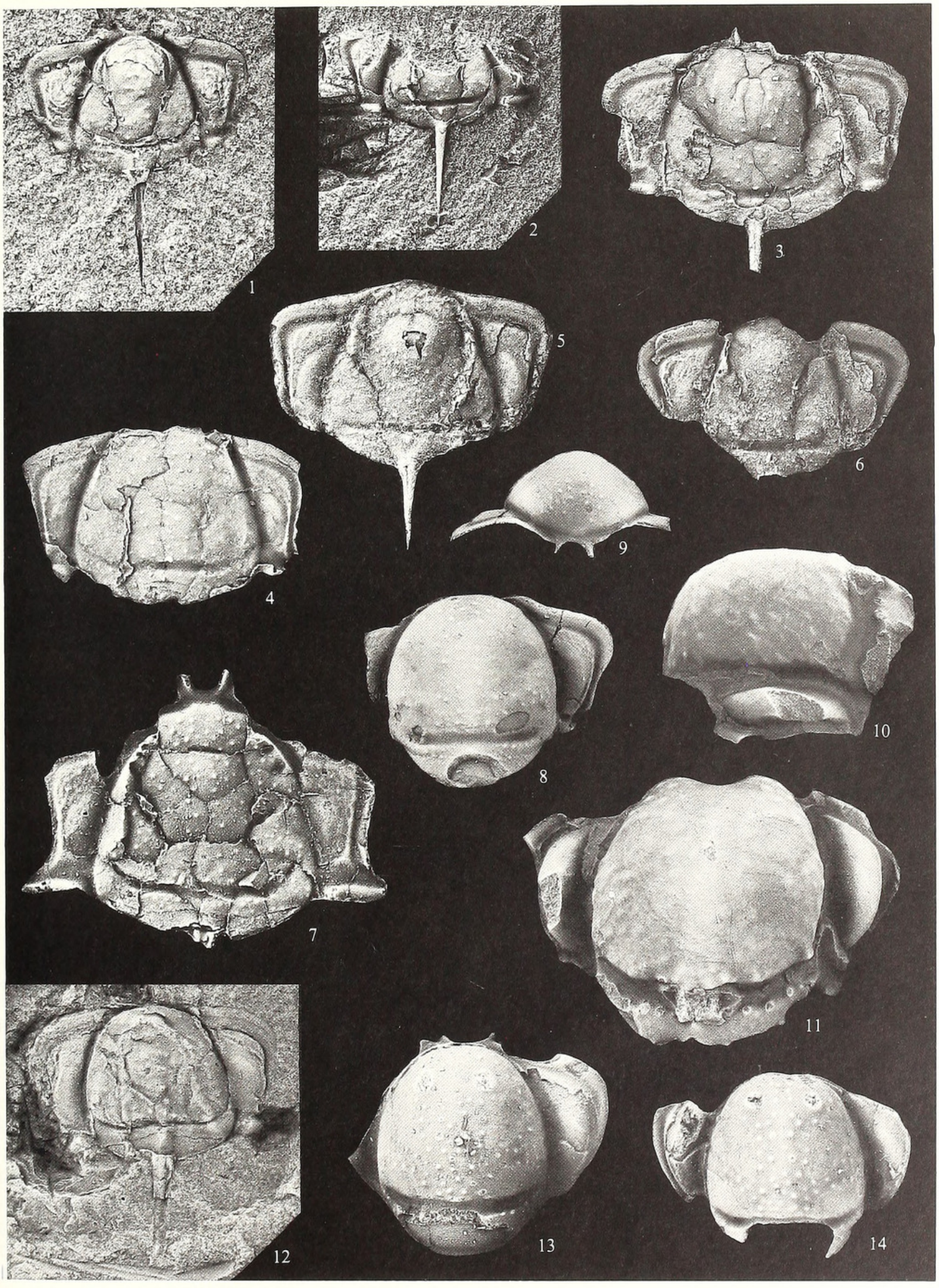
EXPLANATION OF PLATE 4

Figs 1–9. *Telephina wegelini* (Angelin, 1854). All specimens except 8–9 are from the Fjäcka Shale (*Pleurograptus linearis* Biozone) at Amtjärn (1–3; coll. C. Wiman 1906), Enån (4), and Vikarbyn (5–7; coll. S. L. Törnquist) in the Siljan district, Dalarna. 1, PMU D2148; flattened cranidium; ×8. 2, PMU D2146; flattened cranidium with complete occipital spine; ×6. 3, PMU D2147; flattened cranidium; ×6. 4, SGU 8646; flattened cranidium; ×6. 5, neotype, LO 2571T; a nearly complete cranidium; original of Hadding (1913*a*, pl. 2, fig. 18); ×6. 6, LO 6709t; flattened cranidium; latex cast from external mould; ×8. 7, LO 6710t; flattened cranidium; ×8. 8–9, SGU 4106; cranidium in dorsal and anterior views; original of Warburg (1925, pl. 1, figs 16–18); Boda Limestone at Boda, Siljan district, Dalarna; coll. G. Linnarsson; ×6·5.

Figs 10–11. *Telephina* sp. B. SGU 8647; cranidium in left lateral and dorsal views; Andersö Shale, Mellersta Utön, central Storsjön area, Jämtland; ×6.

Fig. 12. *Telephina* sp. A. LO 2548t; flattened cranidium; original of Hadding (1913*a*, pl. 2, fig. 24); Lower Dicellograptus Shale, Kyrkbäken rivulet in Röstånga, Scania; ×8.

Figs 13–14. *Telephina granulata* (Angelin, 1854); upper Andersö Shale (*Nemagraptus gracilis* Biozone), Andersön, central Storsjön area, Jämtland. 13, SGU 8648; cranidium; locality 2 of Hadding (1912, pl. 7A; 1913*b*, fig. 12); coll. P. Thorslund 1956; ×8. 14, LO 2567t; cranidium with glabellar muscle attachment areas; original of Hadding (1913*a*, pl. 1, fig. 9); locality 5 of Hadding (1912, pl. 7A; 1913*b*, fig. 12); coll. A. Hadding 1912; ×7.



AHLBERG, *Telephina*

crescentic and moderately wide (tr.). Palpebral lobe slightly wider anteriorly than posteriorly. Width (tr.) of anterior border (between lateral extremities of spines) about one-third that of occipital ring.

Librigena with approximately semi-elliptical outer margin and extremely long genal spine, which is directed laterally to postero-laterally. Extraocular cheeks narrow and occupied mainly by a convex border, which is strongly downsloping laterally. A distinct, postero-laterally directed metalibrigenal spine is present. Extraocular cheeks widest (tr.) at genal spine. Visual surface bounded on outer side by a deep furrow.

Thoracic rachial rings highly convex (tr.) and with a posteriorly directed spine at posterior margin. Pleurae not known.

Pygidium subtriangular in outline and slightly wider than long (length/width ratio about 1·0:1·3). Rachis highly convex (tr.), tapering backwards, and occupying slightly more than half of the maximum pygidial width at its anterior end. Terminal piece small, poorly defined, and fused with the posterior rachial ring. Rachial rings bear a pair of spines or prominent tubercles very close together at mid-line. Posterior end of rachis truncate and sloping down almost vertically to the short (sag.) post-rachial field. Pleural region narrow, steeply downsloping laterally, and with a narrow, convex border. Anterior margin of pleural region a narrow, raised rim. Antero-lateral corners of pygidium pointed or with a short spine. Pleural furrows not apparent.

Surface sculpture consists of fairly widely spaced tubercles on the glabella, the occipital ring and the thoracic rachial rings. In addition, transversely arranged terrace lines are present on the ventral surface of the occipital ring, and the external exoskeletal surface of the pygidial pleural region exhibits fine, raised lines arranged in a Bertillon pattern. At least two pairs of smooth muscle attachment areas appear to be present on the glabella. The posterior pair is transversely elongate and situated immediately in front of the outer parts of the occipital furrow. The anterior pair is larger, composite, diagonally directed, and situated at about half-way along the length of the glabella.

Remarks. The material of *T. granulata* displays considerable morphological variation. Much of this variability is due to variation in the width and shape of the fixigenae, and in the curvature of the palpebral lobe. Modest variation in the shape of the glabella and in the position of the glabellar spines can also be observed.

The holotype of *T. bos* Nikolaisen, 1963 (PMO 72701) differs from *T. granulata* in having wider fixigenae and a proportionately wider and shorter glabella. It may well be sagittally compressed, however, and is considered a junior synonym (see above).

The specimens described by Nikolaisen (1963, p. 386) as *T. granulata* are from the upper Elnes Formation (probably *Hustedograptus teretiusculus* Biozone) in the Oslo Region, Norway. The small cranidium figured in Nikolaisen's text-fig. 5 differs from *T. granulata* as described herein in having wider (tr.) fixigenae and the glabellar spines close together in a fairly posterior position. In the position of the glabellar spines, it approaches *T. biseriata* (Asklund, 1936), but the wide fixigenae (closely resembling those of *T. bicuspis*) indicate that it cannot be assigned to that species. The narrow palpebral lobe and the extremely long and stout occipital spine distinguishes the cranidium figured in Nikolaisen's pl. 4, fig. 13 from those of *T. granulata*. In addition, it has the glabellar spines fairly close together, and the palpebral lobe is more evenly curved than in most specimens referred to *T. granulata*. Hence, I conclude that the specimens described as *T. granulata* by Nikolaisen (1963) do not belong to that species.

T. bicornis (Ulrich, 1930), from the Effna Limestone (Caradoc; *Prioniodus variabilis* Subzone; S. M. Bergström, pers. comm. 1992) of the southern Appalachians (Virginia), is very similar to *T. granulata*. However, I hesitate to regard them as conspecific because there appear to be slight differences. For instance, the fixigenae are consistently somewhat wider (tr.) and the tubercles are larger and more conspicuous in *T. bicornis*, which in addition, has the short metalibrigenal spine situated much closer to the genal spine. Ulrich (1930, p. 25) emphasized that the glabellar spines are in a more posterior position in *T. bicornis*, but this is a variable feature (compare the cranidia figured by Ulrich 1930, pl. 4, figs 6 and 8).

A fragmentary cranidium from the Brickworks Quarry Shales Member, Knockerk Formation (Caradoc), of eastern Ireland was illustrated and described by Brenchley *et al.* (1967, p. 302, pl. 7, figs 7–8) as *T.* cf. *bos* Nikolaisen. It is closely comparable with *T. granulata*, but differs in having slightly wider (tr.) fixigenae and a less broadly rounded glabellar front. In these respects the Irish specimen is more like *T. bicornis*, and it probably represents that species (cf. Romano 1980, p. 68).

TABLE 4. Dimensions (in mm) of cranidia of *Telephina granulata*.

	Lc	G	Lo	Wc	Wg	Wf
LO 2567t	3·95?	2·95	—	5·45?	3·20	1·30
SGU 8648	4·25	3·10	—	6·15?	3·55	1·50
SGU 8651	4·90	3·75	—	6·70?	3·90	1·60
SGU 8660	5·00?	3·90	—	6·85	4·15	1·65
PMO 72698	5·35	4·00	—	7·10?	4·00	1·65
LO 6712t	5·95	4·45	—	7·75	4·85	1·85
SGU 6427	7·00	5·25	—	9·50	5·80	2·00

Additional material from the Brickworks Quarry Shales was described by Romano and Owen (1993), who reassigned the Irish form to *T.* cf. *bicornis*.

Occurrence. In Jämtland, this species has been collected from limestones in the *Nemagraptus gracilis* Biozone on Andersön (localities 2 and 5 of Hadding 1912, pl. 7A; 1913*b*, fig. 12), on the southwestern shore of Bynäset, Frösön, at Hara about 9 km south of Sunne (see Thorslund 1937, p. 11 for locality data), at Digernäs about 4 km north-east of Sunne, and at Ytterhallen in the Hallen area (loose boulder).

In Västergötland, *T. granulata* is known from an argillaceous limestone in the lowermost part of the upper Dalby Limestone in the Gullhögen quarry on the southeastern slope of northern Billingen (see Jaanusson 1982*b*, p. 176 and Holmer 1989, p. 6 for locality data and stratigraphy). In terms of the graptolite biozonation, the Västergötland specimens were recovered from strata corresponding with the uppermost *Nemagraptus gracilis* Biozone or, more probably, the lowermost *Diplograptus multidens* Biozone.

A nearly complete cephalon is known from the Kukruse Stage in the Blidene drill core (depth 910·85 m) in western Latvia, and a cephalon tentatively assigned to the species has been recorded from the uppermost Uhaku Stage in the Lopatovo-8 drill core (depth 456·30 m) in the Pskov district of western Russia.

Telephina aff. *granulata* (Angelin, 1854)

Plate 6, figures 4–8

v.1919 *Telephus granulatus* Ang.; Funkquist, p. 39, pl. 2, fig. 9.
v.*1951* *Telephus granulatus* Ang.; Nilsson, pp. 684, 688.

Material. One nearly complete cranidium (LO 6714t) and two incomplete cranidia (LO 2966t and 6713t).

Dimensions (mm).

	Lc	G	Lo	Wc	Wg	Wf
LO 6714t	5·65	4·15	—	7·50?	4·35	2·00

Remarks. The cranidia are very like those of *T. granulata* but differ in having a slightly longer glabella, which is truncate in front. In addition, the spines on the glabella are in a slightly posterior position and closer to the mid-line than in *T. granulata*, especially in the specimen figured on Plate 6, figures 7–8.

Occurrence. Killeröd Formation ('*bronni* beds'; equivalent to part of the upper *Hustedograptus teretiusculus* Biozone according to Bergström 1973, p. 15) at Killeröd in south-east Scania (locality 2 of Regnéll 1960, fig. 4; section described by Nilsson 1951, p. 683). It is also known from a loose boulder at Rödmölla in the Tosterup area, south-east Scania (cf. Funkquist 1919, p. 42).

Telephina biseriata (Asklund, 1936)

Plate 6, figures 9–13

v*1936 *Telephus biseriatus* Asklund, pp. 11–12, pl. 1, figs 9–11.

Type data. The holotype by monotypy is a nearly complete cranidium (SGU 6714; Pl. 6, fig. 9), illustrated by Asklund (1936, pl. 1, figs 9–11). It was collected by G. Linnarsson in 1871 from a shore section on northwestern Andersön in the central Storsjön area, Jämtland. Its stratigraphical position is not known precisely, but it was probably collected from a dark grey limestone in the middle–upper part of the *Hustedograptus teretiusculus* Biozone (middle Andersö Shale).

Material. In addition to the holotype, six cranidia, one incomplete pygidium, and fragments of the eyes. The majority of the specimens are preserved as internal moulds in a dark grey limestone and seem to retain their original convexity.

Description. Glabella subequal in length (sag.) and maximum width or slightly wider than long. A pair of horns or spines, situated very close together, is present at 0·6–0·7 of the glabellar length from its posterior end. Occipital spine probably present but not preserved. Anterior border narrow (sag.) with the spines situated very close together (width between lateral extremities of spines one-quarter to one-third that of occipital ring). Thorax and extraocular librigenae not known (Table 5).

Surface sculpture consists of fairly widely spaced tubercles on the glabella and the occipital ring, and terrace lines occur on the ventral surface of occipital ring. The tubercles are most prominent along the mid-line of the glabella. The fixigenae and the pygidium appear to be smooth, except for indistinct 'wrinkles' anterolaterally on the palpebral area.

Remarks. This species is distinctive and differs from *T. granulata* in that the glabellar spines are situated very close together in a posterior position. It is worth noting, however, that the position of the spines is a variable feature. In the holotype (Pl. 6, fig. 9), for instance, they are in an extremely posterior position, whereas they are more anteriorly placed in the cranidium figured on Plate 6, figures 11–12. The expression of the tubercles varies in strength, but this can be attributed probably to the mode of preservation. The glabella is generally subequal in length and maximum width, and comparatively longer than in *T. granulata*. The pygidium is slightly wider than long and very similar to that of *T. granulata*.

Occurrence. Middle Andersö Shale (middle–upper *Hustedograptus teretiusculus* Biozone) on the northwestern and northern shore of Andersön (cf. Thorslund 1937, p. 10), the northern shore of Norderön (see Thorslund and Jaanusson 1960, fig. 22), and 0·5 km E of Lövtorpet on Frösön in the central Storsjön area, Jämtland. In addition, a few cranidia are known from coeval strata at Önsvedsbäcken south of Sunne, Jämtland (see Hadding 1912 for locality data). The majority of the specimens are from a dark grey, bedded limestone generally referred to as the Biseriata Limestone ('*Telephina biseriata* beds' of Thorslund and Jaanusson 1960). Conodonts recovered from this limestone are indicative of the *Eoplacognathus lindstroemi* Sub-biozone and the lower

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EXPLANATION OF PLATE 5

Figs 1–11. *Telephina granulata* (Angelin, 1854). All specimens except 1 are from the upper Andersö Shale (*Nemagraptus gracilis* Biozone), central Storsjön area, Jämtland. 1, neotype, PMO 72698; a nearly complete cranidium; original of Nikolaisen (1963, pl. 4, fig. 8); Vollen Formation, western side of Bygdøy in Oslo, Norway; coll. F. Nikolaisen 1958; ×5·5. 2–4, SGU 6427; cranidium in dorsal, anterior, and left lateral views; original of Hadding (1913*a*, pl. 1, fig. 8a–c); Hara south of Sunne; coll. G. C. von Schmalensee 1884; ×6. 5, RM Ar 9897a; cranidium with glabellar spines; original of Asklund (1936, pl. 2, fig. 2); Ytterhallen, Hallen area (loose boulder); coll. G. C. von Schmalensee; ×6. 6, SGU 8649; cranidium with glabellar muscle attachment areas; Hara south of Sunne; coll. G. C. von Schmalensee 1884; ×7. 7, SGU 8650; cranidium; Hara south of Sunne; coll. G. C. von Schmalensee 1884; ×7. 8, SGU 8651; cranidium; Hara south of Sunne; coll. P. Thorslund 1936; ×7·5. 9, SGU 6721; nearly complete pygidium; original of Asklund (1936, pl. 2, fig. 7); Bynäset, Frösön; ×9. 10, RM Ar 9899; nearly complete librigena; original of Asklund (1936, pl. 2, fig. 4); Ytterhallen, Hallen area (loose boulder); coll. G. C. von Schmalensee 1885; ×2·5. 11, RM Ar 9897b; incomplete librigena in ventral view; Ytterhallen, Hallen area (loose boulder); coll. G. C. von Schmalensee; ×6.

AHLBERG, *Telephina granulata*

Pygodus anserinus Biozone (Bergström *et al.* 1974, table 10), and, in terms of the graptolite biozonation, the Biseriata Limestone seems to represent the middle–upper part of the *H. teretiusculus* Biozone.

Telephina aff. *biseriata* (Asklund, 1936)

Plate 6, figure 14

Material. An incomplete cranidium (SGU 8656), largely exfoliated, collected by P. Thorslund in 1937.

Dimensions (mm). G = 4·20; Wg = 5·00; Wf = 1·60.

Remarks. The cranidium resembles that of *T. biseriata* in having the glabellar spines situated close together, but they are in a more anterior position (at about 0·9 of the glabellar length from its posterior end). In addition, it has a proportionately wider glabella (length/width ratio 1:1·2) and considerably narrower (tr.) fixigenae with the facial suture curved more evenly around the lateral extremity of the palpebral lobe. It seems to represent a new, undescribed species, but with the limited material at hand it is left under open nomenclature.

The glabellar surface sculpture consists of fairly widely spaced tubercles, except for two pairs of large, smooth muscle attachment areas. The posterior pair is transversely elongate and situated immediately in front of the outer parts of the occipital furrow. The anterior pair is larger and situated about half way along the glabella.

Occurrence. Dark grey limestone in the middle Andersö Shale (probably upper *Hustedograptus teretiusculus* Biozone) on the northwestern shore of Andersön, Jämtland (locality 1 of Hadding 1912, pl. 7A; 1913*b*, fig. 12).

Telephina sp. A

Plate 4, figure 12

v.1913*a* *Telephus* sp.; Hadding, p. 42, pl. 2, fig. 24.
v.1913*b* *Telephus* sp.; Hadding, p. 76, pl. 8, fig. 5 [copy of Hadding's (1913*a*, pl. 2, fig. 24) original figure].
v.1930 *Telephus* species undetermined; Ulrich, pl. 1, fig. 2 [copy of Hadding's (1913*a*, pl. 2, fig. 24) original figure].

Material. An internal mould of a flattened cranidium (LO 2548t), collected by A. Hadding in 1911.

Dimensions (mm). Lc = 3·40?; G = 2·50; Lo = 2·25?; Wc = 5·25; Wg = 3·00; Wf = 1·35.

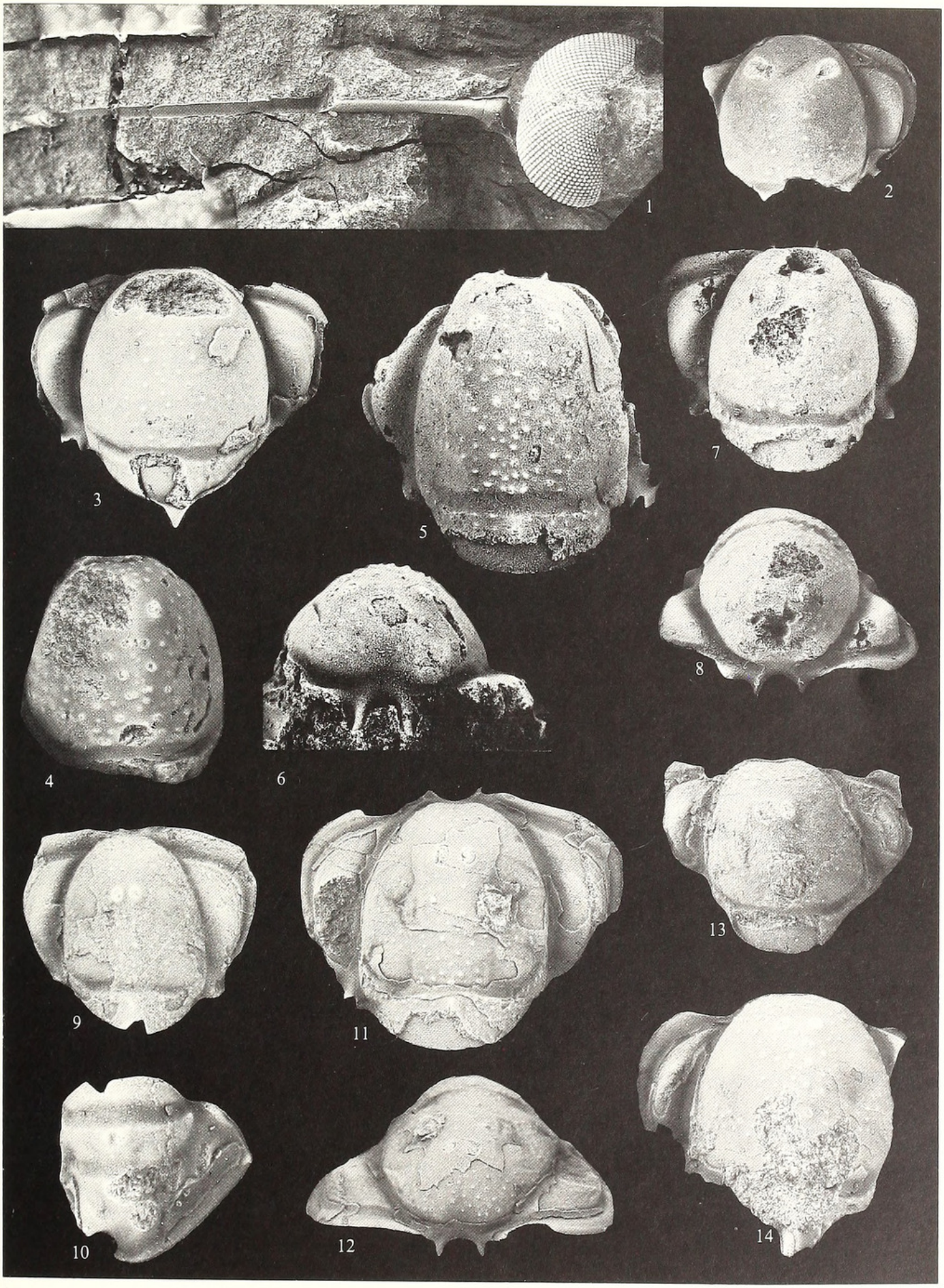
EXPLANATION OF PLATE 6

Figs 1–3. *Telephina granulata* (Angelin, 1854). 1, SGU 8652; incomplete librigena; upper Andersö Shale (*Nemagraptus gracilis* Biozone) at Hara south of Sunne, Jämtland; coll. P. Thorslund 1936; ×6. 2–3, cranidia; upper Dalby Limestone, Gullhögen quarry, Billingen, Västergötland; coll. J. Johansson. 2, LO 6711t. 3, LO 6712t. Both ×6.

Figs 4–8. *Telephina* aff. *granulata* (Angelin, 1854). Killeröd Formation at Rödmölla, Tosterup area (4; coll. K. A. Grönwall) and at Killeröd (5–8; coll. R. Nilsson 1943), south-east Scania. 4, LO 2966t; fragmentary cranidium; original of Funkquist (1919, pl. 2, fig. 9). 5–6, LO 6713t; incomplete cranidium in dorsal and anterior views. 7–8, LO 6714t; nearly complete cranidium in dorsal and anterior views. All ×6.

Figs 9–13. *Telephina biseriata* (Asklund, 1936). Middle Andersö Shale (middle–upper *Hustedograptus teretiusculus* Biozone) on Andersön (9, 11–12) and Norderön (10), central Storsjön area, and at Önsvedsbäcken (13) south of Sunne, Jämtland. 9, holotype, SGU 6714; a nearly complete cranidium; original of Asklund (1936, pl 1, figs 9–11); ×8. 10, SGU 8653; incomplete pygidium; coll. P. Thorslund 1950; ×9·5. 11–12, SGU 8654; nearly complete cranidium in dorsal and anterior views; coll. P. Thorslund 1950; ×7·5. 13, SGU 8655; cranidium; coll. P. Thorslund 1950; ×7.

Fig. 14. *Telephina* aff. *biseriata* (Asklund, 1936). SGU 8656; Middle Andersö Shale, northwestern shore of Andersön, Jämtland (locality 1 of Hadding 1912, pl. 7A, 1913*b*, fig. 12); ×6.



AHLBERG, *Telephina*

TABLE 5. Dimensions (in mm) of cranidia of *Telephina biseriata*.

	Lc	G	Lo	Wc	Wg	Wf
SGU 6714	3·55	2·65	—	4·35	2·55	1·20
SGU 8655	4·45	3·40	—	6·00?	3·55	1·30?
SGU 8654	5·20	3·70	—	6·70	4·00	1·65

Remarks. The specimen is strongly flattened and imperfectly preserved. A comparison with named taxa is therefore difficult. The overall shape of the cranidium and the glabella is similar to that of *T. bicuspis* and it may belong to that species. It differs, however, in having a stouter occipital spine, narrower (tr.) fixigenae, and less strongly curved palpebral lobes. The posterior part of the palpebral area is fairly wide (tr.), and in this respect it is similar to flattened specimens of *T. wegelini*.

Occurrence. Lower Dicellograptus Shale (probably middle part of the *Hustedograptus teretiusculus* Biozone) at the Kyrkbäcken rivulet in Röstånga, Scania, southern Sweden (locality IIIb of Moberg 1910, p. 114, pl. 3; section III:3 of Hadding 1913*b*, p. 19).

Telephina sp. B

Plate 4, figures 10–11

Material. An internal mould of a nearly complete cranidium (SGU 8647), collected by G. Linnarsson in 1871.

Dimensions (mm). Lc = 7·60; G = 5·00; Wc = 10·00?; Wg = 5·85; Wf = 2·25?.

Remarks. The cranidium slopes down steeply anteriorly and differs from those of most other species of *Telephina* in having a strongly convex glabella and extremely convex palpebral areas, which are steeply downsloping laterally. The fixigenae are narrow (tr.) with a crescentic and ridge-like palpebral area. The dorsal and palpebral furrows are wide and deeply incised. The glabella is tapered forwards and steeply downsloping anteriorly. The glabellar frontal lobe is truncate and distinctly arched backwards medially. The occipital furrow is very wide (sag.) and deep. Tubercles are present on the glabella and the occipital ring.

A broadly similar form from the Engervik Member of the Elnes Formation at Huk in Oslo, Norway, was described and figured by Nikolaisen (1963, p. 384, pl. 3, figs 15–16) as *Telephina* sp. no. 2.

Occurrence. Andersö Shale (probably lower part; *Hustedograptus teretiusculus* Biozone) on Mellersta Utön in the central Storsjön area, Jämtland.

Telephina sp. C

(not figured)

v.1948 *Telephus* sp.; Thorslund, p. 362, pl. 11, fig. 10.
v.*1964* *Telephina* sp.; Jaanusson, p. 17.

Material. A flattened and poorly preserved cranidium (PMU Vg 37), about 1·3 mm long (sag.; excl. occipital spine).

Remarks. The poor preservation makes evaluation difficult, but the specimen shows the following: the glabella is tapered forward, rounded in front, and subequal in length and maximum width; the occipital ring is fairly long (sag.) with a stout and broad-based occipital spine, and the fixigenae are wide (tr.).

Occurrence. Lower Dalby Limestone in the Kullatorp drill core, Kinnekulle, Västergötland (depth 86·50–86·52 m). In terms of the graptolite biozonation, it was probably recovered from strata corresponding to the *Nemagraptus gracilis* Biozone (e.g. Jaanusson 1964, table 1, 1982*a*, fig. 4).

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PER AHLBERG

Department of Historical Geology
and Palaeontology, Sölvegatan 13
S-223 62 Lund, Sweden

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