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NEW SPECIES OF THE LICHID TRILOBITE *CERATARGES* FROM THE MIDDLE DEVONIAN IN MOROCCO

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(1 figure, 4 plates)

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ABSTRACT. Members of *Ceratarges* Gürich are known from Devonian strata in various countries but they have not yet been formally described from Morocco. *Ceratarges ziregensis* sp. nov., *Ceratarges koumalii* sp. nov. and *Ceratarges aries* sp. nov. are herein described from the El Otfal Formation (Eifelian) in Morocco on the basis of complete specimens. Supplementary material is illustrated of *Ceratarges cognatus* van Viersen from the Jemelle Formation (Eifelian) in France. The relationships between *Ceratarges*, *Mephiarges* Richter & Richter and *Asawikwanabe* Basse *in* Basse & Müller are briefly elaborated on.

Keywords: Trilobita, Trochurinae, Eifelian, Morocco, France.

RESUME. Des nouvelles espèces de *Ceratarges* (Trilobita, Lichidae) dans le Dévonien moyen au Maroc. Les espèces du genre *Ceratarges* Gürich étaient connues dans le Dévonien de certains pays mais elles ne sont pas déjà formellement décrites au Maroc. *Ceratarges ziregensis* sp. nov., *Ceratarges koumalii* sp. nov. et *Ceratarges aries* sp. nov. sont décrites dans la Formation de El Otfal (Eifelien) au Maroc sur base de spécimens complets. Des spécimens supplémentaires de *Ceratarges cognatus* van Viersen de la Formation de Jemelle (Eifelien) en France sont illustrés. Les relations entre *Ceratarges*, *Mephiarges* Richter & Richter et *Asawikwanabe* Basse *in* Basse & Müller sont brièvement discutées.

Mots-clés: Trilobita, Trochurinae, Eifelien, Maroc, France.

1. Introduction

Devonian strata in Morocco are well-known for their richly diversified trilobite faunas. In the past few decades, numerous articulated and well-preserved trilobite specimens have become available to a broad public as a result of commercial mining yet surprisingly few of these have been described in scientific publications. This is at least in part due to the fact that the specimens often come with vague or incorrect geographic and stratigraphic provenances. Members of the lichid *Ceratarges* are among these trilobites. The authors of the present note have recovered well-preserved specimens of this genus from Eifelian outcrops in Morocco and the Ardenno-Rhenish Mountains (Belgium, Germany). In this first part of a review of *Ceratarges* which is underway (AVV & HP, work in prep.), three new species from southeastern Morocco are described. Additional material of *Ceratarges cognatus* van Viersen, 2006 from the type locality in the Ardennes (northern France) is also recorded.

2. Geological context

2.1 Jbel Zireg, Morocco

The fossiliferous beds of the so-called "*Ceratarges* horizon", upper part of the El Otfal Formation (Eifelian), in Jbel Zireg (N 30° 36´ 41.7; W 04° 32´ 21.8 to N 30° 36´ 46.0; W 04° 32´ 26.5), outcrop at the southern end of the Maider Basin (pre-Sahara). This section was visited and measured by one of us (HP) between March 2008 and October 2009. All three *Ceratarges* species recorded herein range throughout an 18 to 30 cm thick limestone bank (Fig. 1) that comprises a bluish, dark grey lower part and a grey to ochreous-brown upper part. All specimens collected and described here came from the upper part. Relative occurrences of *Ceratarges ziregensis* sp. nov.,

Figure 1. Embankment in the El Otfal Formation in Zireg, Morocco. The white arrows indicate the upper and lower limits of the 18 to 30 cm thick layer; the black arrow indicates the boundary between the upper and lower banks.

Ceratarges koumalii sp. nov. and *Ceratarges aries* sp. nov. are estimated at about 75%, 20% and 5%, respectively.

Lerosey-Aubril *et al*. (2007) described a rare new species *Otarionella lkomalii* (sic) which co-occurs with the three *Ceratarges* species in the Jbel Zireg locality. However, *Otarionella lkomalii* has a much larger range as specimens have been recovered from banks as high as 15 meters above the "*Ceratarges* horizon" by Mr Dieter Holland (Ilsede) on field trips together with HP.

2.2 Vireux-Molhain, France

Outcrop of the Vieux Moulin Member (lower Eifelian) of the Jemelle Formation which is locally known as the "Mur des douaniers" and situated just west of the northern French village of Vireux-Molhain (Crônier & van Viersen, 2008; Dumoulin & Blockmans, 2008). The specimens of *Ceratarges cognatus* that are illustrated herein were collected from the "Mur des douaniers" before it was shut down by French authorities in the 1990s; these were subsequently obtained by AVV from A. Weug and J. Boel.

3. Systematic palaeontology

All specimens were whitened with ammonium chloride prior to photography and are deposited in the Natuurhistorisch Museum Maastricht (The Netherlands), abbreviated NHMM. Morphologic terminology follows that of Thomas & Holloway (1988).

Family Lichidae Hawle & Corda, 1847
Subfamily Trochurinae Phleger, 1936

Discussion. Adrain (1994) discussed his Siluro-Devonian *Borealarges* genus group and suggested that beside *Borealarges* Adrain, 1994, *Richterarges* Phleger, 1936 and *Terranovia* Maksimova, 1977, the highly derived *Ceratarges* Gürich, 1901 may also be a member although its origin and affinities remain unclear. The closest relatives of *Ceratarges* known to date are probably the slightly stratigraphically younger and monotypic genera *Mephiarges* Richter & Richter, 1930 and *Asawikwanabe* Basse *in* Basse & Müller, 2004, from the Junkerberg Formation (middle Eifelian) in the Eifel. Thomas & Holloway (1988) contrasted *Ceratarges* with *Terranovia* while dismissing Ormiston's (1982) suggestion that the two are closely related. In the same paper Thomas & Holloway considered that the most closely similar form to *Mephiarges* is *Terranovia*. Despite *Mephiarges* being known only from an incomplete cephalon (see Richter & Richter, 1930, figs 7a-c; Basse *in* Basse & Müller, pl. 54, figs 704, 705) we agree with Basse *in* Basse & Müller (2004) who argued that this genus in fact stands close to *Ceratarges* and that the two may turn out to be synonyms.

Asawikwanabe is much better known than *Mephiarges* (see Basse *in* Basse & Müller, 2004) and has a pygidium that is exceedingly similar to that of *Ceratarges*, notably by the configuration of the three pairs of pleurae and associated pleural spines. In *Asawikwanabe* however, the entire dorsal exoskeleton is covered with tubercles, the second and third pygidial pleural spine pairs are clearly reduced in length, the spines on the median glabellar lobe and pygidial axis are reduced to no more than single tubercles, and the second pygidial pleural spine pair is proximally subhorizontally directed instead of weakly to strongly dorsally. The subconically inflated cranidium that characterises *Ceratarges* is trimmed down in *Asawikwanabe* to resemble Early Devonian trochurines and especially members of *Belenopyge* Pek & Vaněk, 1991 (= *Lobopyge* Přibyl & Erben, 1952, preoccupied, according to Özdikmen, 2006) and *Jasperia* Thomas & Holloway, 1988. While a subconically inflated cranidium appears to be a synapomorphy of species included in *Ceratarges* at present, the cranidium of *Asawikwanabe* may well reflect the plesiomorphic condition of these taxa (which would seem to be more likely than the possibility that it arose by homoeomorphy). Provided that *Asawikwanabe* indeed proves to be closely allied with *Ceratarges*, its cephalic morphology may shed new light on the origin of the latter genus.

Genus *Ceratarges* Gürich, 1901

Type species. *Lichas armatus* Goldfuss, 1839, from the Ahrdorf Formation (Eifelian) of the Eifel, Germany, by monotypy.

Discussion. It is possible that the putative monophyly of *Ceratarges* needs to be reconsidered. For instance, *Ceratarges berolinensis* (Richter, 1909) is rather easily distinguished from co-occurring *Ceratarges armatus* in the middle Eifelian "Trilobitenfelder" (see van Viersen *et al*., 2009, and references therein for details on this locality) through its proximally anterodorsally directed spines on the glabella (this feature is also displayed by *Ceratarges aries* sp. nov.), a small, narrow (tr.), trapezoidal pygidium with undeveloped borders, a shorter (sag.) and narrower (tr.) pygidial axis which has the dorsal spine reduced to a small tubercle, weakly vaulted second and third pygidial pleurae and postaxial ridge, and exceedingly long pygidial pleural spines, among other features. Thomas & Holloway (1988) provided a diagnosis for *Ceratarges* but only considered *Ceratarges faouensis* Morzadec, 1969 (which is known only from internal moulds of pygidia) and the stratigraphically high type species. Potential apomorphies of *Ceratarges* are probably best addressed in the light of a thorough restudy especially of its basal members. Hence, we prefer to postpone a revised diagnosis.

Distribution. Members of *Ceratarges* have been recorded from upper Emsian(?) to mid-Eifelian strata in Germany (e.g. Goldfuss, 1839; Richter, 1909; Basse *in* Basse & Müller, 2004), France (Morzadec, 1969; van Viersen, 2006), England (Kennedy, 1994), Belgium (van Viersen, 2007), Morocco (herein), and probably also Russia (see Basse *in* Basse & Müller, 2004).

Ceratarges ziregensis sp. nov.

(Pl. 1, Figs A-H)

2004 *Ceratarges* sp. n. 2; Basse *in* Basse & Müller, p. 107, pl. 40, figs. 503-506, pl. 41, figs. 507-510.

Etymology. For being the commonest *Ceratarges* species in Zireg.

Holotype. NHMM 2011 001, complete specimen (Pl. 1, Figs A-H).

Type locality and horizon. El Otfal Formation, Jbel Zireg.

Diagnosis. Eye stalks are high. Glabella is weakly vaulted (sag., tr.). Second pygidial pleural spine depicts a quarter of a circle. Second and third pygidial pleural spine pairs are robust and bear about four well-developed secondary spines dorsally. Narrow (tr.), elongated (sag.), very weakly vaulted (tr.) pygidial axis bearing about nine rings and no median spine or tubercle.

Description. Cranidium. Anterior border is short medially. Glabella is weakly subconically inflated, overhanging anterior border. Wholly moderately wide (tr.) median glabellar lobe bearing few tubercles medially in front of a pair of robust, proximally upwardly directed, divergent, and distally downwardly and inwardly curved spines that bear densely spaced, small granules alternated by larger granules with backwardly directed, acuminate tips; median glabellar lobe is inflated and expanded (tr.) near these spines, bears two pairs of faint granules posteriorly to these and is otherwise devoid of sculpture; a third, slightly more widely spaced pair of granules is positioned further posteriorly, adaxially on posterolateral cranidial lobes. Longitudinal furrow originates in anterior border furrow about halfway (tr.) along bullar lobe, converges until halfway towards the highest point of median glabellar lobe, momentarily deepens before passing subexsagitally underneath the base of the dorsal spine, flexes adaxially after this point before smoothly running weakly adaxially backwards until merging with axial furrow in a shallow, subtriangular depression. Reniform bullar lobe, bearing randomly scattered, faint granules. Axial furrow is shallow anteromedially, moderately deep anterolaterally from where it becomes increasingly shallow posteriorly. Anterior sutural ridge is prominent, devoid of sculpture, smoothly curved towards eye; posterior sutural ridge is short and moderately strong. Wide (tr.) posterolateral cranidial lobe that merges adaxially with median glabellar lobe. S0 is shallow, runs transversely medially, is flexed posterolaterally distally, deepened, and extended as a distinct furrow similar to the axial furrow which curves widely anterolaterally along the posterior border and towards the posterior sutural ridge. Occipital ring is moderately weakly vaulted (tr.), narrowing (exsag.) only distally, bearing a pair of (broken off) thorns medially on the posterior margin.

Librigena. Moderately weakly vaulted lateral border anterior half of which shows fine terrace lines that disappear posteriorly, ventrally; posterior half of border bears granules. Librigenal field is smooth, adaxially demarcated by sutural ridge and eye stalk and posteriorly by short (tr.), shallow border furrow and smooth, moderately weakly vaulted posterior border; librigenal field is triangularly depressed where sutural ridge and lateral border meet. Slightly posterolaterally directed stalk, covered with numerous, randomly scattered granules occasionally alternating with small tubercles, and a single band of tubercles near the top under the subhemispherical eye. Lateral and posterior borders merge abaxially and are prolonged into a robust, proximally broad and weakly vaulted (exsag.), distally backward and slightly inward curved genal spine of gradually decreasing thickness and with similar sculpture to that of the dorsal spine pair on the median glabellar lobe.

Thorax is comprised of 11 segments. Axial rings are convexly rounded (tr.) and bear randomly scattered granules. Articulating half ring is straight (tr.) as far as is visible in the available material so that articulating furrow is shallow and narrow (sag., exsag.) adaxially, moderately deep and broad (exsag.) abaxially. Axial furrow is distinct throughout. Pleurae are convexly rounded in section (exsag.). The bases of (broken off) spines or tubercles are visible axial-symmetrically, distally on at least the second, eighth and tenth pairs of posterior pleural bands. Abaxial half of inner portion of pleura is impressed by a proximally thin, distally broad, deepening furrow. Pleura is distally prolonged into a proximally evenly thick (exsag.), weakly downwardly and anteriorly curved, distally outwardly and slightly backwardly curved spine; this spine slowly decreases in thickness distally and is about 1.5 times longer than associated inner portion of pleura.

Pygidium is convex (sag., exsag.) to somewhat subtrapezoidal in outline with length:width ratio of 0.75. First axial ring is well-developed, similar to the anteriorly lying thoracic axial ring but adaxially slightly narrower (sag., exsag.) and ascending backwards; inner portion of pleura is subtransversally, slightly backwardly directed, distally impressed by a moderately thin (exsag.), short (tr.) furrow, prolonged into a short, backward and ventrally directed spine. Articulating furrow is straight (tr.), adaxially shallow, distally deep. About 10 additional axial rings are defined through weakly expressed, transverse ridges of various but axially symmetrical lengths, usually with the adaxial ends accentuated by a small tubercle. Axis is weakly vaulted (tr.), constricted (tr.) lateral to second pleura by slightly anteriorly inward directed derivative of axial furrow, slightly and gradually decreases in height backwardly over entire width, has an indistinctly demarcated, transverse posterior margin, bears numerous, randomly scattered, fine granules, especially on posterior portion; a median dorsal spine or tubercle is absent. Length of axis measures about 0.78 of pygidium (sag.) and width of axis about 0.36 of pygidium (tr.). Broad (exsag.), moderately shallow furrow separates first and second pleura. Second pleura has a weakly vaulted

(exsag.) anterior band that is centrally (tr.) separated from convexly rounded (exsag.) posterior band by shallow, broad (exsag.), abaxially slightly deepening furrow; posterior band is separated from axis by weakly impressed axial furrow here, is posterolaterally directed and ascends slightly proximally, bears a single tubercle or spine, then flexes laterally towards border where it is extended into a proximally evenly thick, transversally directed pleural spine, ascending at about 40 degrees, that distally curves backwardly and eventually slightly inwards. Area between second and third pleurae is triangular with a more or less straight angle between second pleura and lateral border, slightly more depressed laterally and posteriorly, covered with randomly scattered granules of varying size. Third pleura starts about halfway along the axis, runs subexsagitally, bears a single tubercle or spine near the border before the posterior to which it merges with bifid postaxial ridge and is subsequently prolonged into a proximally weakly outwardly, and distally inwardly curved spine that remains entirely in the horizontal plane. Second and third pleural spine pairs are covered with small granules sometimes alternating with larger, acuminate granules with backwardly directed tips, and four or five, evenly spaced, centrally (exsag.) and axial-symmetrically positioned dorsal spines. Area between third pleura and postaxial ridge consists of higher plane anteriorly that gently slopes off of third pleura and a triangular depression posteriorly. Lateral border is broad (tr.), very weakly vaulted, downward sloped abaxially. Postaxial ridge gently slopes off of axis, broadens and flexes posterolaterally, bears few granules and is otherwise smooth. Postaxial field slopes weakly downwards towards the rear. There are about four, straight, slowly narrowing, weakly downward directed marginal spines positioned near pygidial doublure between second and third pleural spines; between the third pair of pleural spines there are five similar but slightly more horizontally directed marginal spines the middle one of which is the largest.

Discussion. Most congeners are easily distinguished from *Ceratarges ziregensis* sp. nov. in having a dorsal spine on the pygidial axis. Only *Ceratarges berolinensis* has this spine reduced to a small tubercle but that species is different from the new species as portrayed above through a comparison with co-occurring *Ceratarges armatus*.

Ceratarges koumalii sp. nov.

(Pl. 2, Figs A-G)

2004 *Ceratarges* sp. n. 1; Basse *in* Basse & Müller, p. 107, pl. 40, figs 500-502.

Etymology. After Addi Koumali, in recognition of his kindness and hospitality during field excursions by HP to Morocco.

Holotype. NHMM 2011 002, complete specimen (Pl. 2, Figs. A-G).

Type locality and horizon. El Otfal Formation, Jbel Zireg.

Diagnosis. Glabella is strongly inflated (sag., tr.). Median glabellar lobe is wide (tr.) throughout and considerably higher than bullar lobes. Genal and pygidial pleural spines are strongly upward curved distally. Dorsal spine on pygidial axis is subvertical and short.

Discussion. The strongly inflated glabella is a striking feature which renders *Ceratarges koumalii* sp. nov. rather distinct from other *Ceratarges* species. The type species has a similar yet more widely rounded pygidium with a proximally sharply posteriorly flexed second pygidial pleural spine, and an axis that is shorter (sag.), less vaulted (tr.) and which has a further anteriorly positioned dorsal spine.

Ceratarges aries sp. nov.
(Pl. 3, Figs. A-E)
2004 *Ceratarges* sp. n. 3; Basse *in* Basse & Müller, p. 107, pl. 41, figs 511-515, pl. 54, fig. 703.

Etymology. From *aries* (Lat.) = ram, in reference to the forward directed head and horns (i.e., dorsal spines on the glabella) of this species.

Holotype. NHMM 2011 003, complete specimen (Pl. 3, Figs. A-E).

Type locality and horizon. El Otfal Formation, Jbel Zireg.

Diagnosis. Glabella overhangs anteriorly (when occipital ring is held in the vertical plane), has its highest point above anterior border of cranidium and bears a pair of proximally forward directed spines. Median glabellar lobe is weakly inflated and slightly higher than bullar lobes. Second pygidial pleural spine ascends slightly and curves anteriorly proximally. Pygidial axis bears a thick, moderately short dorsal spine.

Discussion. As mentioned earlier, *Ceratarges aries* sp. nov. is very rare. We examined several additional specimens, some better and some more poorly preserved. All of these matched the characters shown by the holotype except for the prominent spine pair on the occipital ring which has broken off. In other species including *Ceratarges armatus*, however, the presence of this spine pair can vary.

Of the other two species occurring in the Jbel Zireg locality, *Ceratarges ziregensis* sp. nov. is probably the most similar to *Ceratarges aries* sp. nov. yet principally different in having a more weakly inflated cranidium and pygidial axis which besides lacks a dorsal spine.

Ceratarges cognatus van Viersen, 2006
(Pl. 4, Figs A-G)

1991 *Ceratarges armatus*; Gibout, unnumb. fig.

* 2006 *Ceratarges cognatus* van Viersen, pp. 65, 66, pl. 1, figs 1-6.

Material. NHMM 2011 004, one internal mould of a complete specimen. NHMM 2011 005, one complete specimen with the cephalon and part of the thorax preserved as an internal mould and posterior part of thorax and the pygidium preserved as an external mould (of which a silicone cast was made). Both specimens come from the Vieux Moulin Member of the Jemelle Formation in Vireux-Molhain (type locality and horizon).

Discussion. *Ceratarges cognatus* is among the largest of known members of this genus in the Ardenno-Rhenish Mountains (complete specimens usually exceed a sagittal length of 30 mm). Characteristic are the exceedingly long genal spines which may reach as far as the posterior pygidial border (cf., e.g., Gibout, 1991), and the strongly vaulted (tr.) pygidial axis with a far posteriorly positioned dorsal spine. Furthermore noteworthy is the presence of about seven pairs of drop-shaped (tr.) impressions laterally on internal moulds of the pygidial axis. These features seem to be remnants of axial rings and may have been sites for muscle attachment.

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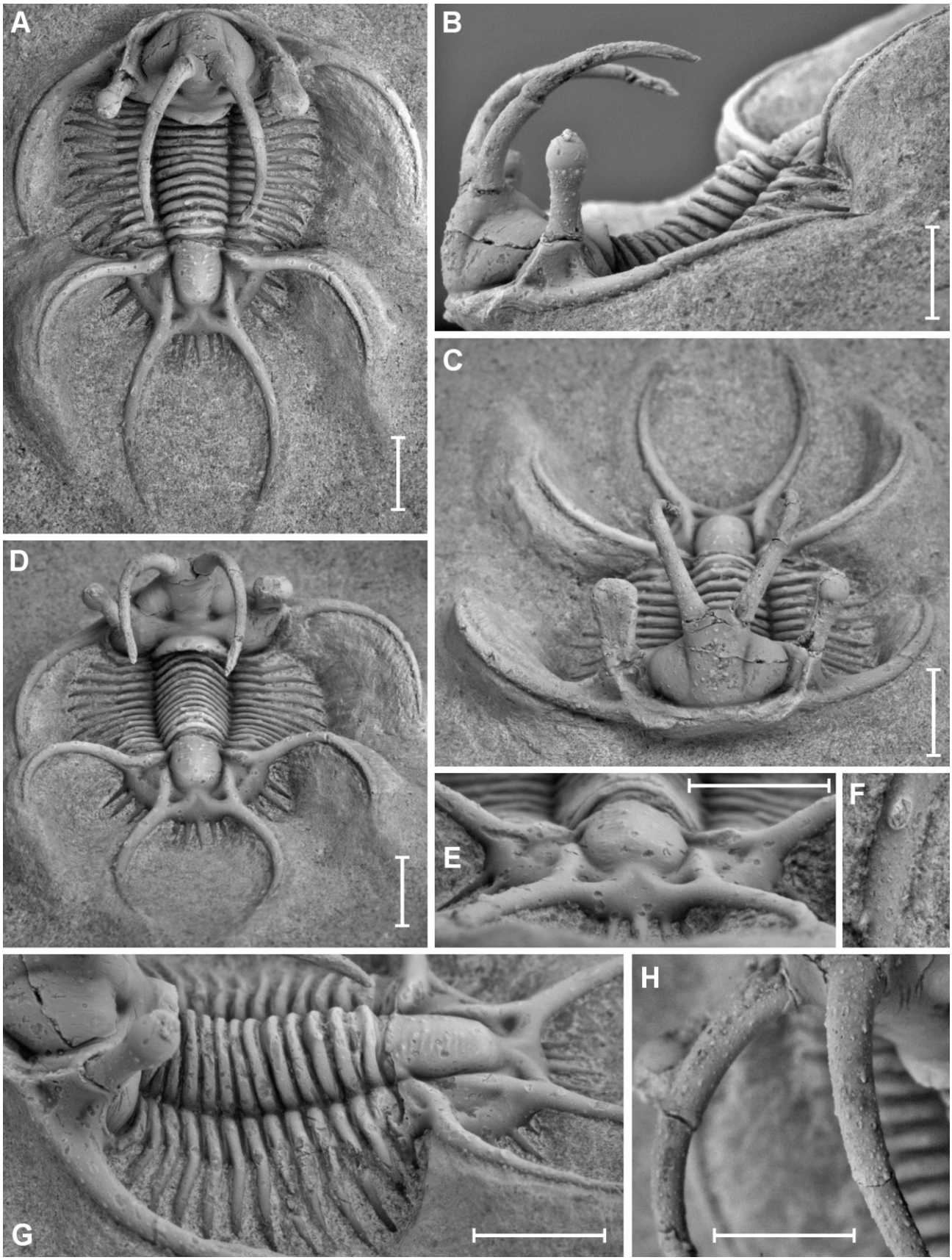

PLATE 1

Ceratarges ziregensis sp. nov. from the El Otfal Formation in Zireg, Morocco.

A-H. holotype complete specimen, NHMM 2011 001, in dorsal (A), oblique left lateral (B), anterior (C), oblique posterior (D), posterior (E), left dorsolateral (G) and right dorsolateral (H) views. F is close-up of anterior one-third of third pygidial pleural spine on the left side.

All scale bars indicate 5 mm, except for 1F (figure frame is 4 mm high).

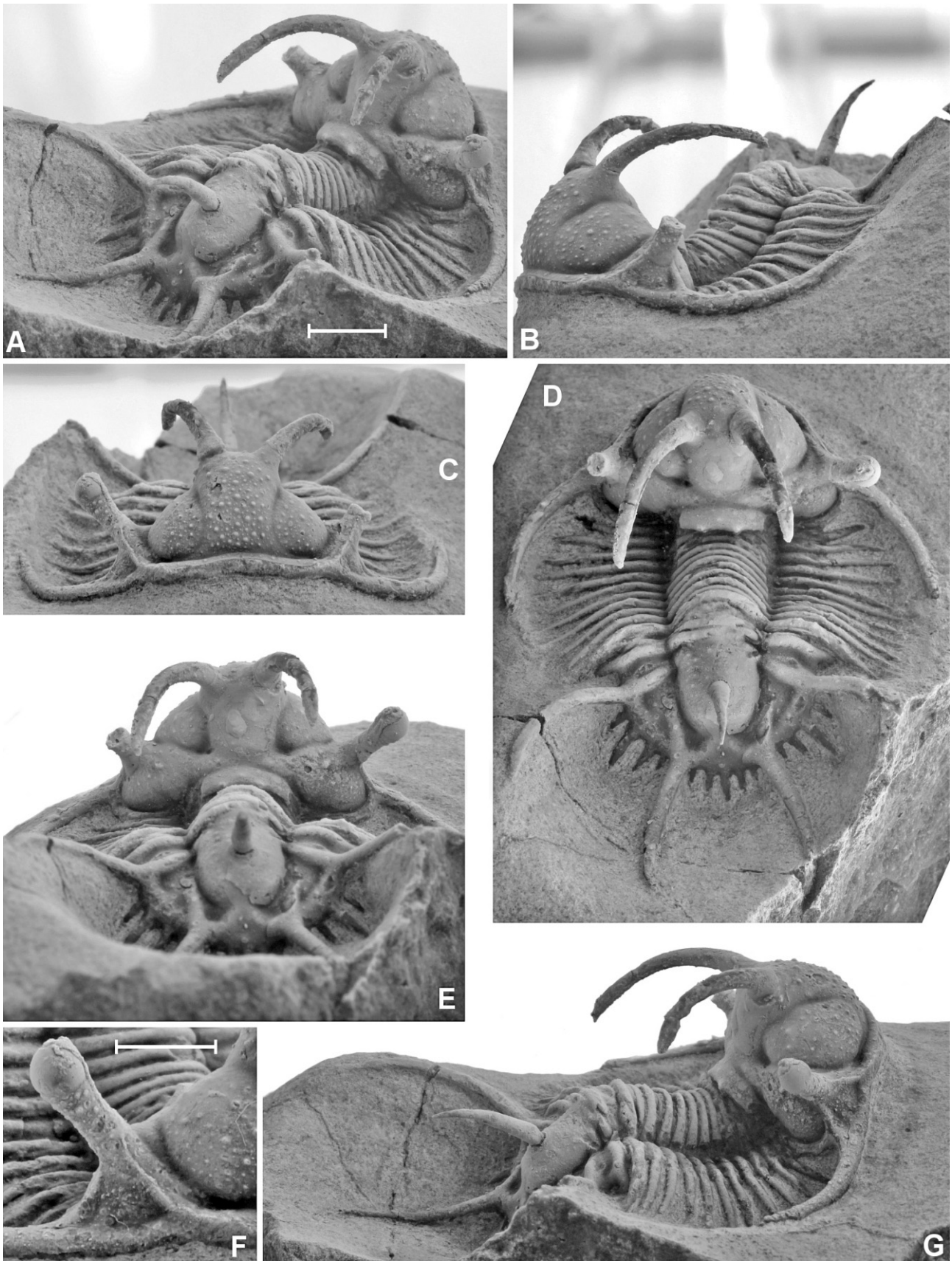

PLATE 2
Ceratarges koumalii sp. nov. from the El Otfal Formation in Zireg, Morocco.
A-G. holotype complete specimen, NHMM 2011 002, in posterolateral (A), anterolateral (B), anterior (C), dorsal (D), posterior (E), anterior (F) and right lateral (G) views.
All scale bars indicate 5 mm. Figs 2B-E and 2G are of same magnification as 2A.

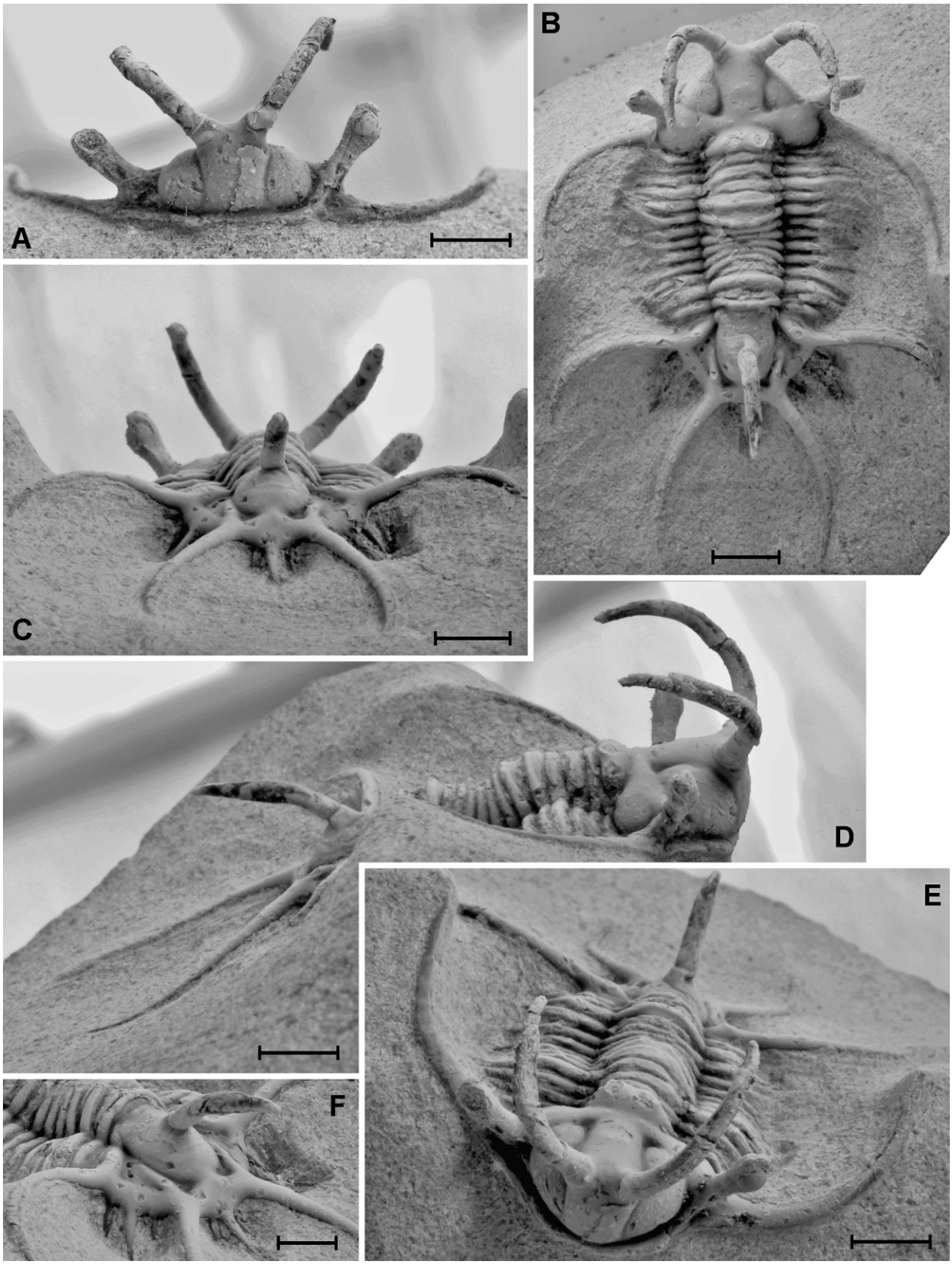

PLATE 3

Ceratarges aries sp. nov. from the El Otfal Formation in Zireg, Morocco.

A-E. holotype complete specimen, NHMM 2011 003, in anterior (A), dorsal (B), obliquely posterior (C), right lateral (D), obliquely anterior (E) and posterior (F) views.

All scale bars indicate 5 mm.

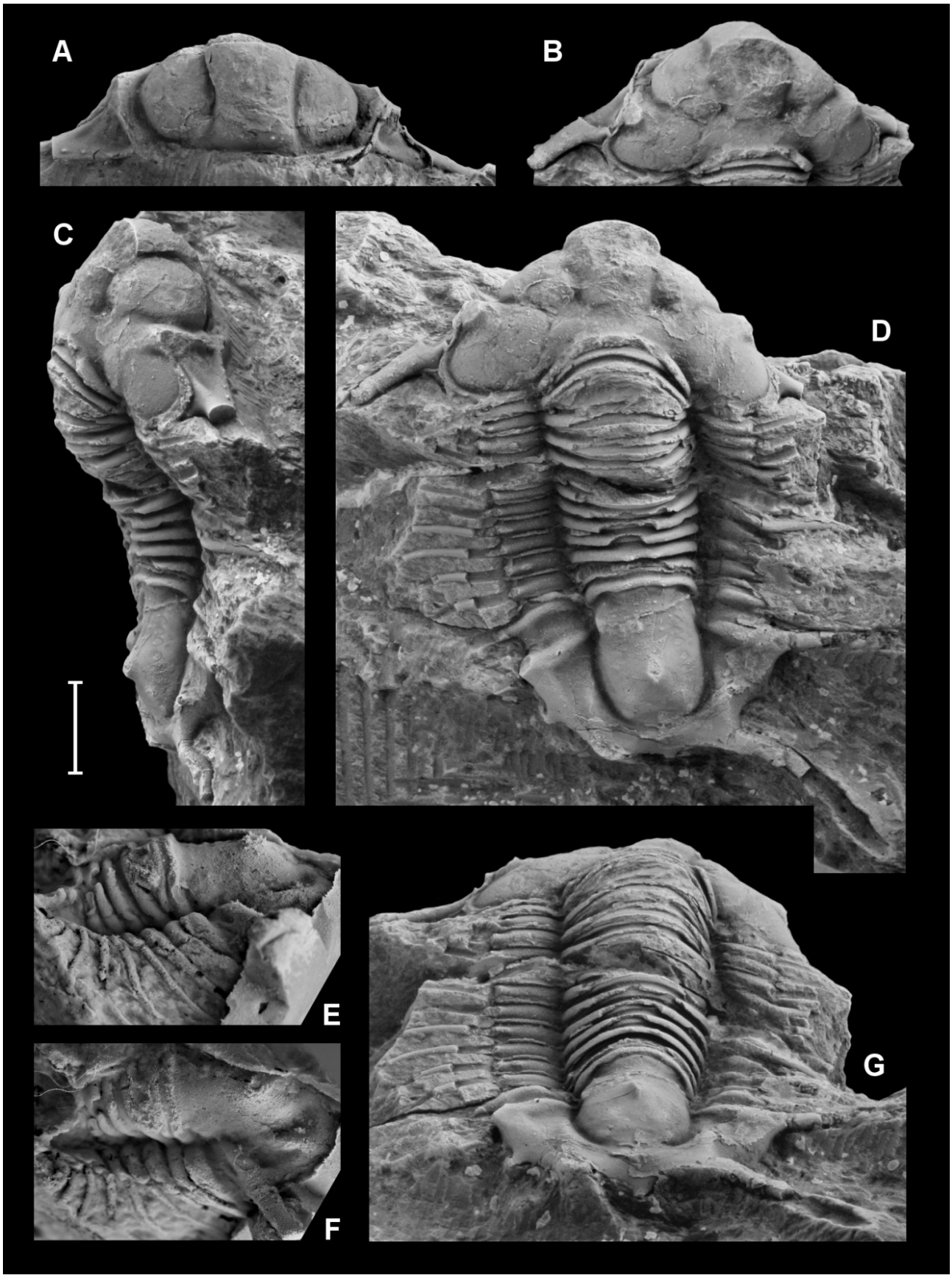

PLATE 4

Ceratarges cognatus van Viersen, 2006 from the Vieux Moulin Member of the Jemelle Formation in Vireux-Molhain, France.

A-D, G. internal mould of a complete specimen, NHMM 2011 004, in anterior (A), oblique dorsal (B) right lateral (C), dorsal (D) and posterior (G) views.

E, F. silicone cast of part of the thoracopygidium of a complete specimen, NHMM 2011 005, in left lateral (E) and dorsal (F) views.

All scale bars indicate 5 mm.