

# The Cambrian (Paibian–Jiangshanian; Steptoean) dokimocephalid trilobite *Deckera* Frederickson, 1949 in Laurentian North America

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**Non-technical Summary.**—New samples of *Deckera*, an uncommon genus of trilobites, show that it is widespread in marine Cambrian rocks of North America in the range of ~492–494 million years old. It could be represented by as many as nine species. The genus was originally defined in part by eyes that are elevated at or above the crest of the head region, but the oldest species are characterized by eyes that are much lower. All species share a relatively wide head region, which is now the most important diagnostic characteristic of *Deckera*.

**Abstract.**—The Cambrian dokimocephalid trilobite genus *Deckera* Frederickson, 1949 is a minor component of Steptoean (Jiangshanian) faunas of Laurentian North America. The original diagnosis emphasized strongly inflated palpebral areas of fixed cheeks and elevated palpebral lobes as important and novel characters. An appraisal of archival and new specimens from Oklahoma, Missouri, Pennsylvania, Nevada, Utah, and Newfoundland show that the genus is geographically widespread and likely represented by as many as nine species, although only two of them are named formally. *Deckera* cf. *D. aldenensis* Frederickson, 1949 from Nevada extends the stratigraphic range of *Deckera* down to the base of the Jiangshanian Stage, and new species from Nevada and Newfoundland take the genus down farther, into upper Paibian strata. Paibian species show that some basal members of the genus have weakly inflated, nearly flat palpebral areas with palpebral lobes that sit well below the crest of the glabella. A revised diagnosis of *Deckera* focuses on the broad cranidium with width across the palpebral lobes much greater than the sagittal length. Pygidia are known for a few species and all of them have an unusual flexure of the posterior margin and border. Lectotype and paralectotype specimens are designated for *Deckera completa*.

## Introduction

*Deckera* Frederickson, 1949 was named for a single figured cranidium from the Honey Creek Formation (Jiangshanian; Steptoean; *Elvinia* Biozone) from Oklahoma and was reported soon afterward from the coeval Gatesburg Formation of Pennsylvania (Wilson, 1951) with a larger sample that included a pygidium and librigena. However, the ensuing 50 years added only a handful of cranidia from Wyoming (Lochman and Hu, 1960), Oklahoma (Stitt, 1971), and Missouri (Kurtz, 1975), so that the genus remains at best a minor component of *Elvinia* Zone faunas of Laurentian North America.

Discovery of sclerites of two species from Nevada and Utah prompted restudy of type and new material of *Deckera aldenensis* Frederickson, 1949 from Oklahoma and the types of *Deckera completa* Wilson, 1951 from Pennsylvania. In addition, a few new specimens from Nevada and Newfoundland extend the range of *Deckera* down into Paibian strata and provide new information of character states of basal members of the clade. Although unquestionably rare, the new material documented

in this paper show that *Deckera* is surprising diverse and has some biostratigraphic utility. There could be as many as nine species in Steptoean strata of Laurentia, although small sample sizes prevent most of them from being named formally. This paper also continues a long-term project revising the diverse agnostid and trilobite faunas of the *Elvinia* Zone of the Great Basin and Oklahoma (Westrop et al., 2007, 2008, 2010; Westrop and Adrain, 2009a, b, 2013, 2016).

## Study areas and stratigraphic settings

The revision of *Deckera* makes use of type and other archival material from Oklahoma, Missouri, and Pennsylvania, and new specimens from Oklahoma, Nevada, Utah, and Newfoundland.

**Oklahoma.**—*Deckera aldenensis* occurs in the Honey Creek Formation in the hills on the north flank of the Wichita Mountains, Comanche County. The holotype is from exposures that lie immediately to the east (rather than west as stated by Frederickson, 1949, p. 345) of the current course of Highway 58 through a road cut in Blue Creek Canyon, in the northern half of section 24, township 4N, range 13W (Frederickson locality 6). New collections from the Honey Creek Formation

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that yielded this species are from Ring Top Mountain (Fig. 1.4; 34°51'1"N, 98°31'40"W), ~4.7 km north of locality 6. The succession was measured and logged as three stratigraphic sections (sections KR1, KR2, and KR3) that were correlated physically by pacing out a conspicuous carbonate marker bed around the western slopes of the hill (see Westrop et al., 2010, fig. 1, for locations and lithologic logs of the *Elvinia* Zone segments of the three sections and their correlation). A sample from section KR2 (KR2 50.3) that yielded *Deckera*, including *Deckera aldenensis*, was collected near the top of the marker bed, which comprises glauconitic, rippled bioclastic grain-and-rudstone with thin siliciclastic drapes. Associated species included *Dokimocephalus intermedius* (Resser, 1942) (see Westrop et al., 2010, fig. 1), *Camaraspis convexa* (Whitfield, 1878), *Dellea* cf. *D. suada* Wilson, 1949, and *Pterocephalia sanctisabae* Roemer, 1849. The highest occurrences of *Plataspella* Wilson, 1949 (Westrop et al., 2010, fig. 1) and *Kindbladia* Frederickson, 1948 (unpublished data, Westrop, 2024) are < 1 m below the sample horizon. This places *Deckera aldenensis* at the base of an informal upper division (Stitt, 1977; Westrop et al., 2007) of the *Elvinia* Zone that directly underlies the *Irvingella 'major'* Zone (Fig. 2). *Deckera* cf. *D. completa* (see Systematic paleontology section) occurred with *Deckera aldenensis* in collection KR2 50.3, and restudy of Frederickson's (1949, p. 345) material from his locality 9 in Kiowa County (which is the same locality as section BM of Blackwell and Westrop, 2023, fig. 1) yielded the same association.

A single cranidium assigned questionably to *Deckera completa* was recovered from the Dotson Ranch section (DR; Fig. 1.3; 34°29'33.09"N, 97°17'54.69"W; Westrop and Adrain, 2007; Westrop et al., 2010) in the Arbuckle Mountains of Garvin County. *Deckera completa?* is from collection DR 11.77–12.0, which lies immediately below the coincident bases of *Irvingella 'major'* Zone and the Sunwaptan Stage. It was associated with *Pterocephalia sanctisabae* and *Dokimocephalus oliveri* Westrop, Waskiewicz Poole, and Adrain, 2010. This collection was 6 m above the highest occurrence of *Kindbladia* and *Plataspella* (collection DR 5.75; Westrop et al., 2010; unpublished data, Westrop, 2024). The base of *Irvingella 'major'* Zone is 20 cm above collection DR 11.77–12.0 (collection DR 12.2) and is marked by the entry of *Bartonaspis fredericksoni* Westrop and Adrain, 2007, *Irvingella media* Resser, 1942 (Westrop and Adrain, 2016, fig. 18), and *Comanchia amplooculata* (Frederickson, 1949).

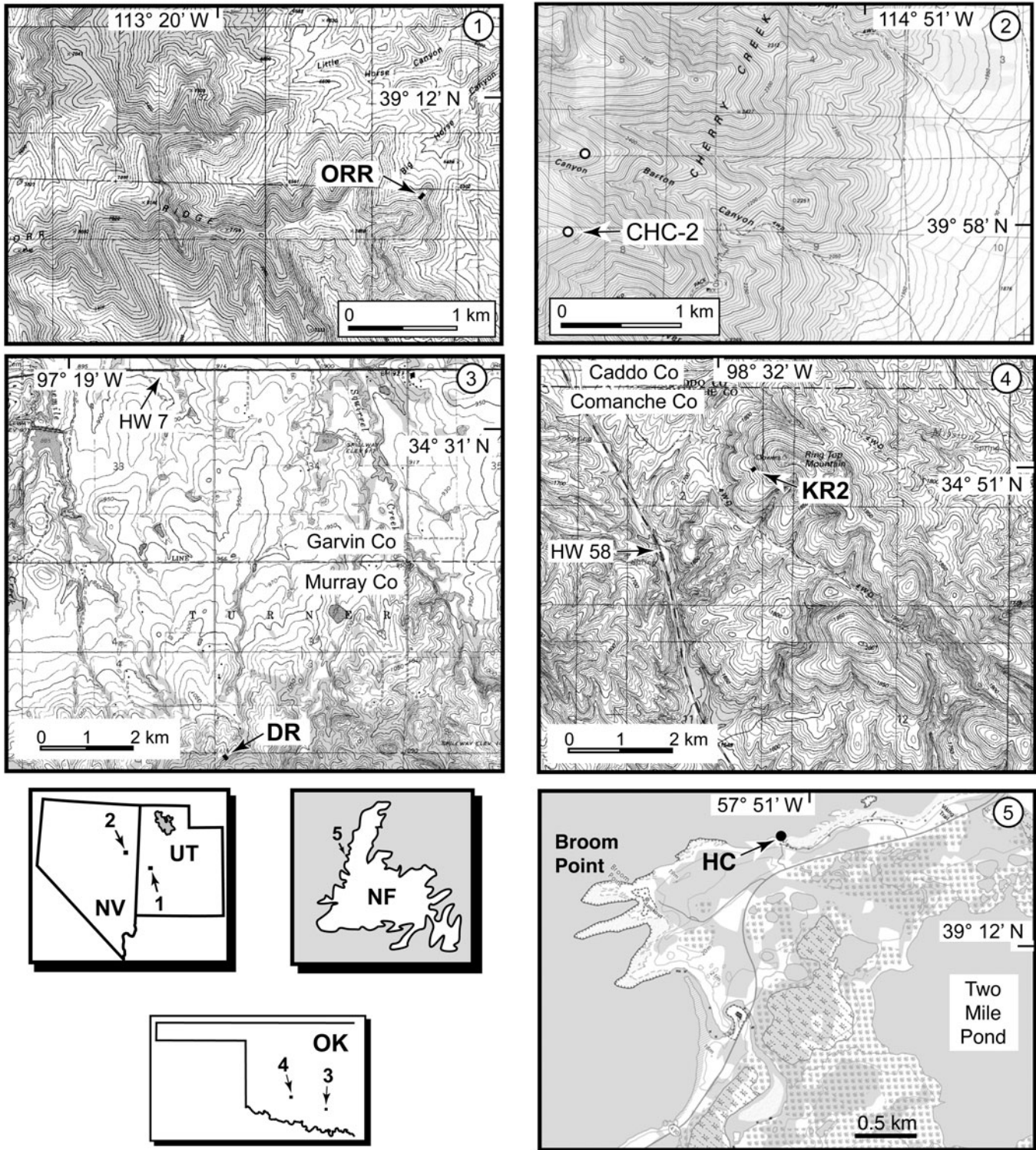
*Nevada*.—*Deckera* cf. *D. aldenensis* was recovered from a sample of bioclastic grain-and-rudstone (CHC-2-203.1) at the base of Barton Canyon Limestone Member of the Windfall Formation at Barton Canyon, Cherry Creek Range, White Pine County, Nevada. The section (CHC-2; Fig. 1.2) was measured on the western side of the canyon (39°57'58"N, 114°52'46"W) and extends down from the lower Catlin Member of the Windfall Formation to the base of the Dunderberg Formation. At section CHC-2, the Barton Canyon Limestone Member is a 14.1 m, cliff-forming carbonate unit (see Westrop et al., 2023, fig. 3 for a stratigraphic column). It consists mostly of stylo-bedded, bioturbated wackestone and cm-thick horizons of bioclastic packstone (e.g., Westrop et al.,

2023, fig. 8.5, 8.6), with a thicker interval of bioclastic grainstone and packstone at the base. A 10–20 cm thick, condensed bioclastic lag at the top of the member includes the *Irvingella 'major'* Zone (Westrop et al., 2023, fig. 9), which defines the base of the Laurentian Sunwaptan Stage. Trilobites associated with *Deckera* cf. *D. aldenensis* in collection CHC-2-203.1 included *Kindbladia* cf. *K. affinis* (Walcott, 1884) and undescribed species of *Dellea* Wilson, 1949 and *Pseudosaratogia* Wilson, 1951. *Kindbladia* is characteristic of the lower informal division of the *Elvinia* Zone (Stitt, 1977; Westrop et al., 2007, 2010), so that *Deckera* cf. *D. aldenensis* is older than *Deckera aldenensis* in Oklahoma.

The underlying Dunderberg Formation at CHC-2 is a 203 m thick succession of shale and carbonate that forms a recessive slope below the Barton Canyon Limestone Member. A single cranidium of *Deckera* new species 1 was recovered from a small collection made 138.5 m above the base of the formation. It lies in the Paibian *Dunderbergia* Zone (Fig. 2), 13 m below the base of *Elvinia* Zone, as marked by the lowest occurrence of *Housia ovata* Palmer, 1960 at 151.5 m in the section.

*Utah*.—The upper Orr Formation was studied at Orr Ridge (section ORR) in the northern House Range, Millard County, Utah (Fig. 1.1). The section was measured and logged on a NE–SW trending ridge that forms the southern side of Big Horse Canyon; the type section of the Orr Formation (Hintze and Palmer, 1976) is on the ridge immediately to the north. It was measured from the base of the Corset Spring Shale Member. At Orr Ridge, this member forms a recessive slope above the cliff-forming Johns Wash Limestone Member. It includes a poorly exposed, basal 8 m interval of green shale with minor carbonates that records a lowstand (Evans et al., 2003; Miller et al., 2012). Collection ORR 7.5 is a float sample from near the top of this interval and yielded rare cranidia of *Deckera* cf. *D. aldenensis* (Fig. 2). Associated with *Deckera* cf. *D. aldenensis* in this collection were *Irvingella angustilimbata* Kobayashi, 1938 (see Westrop and Adrain, 2016); *Bynumina globosa* (Walcott, 1884) (see Westrop et al., 2007); *Pseudokingstonia exotica* Palmer, 1965 (see Westrop and Adrain, 2009b); *Kindbladia* cf. *K. affinis*; as well as undescribed species of *Dellea* and *Pseudosaratogia* that also occur in collection CHC-2-203.1 at Barton Canyon, Nevada (see above). As in the occurrence in collection CHC-2-203.1, this assemblage also placed *Deckera* cf. *D. aldenensis* in the lower informal division of the *Elvinia* Zone. From its position in the Corset Spring Shale with *I. angustilimbata*, it extends the range of the genus down toward the base of the zone and the base of the Jiangshanian Stage.

Higher in the succession at Orr Ridge, the Sneakover Limestone Member overlies the Corset Spring Shale. A cranidium and pygidium of *Deckera* sp. indet. 1 were recovered from a collection made 59.4 m above the base of section ORR, which also included *Elvinia* cf. *E. roemeri* (Shumard, 1861), *Labiostria* cf. *L. westropi* Chatterton and Ludvigsen, 1998, and *Pterocephalia* sp. indet. The collection was less than a meter below the base of the Sunwaptan Stage, as defined by collection ORR 60.3–60.4, which yielded *Bartonaspis palmeri* Westrop and Adrain, 2007, *Bartonaspis wilsoni* Westrop and Adrain, 2007, *Kormagnostella advena* Westrop and Adrain, 2013, as well as species of



**Figure 1.** Maps showing localities that yielded new material illustrated in this paper: (1) section ORR, measured on the ridge on the southeastern side of Big Horse Canyon, Orr Ridge, northern House Range, western Utah; (2) section CHC-2, measured on the southwestern side of Barton Canyon, Cherry Creek Range, eastern Nevada; (3) Dotson Ranch (DR) section, measured in northern Murray County, southern Oklahoma; (4) section KR2, measured on the western slopes of Ring Top Mountain, southern Oklahoma; (5) Hickey Cove (HC), to the east of Broom Point, Cow Head region, western Newfoundland.

*Irvingella* Ulrich and Resser in Walcott, 1924, *Comanchia* Frederickson, 1949, and *Stenambon* Palmer, 1965. The position in uppermost Steptoean strata indicates that *Deckera* sp. indet. 1 is one of the youngest known representatives of the genus (Fig. 2).

*Newfoundland.*—Two cranidia of what is among the older species of *Deckera*, *Deckera* new species 2, are from a boulder (HC 166) in a debris flow conglomerate near the top of the Downes Point Member of the Shallow Bay Formation

Stages	Zones	Nevada	Utah	Oklahoma	Penn.	Newf.
Paibian	Steptoean	Dunderbergia	Dunderberg Formation	Johns Wash Limestone Mbr.	Lower Sandy Member	Shallow Bay Formation
I. 'major'	Windfall Formation	Sneakover Limestone Member	Reagan Sandstone Fm.	Ore Hill Member	6	
						Taenicephalus
Sunwaptan	Catin Member	1	2?	2		
					Jianshangian	Windfall Formation
5	6	1	2	2		

**Figure 2.** Stratigraphic distribution of species of *Deckera* treated in this paper. The biostratigraphy of the *Elvinia* Zone is based on Stitt's (1977) informal division into three subunits. The youngest of these was formalized by Chatterton and Ludvigsen (1998) as the *Irvingella* 'major' Zone; 'lower' and 'upper' represent the two underlying divisions. Species indicated by numbers are: (1) *Deckera aldenensis* Frederickson, 1949 and *Deckera* cf. *D. completa* Wilson, 1951; (2) *Deckera completa* Wilson, 1951; (3) *Deckera* cf. *D. aldenensis* Frederickson, 1949; (4) *Deckera* sp. indet. 1; (5) *Deckera* n. sp. 1; (6) *Deckera* n. sp. 2 and *Deckera* n. sp. 3.

at Hickey Cove, western Newfoundland (Fig. 1.5). Westrop and Eoff (2012, fig. 2) provided a stratigraphic column showing the position of the conglomerate. Agnostoid arthropods from HC 166 were assigned to the *Acmahachis kindlei* Fauna by Westrop and Eoff (2012), which they correlated with the *Dunderbergia* Biozone of the Great Basin. *Deckera* new species 3 is from a different boulder (HC 202) from the same conglomerate at Hickey Cove that also belongs to the *Acmahachis kindlei* Fauna (Westrop and Eoff, 2012). Trilobites present in HC 166 and/or HC 202 included *Onchopeltis* cf. *O. spectabilis* Rasetti, 1944, *Pterocephalops* cf. *P. tuberculineata* Clark in Clark and Shaw, 1968, *Quebecaspis* cf. *Q. marylandica* Rasetti, 1961, *Q.* cf. *Q. conifrons* Rasetti, 1961, and undescribed species of *Bathyholcus* Rasetti, 1959 and *Glyptometopsis* Rasetti, 1959. This trilobite fauna is also consistent with a correlation into the *Dunderbergia* Zone (Westrop and Engel, 2023).

**Pennsylvania.**—Our study is restricted to the type specimens of *Deckera completa* from the Ore Hill Member of the Gatesburg

Formation. Loch and Taylor (1995, 2004; Taylor et al., 1999) restudied the Ore Hill Member at several of Wilson's (1951) localities, and their measured sections (Taylor et al., 1999, fig. 2; Loch and Taylor, 2004, fig. 3) showed that it comprises a succession of shallow water carbonates, including microbial reefs. Their abundance data for reef, inter-reef grainstone, and subtidal tempestite facies (Taylor et al., 1999, fig. 6; Loch and Taylor, 2004, table 1) showed that *Deckera* is, as in other regions, a minor component of the trilobite fauna. *Deckera completa* enters the succession at the base of the *Cliffia latagenae* Subzone of the *Elvinia* Zone as defined by Loch and Taylor (1995, fig. 8), and extends to the top of this unit, which is defined by the base of the overlying *Irvingella* 'major' Zone. The occurrence of species of *Kindbladina* and *Plataspella* in the lower *Cliffia latagenae* Subzone (Loch and Taylor, 1995, fig. 8; 2004, fig. 2), indicates that the basal part of this unit is correlative with Stitt's (1977) lower informal division of the *Elvinia* Zone.

**Missouri.**—Kurtz (1975) illustrated a single cranidium that he identified as *Deckera* cf. *D. aldenensis*, but it is clearly

distinct from *Deckera aldenensis* and is regarded as an indeterminate species here (see remarks on *Deckera* sp. indet. 2 below). This specimen is from Member B of the Davis Formation at Kurtz's (1975) section 9 (collection 977.67-2), where it is part of a diverse fauna that includes *Calocephalites vulgaris* Kurtz, 1975, *Calocephalites minimus* Kurtz, 1975, *Elvinia roemeri*, *Iddingsia missouriensis* Resser, 1942, *Pseudosaratogia davisii* Kurtz, 1975, *Pterocephalia sanctisabae*, *Pulchricapitus davisii* Kurtz, 1975, and *Kindbladia affinis*. This places the cranidium in Stitt's (1977) lower informal division of the *Elvinia* Zone, although Kurtz (1975, p. 1026, fig. 6) listed *Deckera* cf. *D. aldenensis* as occurring in the overlying Unit C (collection 977.67-6), which would extend the range into the upper informal division.

## Materials and methods

Specimens were coated with a sublimate of ammonium chloride prior to photography. Depth of field was maximized by rendering digital images from stacks of images focused at 100  $\mu$ m intervals using Helicon Focus 4.0 for the Macintosh (<http://www.heliconsoft.com>). Proportions expressed as percentages in descriptions and diagnoses are means, with the pair of numbers following indicating the range of values; unless indicated otherwise, data were derived from figured specimens. All measurements were made on digital images to the nearest tenth of a millimeter using the Measure Tool of Adobe Photoshop™.

Numbering and descriptive terminology for glabellar lobes and furrows follows Henningsmoen (1957), with the occipital furrow designated as SO (sulcus occipitalis) and the occipital ring designated as LO (lobus occipitalis). Other abbreviations include: exsag. = exsagittal; sag. = sagittal; tr. = transverse.

*Repositories and institutional abbreviations.*—Illustrated specimens are housed at the Geological Survey of Canada, Ottawa (GSC); the Oklahoma Museum of Natural History, University of Oklahoma, Norman (OU); and the Peabody Museum, Yale University, New Haven, Connecticut (YPM).

## Systematic paleontology

Family Dokimocephalidae Kobayashi, 1935  
Genus *Deckera* Frederickson, 1949

*Type species.*—*Deckera aldenensis* Frederickson, 1949 from the Honey Creek Formation, Arbuckle and Wichita mountains, Oklahoma (by original designation).

*Emended diagnosis.*—Dokimocephalidae with subrectangular cranidium with width (tr.) noticeably greater than length (sag.); broad (tr.) fixigenae. Consequently, anterior border forms wide rim. Glabella convex, tapered, and subrounded anteriorly; relatively long, occupying at least 70% of cranial length. In all but some basal species, lateral glabellar furrows weak and can be expressed mostly as smooth regions lacking sculpture. Preglabellar field short. Palpebral area of fixed cheek steeply upsloping abaxially, with top near level of crest of glabella, but some basal species have gently inflated, nearly

flat palpebral areas. Margin of pygidium strongly flexed in posterior view. Long, multisegmented axis with at least five axial rings in front of terminal piece.

*Remarks.*—The original diagnosis of *Deckera* by Frederickson (1949), based on species from Jiangshanian strata, included strongly upsloping fixed cheeks and elevated palpebral lobes as important characters. The discovery of older (Paibian) species in the Dunderberg Formation of Nevada (*Deckera* n. sp. 1 herein) and the Shallow Bay Formation of Newfoundland (*Deckera* n. sp. 2 and *Deckera* n. sp. 3 herein) provides information on the anatomy of what we interpret as basal members of the genus that have some, but not all, of the characters of Jiangshanian species, e.g., *Deckera aldenensis* and *Deckera completa*. As discussed below, *Deckera* n. sp. 1 and *Deckera* n. sp. 3 have gently inflated fixed cheeks that are nearly flat or even slightly down-sloping near the palpebral lobe. However, *Deckera* n. sp. 2 is closer to *Deckera aldenensis*, and has fixed cheeks that slope upward to the level of the crest of the glabella. In other respects, the Paibian species are quite similar and seem to grade toward the more derived set of Jiangshanian species (see remarks on *Deckera* n. sp. 3, below). We modify the diagnosis here to accommodate species with gently inflated fixed cheeks and, consequently, palpebral lobes that are not elevated. The Paibian species also have more firmly incised lateral glabellar furrows. Cranial characters emphasized in the revised diagnosis include a broad cranidium with wide palpebral areas of the fixigenae and, consequently, a wide (tr.) anterior border. Where known, the pygidium has a distinctive flexure of the margin in posterior view.

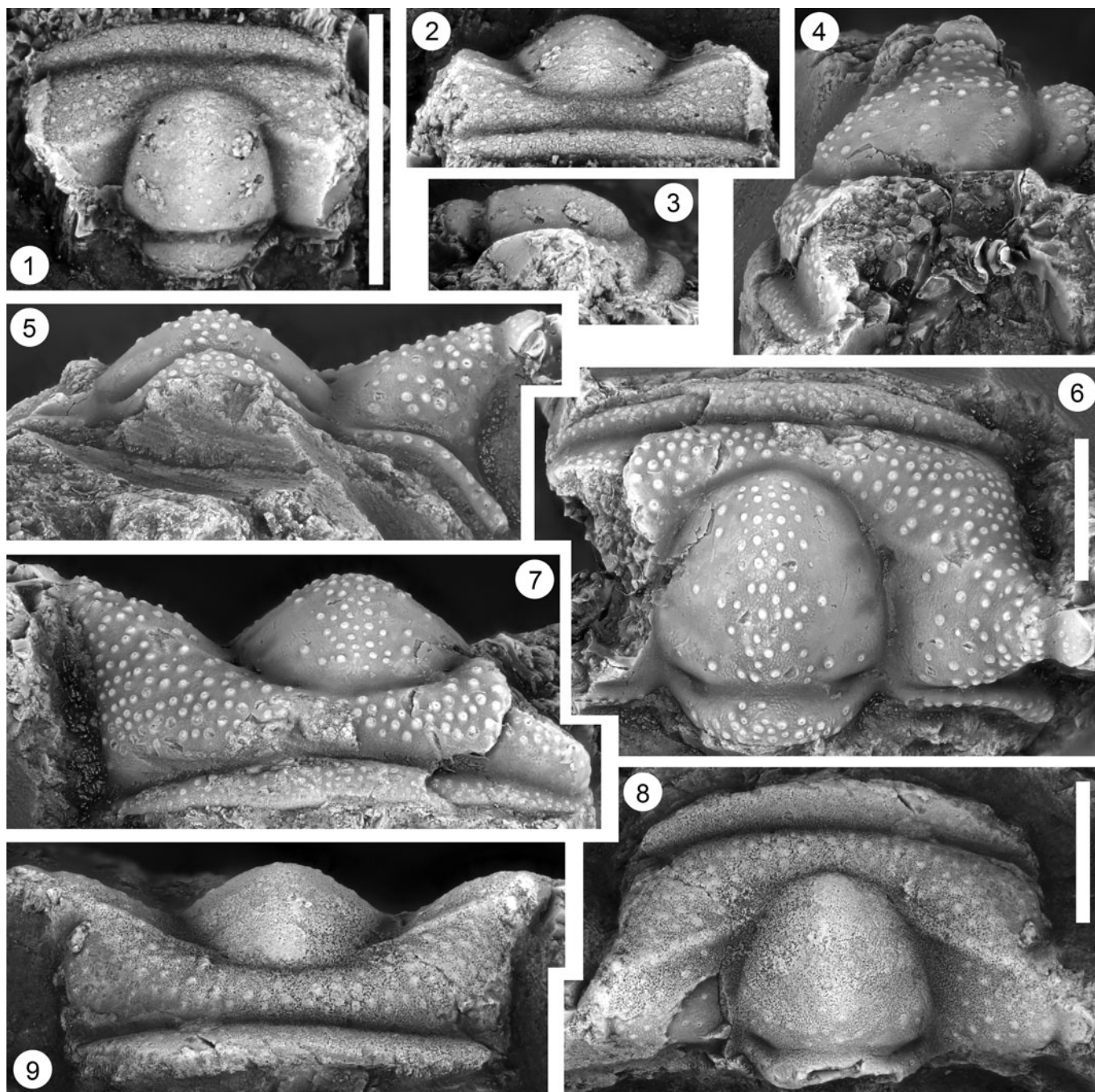
Expanding the diagnosis of *Deckera* is in our view preferable to establishing a new genus for the Paibian species, as such a genus would likely be paraphyletic. Our hypothesis of relationships can be evaluated by a broad phylogenetic analysis of family Dokimocephalidae. This would need to expand an initial revision and analysis of *Dokimocephalus* and closely related genera (Westrop et al., 2010) to include not only *Deckera*, but also such genera as *Kindbladia*, *Dellea*, and *Pseudosaratogia*. This will be a substantial undertaking and is well beyond the scope of this paper.

*Deckera aldenensis* Frederickson, 1949  
Figures 3, 4.7, 4.8

1949 *Deckera aldenensis* Frederickson, p. 350, pl. 68, figs. 22–24.

*Holotype.*—A cranidium (OU 4305; Fig. 3.4–3.7) from the Honey Creek Formation, Blue Creek Canyon region, Comanche County, Oklahoma (Frederickson, 1949, locality 6).

*Diagnosis.*—Palpebral area upsloping at  $\sim 25^\circ$ , rising just above level of crest of glabella. Palpebral lobe short (exsag.), upturned flap opposite L1 glabellar lobe, with length equal to  $\sim 20\%$  of glabellar length. Palpebral furrow shallow; palpebral lobe separated from palpebral area largely by change in slope. Coarse granules on entire external surface, including borders; well developed on crest of glabella and posterior half of LO,



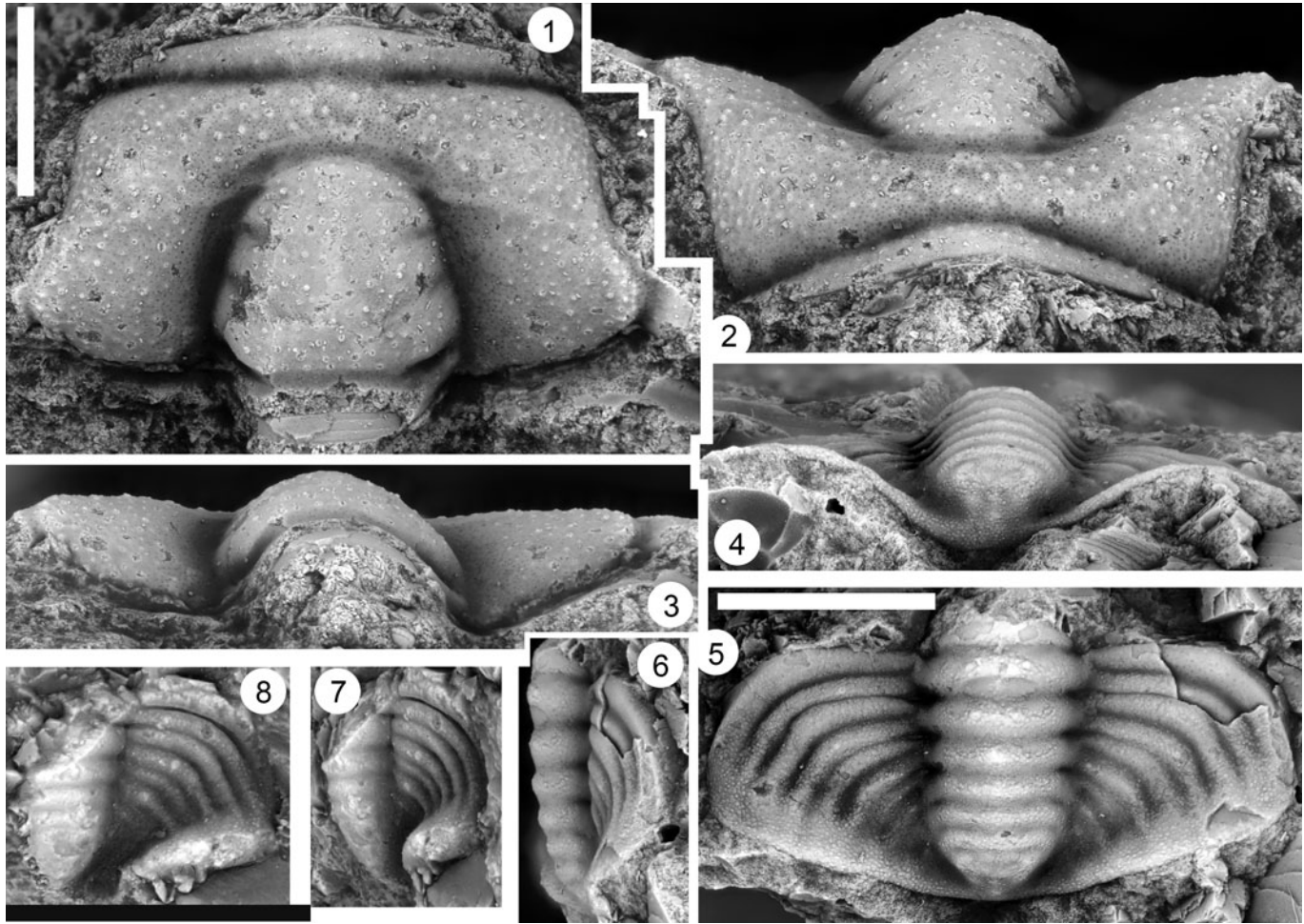
**Figure 3.** Cranidia of *Deckera aldenensis* Frederickson, 1949 from the Honey Creek Formation, Oklahoma: (1–3) OU 12226, dorsal, anterior, and lateral views, Ring Top Mountain, Comanche County, collection KR2 50.3; (4–7) OU 4305 (holotype), lateral, posterior, dorsal, and anterior views, one-third mile west of HW 58, Blue Creek Canyon, Comanche County (Frederickson, 1949, locality 6); (8, 9) OU 55068, dorsal and anterior views, Frederickson's (1949, p. 345) locality 9 (collecting horizon unknown), which is equivalent to section BM of Blackwell and Westrop (2023, fig. 1). Scale bars (each pertaining to set from same catalog number) = 2 mm.

augmented by fine granules, but limited to scattered tubercles on lateral lobes; reduced density of coarse granules on adaxial part of palpebral area.

**Occurrence.**—Honey Creek Formation, Wichita Mountains region, Oklahoma, including Frederickson (1949, p. 345) localities 6 (Comanche County) and 9 (Kiowa County; this is section BM of Blackwell and Westrop, 2023); Ring Top

Mountain, section KR2 (Westrop et al., 2010), collection KR2 50.3 (Comanche County).

**Description.**—Cranidium subrectangular, broad (tr.), width across palpebral lobes 163% (140–176%) of cranial length. Axial and preglabellar furrows deeply incised. Convex, tapered, anteriorly rounded glabella occupying ~35% of width across palpebral lobes and ~75% of cranial length; width of



**Figure 4.** *Deckera* spp. from Missouri, Pennsylvania, and Oklahoma: (1–3) *Deckera* sp. indet. 2, cranium, OU 3522, dorsal, anterior and posterior views, from Unit B, Davis Formation, St. Francois County, Missouri, collection 977.67-2 (Kurtz, 1975); (4–6) *Deckera completa* Wilson, 1951, pygidium, YPM 18566 (paralectotype), posterior, dorsal, and lateral views, from the Ore Hill Member, Gatesburg Formation, Bedford County, Pennsylvania, Potter Creek–Scott Fisher Farm section, collection 47-5w.8a (Wilson, 1951); (7, 8) *Deckera aldenensis* Frederickson, 1949, pygidium, OU 12227, lateral and dorsal views, from the Honey Creek Formation, Ring Top Mountain, Comanche County, Oklahoma, collection KR2 50.3. Scale bars (each pertaining to set from same catalog number) = 2 mm.

glabella at SO is ~78% (76–80%) of glabellar length. LO occupying ~14% (13–15%) of cranial length, 19% (17–21%) of glabellar length. SO widest (sag.) medially, turning anteriorly, tapering abaxially. Two pairs of faint, oblique glabellar furrows defined in part by absence of sculpture. S1 gently impressed but more distinct, extending farther inward than S2. Palpebral area of fixed cheeks upsloping at angle of ~25°, rising slightly above glabella; broad, equal to ~70% of glabellar width at anterior end of S1. Convex palpebral ridge present, extending from palpebral lobe to reach axial furrow just beyond S2. Palpebral lobe small, semicircular in outline, upsloping, with length equal to ~20% of glabellar length; situated opposite L1. Frontal area short, occupying ~25% of cranial length, equal to 36% of glabellar length. Preglabellar field steeply sloping, convex; occupying 44% (40–46%) of frontal area length. Firmly impressed border furrow nearly transverse, curved only slightly forward in dorsal view. Anterior border widest (sag.) medially, tapering slightly abaxially, weakly crescent-shaped in outline. Anterior branches of facial suture nearly parallel, directed slightly inward before converging along anterior cranial margin;

posterior branches of sutures descending steeply from palpebral lobe before diverging along short (exsag.; tr.) posterolateral projection. Posterior area short (exsag.), flexed steeply downward abaxially (Fig. 3.5). Posterior border furrow as narrow groove near axial furrow but widening (exsag.) abaxially; posterior border convex, also widening abaxially. Coarse granules scattered over fixigenae, including row on posterior border; density of granules reduced adaxially on palpebral area; coarse and fine granules developed on crest of glabella, including LO, with single rows of widely spaced granules on L1 and L2 glabellar lobes.

Pygidium with strongly curved anterior margin, widest at corner opposite terminal piece. Narrow, convex axis occupying ~30% of maximum pygidial width; at least five transverse axial rings and terminal piece separated by faint ring furrows. Pleural and interpleural furrows as finely etched grooves, nearly straight at axial furrows but curving downward and backward to disappear at border; separate anterior and posterior pleural bands of roughly equal length. Pleural field flexing downward to upturned border, forming ‘valley’ in lateral view (Fig. 4.7), but distinct, independently incised border furrow absent.

Pygidial margin curved downward medially in posterior view. Small granules present throughout the pleural field; single large granule on posterior pleural bands.

*Remarks.*—One of the more distinctive characters of the holotype cranidium of *Deckera aldenensis* is the short (exsag.) palpebral lobe (Fig. 3.6), and a previously unfigured cranidium from Frederickson's (1949) locality 9 (Fig. 3.8) confirms the size and shape of this feature.

The cranidium of *Deckera completa* (Fig. 5) from the Ore Hill Member of the Gatesburg Formation has more steeply inclined fixed cheeks (compare Fig. 5.3, 5.4, 5.9 with Fig. 3.2, 3.7, 3.9). The palpebral lobe of *Deckera aldenensis* is equal to only approximately one-fifth (21%) of glabellar length, whereas the palpebral lobe of *Deckera completa* is longer (exsag.) and equal to slightly more than one-third (36%) of glabellar length (e.g., Fig. 5.1, 5.10). The well-defined palpebral furrow of *Deckera completa* differs from the more gently impressed furrow of *Deckera aldenensis*, although preservation as internal molds (Fig. 5.1, 5.5, 5.10) could have accentuated the greater incision in the former. *Deckera aldenensis* has coarser granules on the fixigenae that are more abundant than those of *Deckera completa*, and the crest of the glabella also carries more coarse granules (compare Fig. 3.6, 3.7 with Fig. 5.9, 5.10); coarse granules are also present on the posterior pleural bands of the pygidium of *Deckera aldenensis* (Fig. 4.7, 4.8). The pygidium also differs from *Deckera completa* (Fig. 4.4–4.6) in having a narrower pleural field, and the pleural and interpleural furrows start curving backward relatively closer to the axis.

*Deckera completa* Wilson 1951  
Figures 4.4–4.6, 5, ?6.6–6.8

1951 *Deckera completa* Wilson, p. 634, pl. 90, figs. 10–17.  
non 1971 *Deckera completa*; Stitt, p. 18, pl. 1, fig. 16 (= *Deckera* sp. indet.).

*Type specimens.*—Wilson (1951, p. 634) did not designate a holotype among his type specimens, although he referred to both a “type cranidium” and a “type pygidium” in the caption to his plate 90. This “type cranidium” (Wilson, 1951, pl. 90, fig. 10; YPM 18565), from the northern side of Potter Creek, 55 ft (16.75 m) above the base of the Orr Hill member, Gatesburg Formation, Pennsylvania, is here designated as the lectotype. Four other specimens (YPM 18564, 18566, 18567, 18568) are designated as paralectotypes.

*Diagnosis.*—Crescent-shaped anterior border longer than preglabellar field, occupying up to 57% of frontal area length (sag.). Glabellar furrows faint, defined largely by absence of sculpture on external surface (Fig. 5.10), but weakly incised on internal mold (Fig. 5.1). Palpebral area sloping steeply upward at ~45°, rising above crest of glabella. Palpebral lobe equal to more than one-third (36%) of glabella and located opposite L1 glabellar lobe, with posterior tip extending back to level of SO. Sculpture of fine granules with scattered coarser granules on glabella except for lateral furrows. Sparsely distributed larger granules on fixed cheeks, better

expressed on internal mold; anterior border carrying only very fine granules.

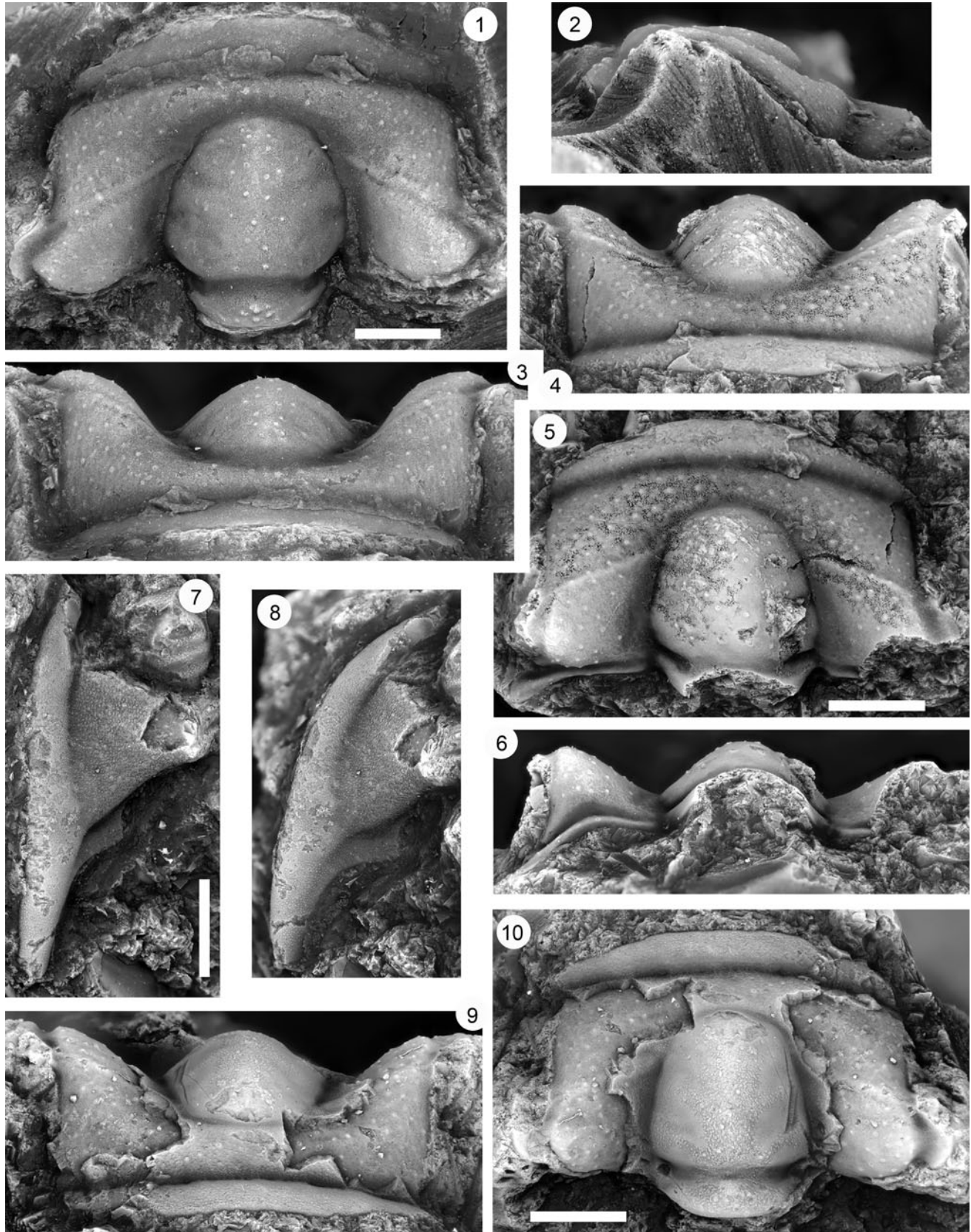
*Occurrence.*—Ore Hill Member, Gatesburg Formation, Pennsylvania; ?Honey Creek Formation, Dotsen Ranch (section DR), Garvin County, Oklahoma, collection DR 11.77–12.0.

*Description.*—Cranidium subrectangular, broad. Cranial width across palpebral lobes equal to 157% (153–161%) of length. Well-incised axial and preglabellar furrows. Glabella convex, elliptical in outline, rounded anteriorly, occupying 36% (36–37%) of cranial width. Glabella accounting for 71% (70–72%) of cranial length. LO length 15% (14–16%) of cranial length, 21% (19–23%) of glabellar length. SO shallowest medially, deeply incised, curving forward abaxially. S1 and S2 faint, oblique, defined mostly as smooth areas that lack granulate sculpture like rest of glabella; S1 extending farther inward. Palpebral area of fixed cheeks sloping steeply upward, cresting above glabella. Width of palpebral area 71% (65–75%) of glabellar width at L1. Gently convex palpebral ridge extending obliquely to reach axial furrow just in front of S2. Palpebral lobe semicircular in outline, situated opposite L1, of length 36% (36–37%) of glabellar length. Frontal area occupying 28% of cranial length, equal to 40% of glabellar length. Preglabellar field short, steeply sloping, accounting for 12% (11–13%) of cranial length, 43% (39–47%) of frontal area. Anterior border furrow firmly impressed and gently curved. Anterior border arcuate, broad, nearly flat. Anterior branches of facial suture nearly parallel between palpebral lobe and anterior border, flexing slightly abaxially; posterior branches angling sharply outward. Posterolateral projection very short (exsag.; tr.), flexing backward and downward. Posterior border narrow (exsag.) near axial furrow but widening abaxially. Posterior border furrow as well-defined groove, deepening abaxially. Sculpture of external surface of preglabellar field and fixed cheeks finely granulate, augmented by scattered large granules. Combination of finer and scattered coarse granules also present on glabella aside from furrows. Anterior border very finely granulate.

Librigenal field of free cheek convex, tall, sloping steeply upward from border furrow. Lateral border of free cheek broad near base of genal spine, tapering anteriorly. Genal spine stout, short, curving inward slightly in dorsal view, nearly horizontal in lateral view. Border furrow shallow throughout but becoming very faint toward base of genal spine. Posterior border well defined, broad. Fine granules present throughout; ill-defined coarser granules present on librigenal field.

Pygidium subtrapezoidal in outline. Anterior margin transverse, then flexing backward, with maximum width opposite fourth axial ring at distinct ‘corner.’ Pygidial length ~53% of maximum pygidial width. Axis convex, occupying ~90% of pygidial length; width at first axial ring equal to ~30% of maximum pygidial width. Six transverse axial rings; short terminal piece. Axial ring furrows firmly impressed. Pleural furrows well incised; interpleural furrows more finely etched. Pleural bands roughly equal in length (exsag.), nearly straight near axial furrow but curving strongly backward abaxially. Pleural





**Figure 5.** *Deckeria completa* Wilson, 1951 from the Ore Hill Member, Gatesburg Formation, Pennsylvania: (1–3) cranidia, YPM 18565 (previously unfigured specimen cataloged under the same number as the lectotype), dorsal, lateral, and anterior views, Potter Creek-Scott Fisher Farm section, Bedford County, collection 47-5w.8a; (4–6) cranidia, YPM 18567 (paralectotype), anterior, dorsal, and posterior views, Potter Creek-Scott Fisher Farm section, Bedford County, collection 47-5w.3; (7, 8) *librigena*, YPM 18568 (paralectotype), lateral and dorsal views, Potter Creek South section, Bedford County, collection 47-6w.6; (9, 10) cranidia, YPM 18564 (paralectotype), anterior and dorsal views, Drab section, Blair County, collection 47-3w.19. Scale bars (each pertaining to set from same catalog number) = 2 mm.

field flexing downward to upturned border. Border defined largely by absence of pleural and interpleural furrow; narrowing posteriorly. Posterior margin curving downward medially in posterior view. Fine granules present on axis, pleural bands, and border. Two anterior axial rings with pair of poorly defined larger granules.

**Materials.**—A cranidium (YPM 18564, paralectotype), from south side of an asphalt township road west of Drabb-Beavertown, Drabb, Pennsylvania, collection 47-3w.19, 48 ft (14.6 m) above the base of the Ore Hill Member (Wilson, 1951). Free cheek (YPM 18568, paralectotype) from the southern side of Potter Creek, just north of Maria, Pennsylvania, collection 47-6w.6, 77 ft (23.5 m) above the base of the Ore Hill Member (Wilson, 1951). A pygidium (YPM 18566, paralectotype) and a previously unillustrated cranidium (YPM 18565, not type material) from northern side of Potter Creek, collection 47-5w.8a, 55 ft (16.75 m) above the base of the Orr Hill Member (Wilson, 1951). A cranidium (YPM 18567; paralectotype) from the northern side of Potter Creek, collection 47-5w.3, 32 ft (9.75 m) above the base of the Ore Hill Member (Wilson, 1951). A cranidium (Fig. 6.6–6.8) from the Honey Creek Formation at Dotson Ranch, Oklahoma, is assigned questionably to the species.

**Remarks.**—Stitt (1971, pl. 1, fig. 16) assigned an incomplete cranidium from the Honey Creek Formation at Royer Ranch, Murray County, Oklahoma, to *Deckera completa*, but this specimen is too poorly preserved to be identified with any confidence. As recognized by Kurtz (1975, p. 1026), it is unusual in displaying a transverse posterior margin. A cranidium (Fig. 6.6–6.8) from the Honey Creek Formation at Dotson Ranch (5.6 km northwest of the Royer Ranch section), Murray County, is more informative, and is assigned questionably to *Deckera completa*. It is closely comparable to the type material of *Deckera completa* (Fig. 5). The relative proportions and slope of the anterior border and preglabellar field are identical, as are the size and position of the palpebral lobe, expression and orientation of the palpebral ridge, and the width (tr.) of the palpebral area of the fixigena (compare Fig. 5.1, 5.2, 5.5 with Fig. 6.6, 6.8). The fixigenae of cranidia from Pennsylvania appear to be more steeply upsloping (compare Fig. 5.3, 5.4, 5.9 with Fig. 6.7). The sculpture of fine granules with scattered coarse granules on the fixigenae and crest of the glabella is shared between cranidia from Pennsylvania and the specimen from Oklahoma, but the coarser granules of the latter are more conspicuous, particularly on the anterior border. However, this difference is difficult to evaluate because expression of coarse granules on the border can vary between sclerites from a single collection in other species (e.g., compare Fig. 7.1, 7.3 with Fig. 7.10, 7.11).

*Deckera* cf. *D. aldenensis* Frederickson, 1949  
Figure 7

cf. 1949 *Deckera aldenensis* Frederickson, p. 350, pl. 68, figs. 22–24.  
non 1975 *Deckera* cf. *D. aldenensis*; Kurtz, p. 1025, pl. 2, fig. 23.

**Occurrence.**—Barton Canyon Limestone Member, Windfall Formation, Barton Canyon, Cherry Creek Range (CHC-2 203.1) and the Corset Spring Shale Member, Orr Formation, Orr Ridge, northern House Range (ORR 7.5). An association with *Irvingella angustilimbata* in the latter collection indicates that the range *Deckera* cf. *D. aldenensis* extends to a point near the bases of the *Elvinia* Zone and Jiangshanian Stage.

**Remarks.**—Cranidia from Nevada and Utah are related to the type species, *Deckera aldenensis* (Fig. 3), in sharing a short anterior border, a conical, anteriorly rounded glabella, and coarse granulose sculpture over most of the cranidium. They differ from *Deckera aldenensis* in that the palpebral lobes are centered farther forward, opposite S1 (e.g., Fig. 7.1), rather than L1 (e.g., Fig. 3.6). Additionally, the preglabellar field of *Deckera* cf. *D. aldenensis* occupies 57% (52–62%) of the frontal area length, whereas the preglabellar field of *Deckera aldenensis* is 44% (40–46%) of the frontal area length. The posterolateral projection of *Deckera* cf. *D. aldenensis* is deflected more strongly backward than in *Deckera aldenensis* (compare Fig. 3.6 and Fig. 7.10). The significance of these differences cannot be evaluated with the small number of sclerites available for study, therefore, the cranidia from Nevada and Utah are placed in open nomenclature.

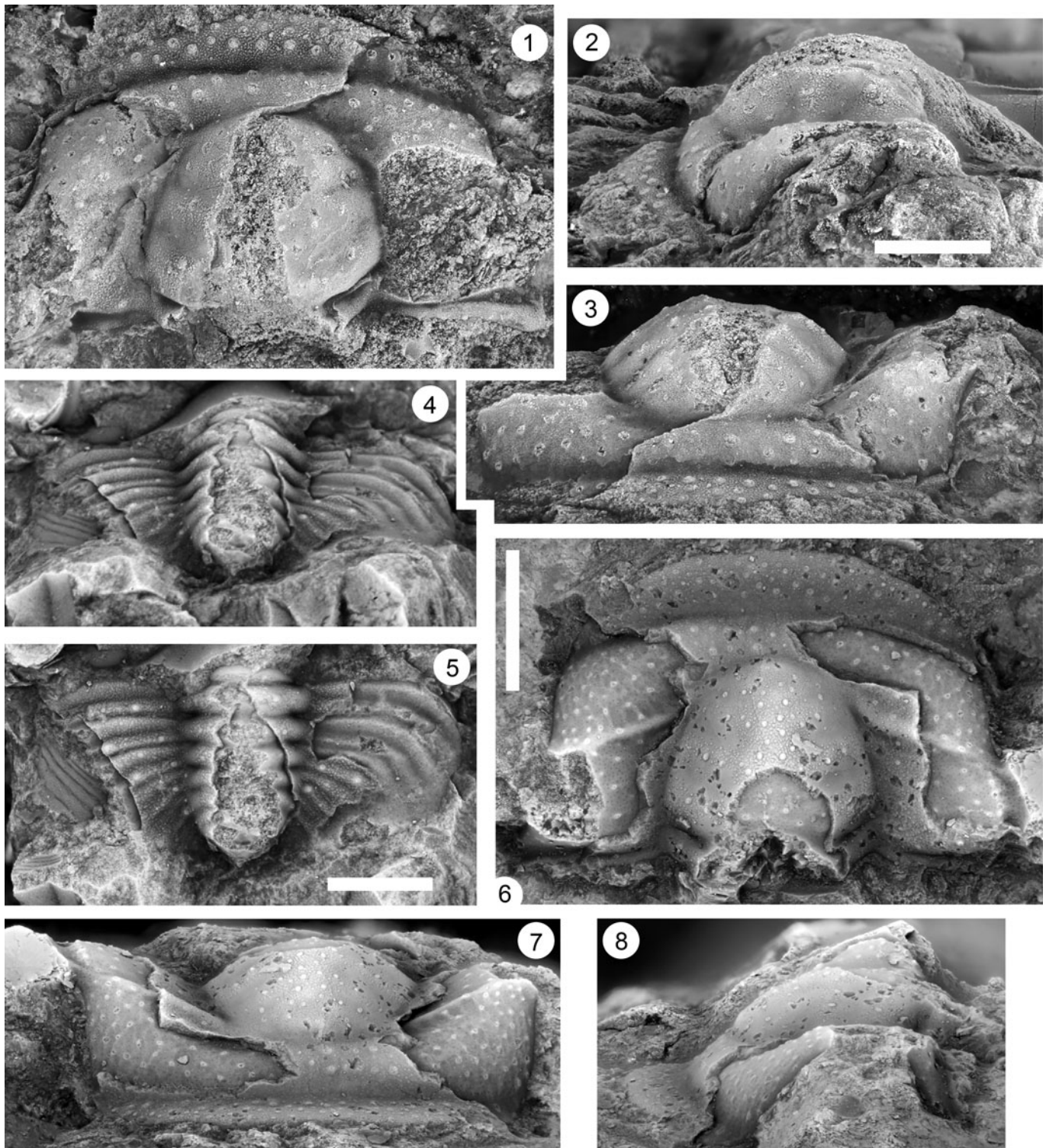
An associated free cheek (Fig. 7.7, 7.8) is assigned to *Deckera* cf. *D. aldenensis* because, although partly broken, it has a tall librigenal field that rises steeply from the border furrow. The long, slender genal spine is deflected downward in lateral view, producing a distinct curve in the lateral margin. Well defined anteriorly, the lateral border furrow becomes shallower posteriorly, and does not join the posterior border. The lateral border is of nearly equal thickness until it reaches the base of the genal spine where it thickens; the posterior border narrows slightly toward the genal spine. The borders and genal spine have fine granules; indistinct larger granules are present on the upper part of the librigenal field.

The free cheek of *Deckera completa* (Fig. 5.7, 5.8) has a stouter genal spine than that of *Deckera* cf. *D. aldenensis*, which also lacks any downward deflection. Among other characters, the anterior cranial border (e.g., Fig. 5.1, 5.5) is noticeably longer than in *Deckera* cf. *D. aldenensis* (e.g., Fig. 7.1). The palpebral lobe is farther back on the cranidium in *Deckera completa*, opposite L1, rather than opposite S1 as in *Deckera* cf. *D. aldenensis*. From the most complete specimen (Fig. 7.4), the palpebral lobe also appears to have been shorter in *Deckera* cf. *D. aldenensis*.

*Deckera* cf. *D. completa* Wilson, 1951  
Figure 8

cf. 1951 *Deckera completa* Wilson, p. 634, pl. 90, figs. 10–17.  
non 1971 *Deckera completa*; Stitt, p. 18, pl. 1, fig. 16 (= *Deckera* sp. indet.).

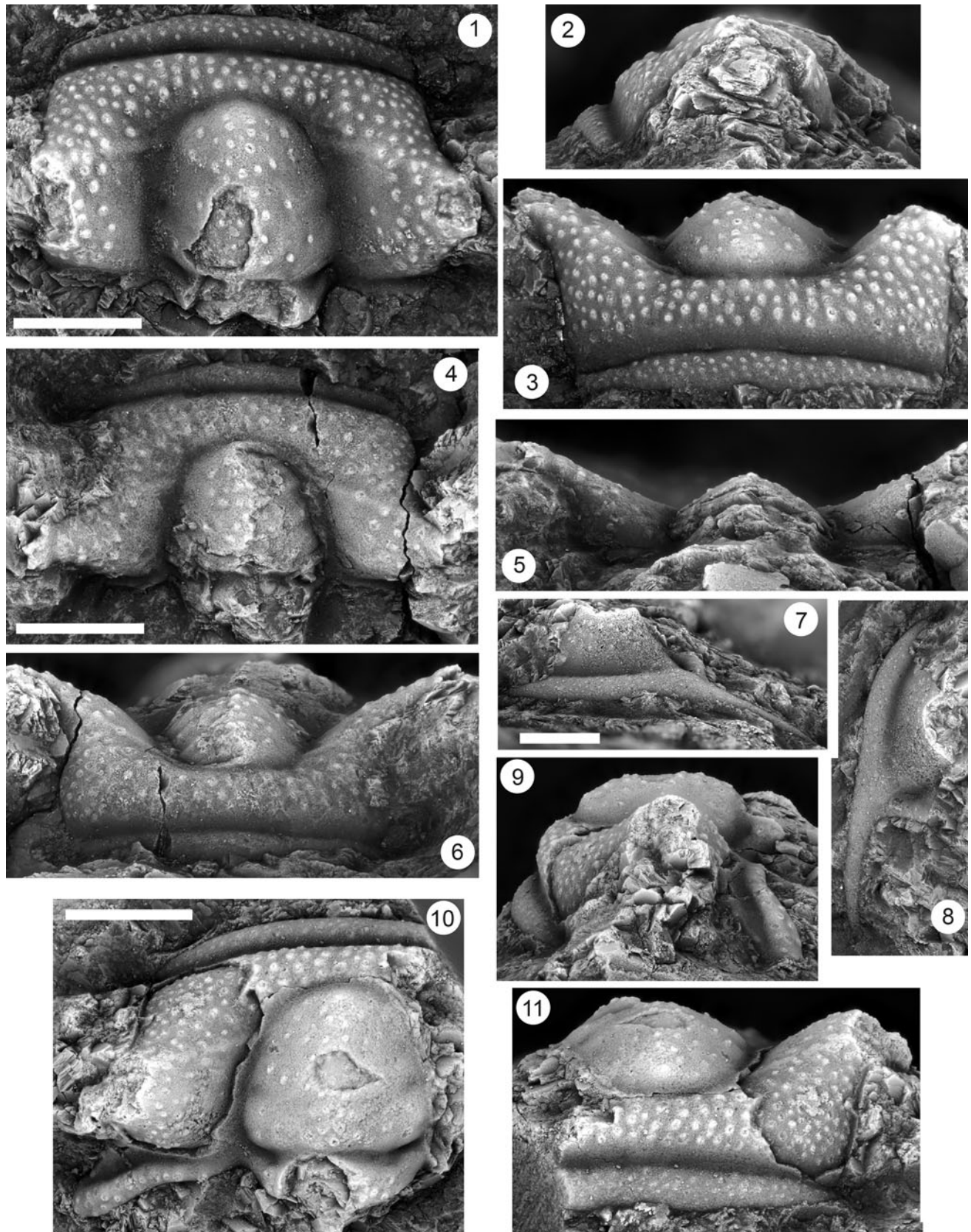
**Occurrence.**—Honey Creek Formation, Wichita Mountains region, Oklahoma. Frederickson (1949, p. 345) locality 9, Kiowa County; Ring Top Mountain, Comanche County, section KR2 (Westrop et al., 2010), collection KR2 50.3.



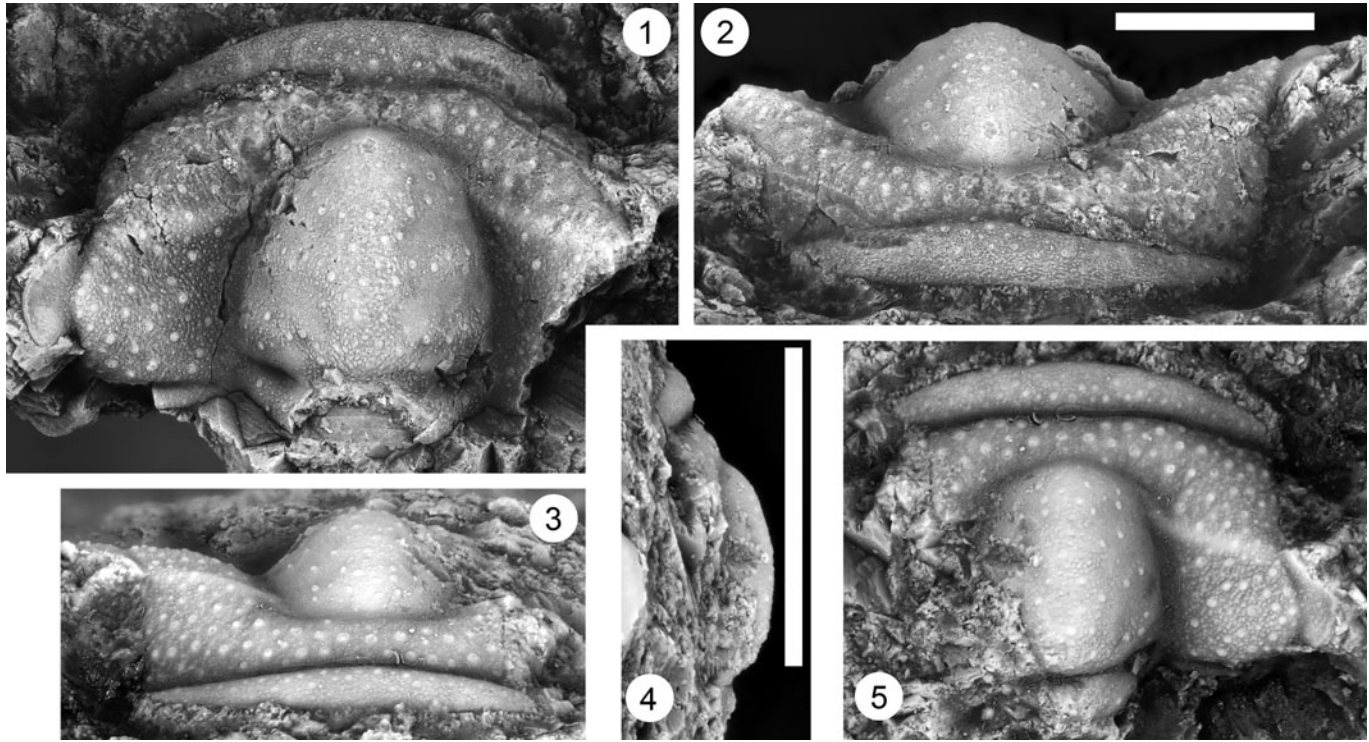
**Figure 6.** *Deckera* spp. from Utah and Oklahoma: (1–5) *Deckera* sp. indet. 1 from the Sneakover Member of the Orr Formation, Orr Ridge, northern House range, Utah, collection ORR 59.4: (1–3) cranium, OU 238141, dorsal, lateral, and anterior views; (4, 5) pygidium, OU 238142, posterior and dorsal views; (6–8) *Deckera completa?* Wilson, 1951, cranium, OU 238209, dorsal, anterior and lateral views, from the Honey Creek Formation, Dotson Ranch section, Murray County, Oklahoma, collection DR 11.77–12.0. Scale bars (each pertaining to set from same catalog number) = 2 mm.

**Remarks.**—Two crania from the Honey Creek Formation differ from *Deckera aldenensis* in possessing much larger palpebral lobes (e.g., compare Fig. 3.6, 3.8 with Fig. 8.1, 8.5). In this respect, they are comparable to the types of *Deckera*

*completa* from Pennsylvania (e.g., Fig. 5.1, 5.5), although the palpebral lobes of the latter are located farther back on the cranium. In addition, the anterior border of *Deckera completa* is somewhat longer (although there are minor



**Figure 7.** Crania of *Deckera* cf. *D. aldenensis* Frederickson, 1949 from the Barton Canyon Limestone Member, Windfall Formation, Barton Canyon, Nevada, collection CHC-2-203.1: (1–3) OU 238137, dorsal, lateral, and anterior views; (4–6) OU 238138, dorsal, posterior, and anterior views; (7, 8) OU 238139, lateral and dorsal views; (9–11) OU 238140, lateral, dorsal, and anterior views. Scale bars (each pertaining to set from same catalog number) = 2 mm.



**Figure 8.** Cranidia of *Deckera* cf. *D. completa* Wilson, 1951 from the Honey Creek Formation, Oklahoma: (1, 2) OU 55069, dorsal and anterior views, Kindblade Ranch, Kiowa County (Frederickson, 1949, locality 9); (3–5) OU 12226, anterior, lateral, and dorsal views, Ring Top Mountain, Comanche County, collection KR2 50.3. Scale bars (each pertaining to set from same catalog number) = 2 mm.

differences in length between specimens from different localities; compare Fig. 5.1 and 5.10), and the palpebral areas are more strongly sloping (compare Fig. 5.3, 5.4 with Fig. 8.2, 8.3). The cranidia from Oklahoma share a sculpture of large tubercles separated by coarse granules. One cranidium of *Deckera completa* from Wilson's (1951, p. 619) Drab section (Fig. 5.9, 5.10) has finer sculpture dominated by fine granules, whereas the lectotype from the Potter Creek section (Wilson, 1951, p. 619, pl. 90, fig. 10) has scattered coarse tubercles. Because the specimens are from different sections, the significance of this apparent variability cannot be assessed fully. The specimens from the Honey Creek Formation might well record a new species but are placed in open nomenclature here because of the small number of specimens available for study.

*Deckera* new species 1  
Figure 9.9–9.11

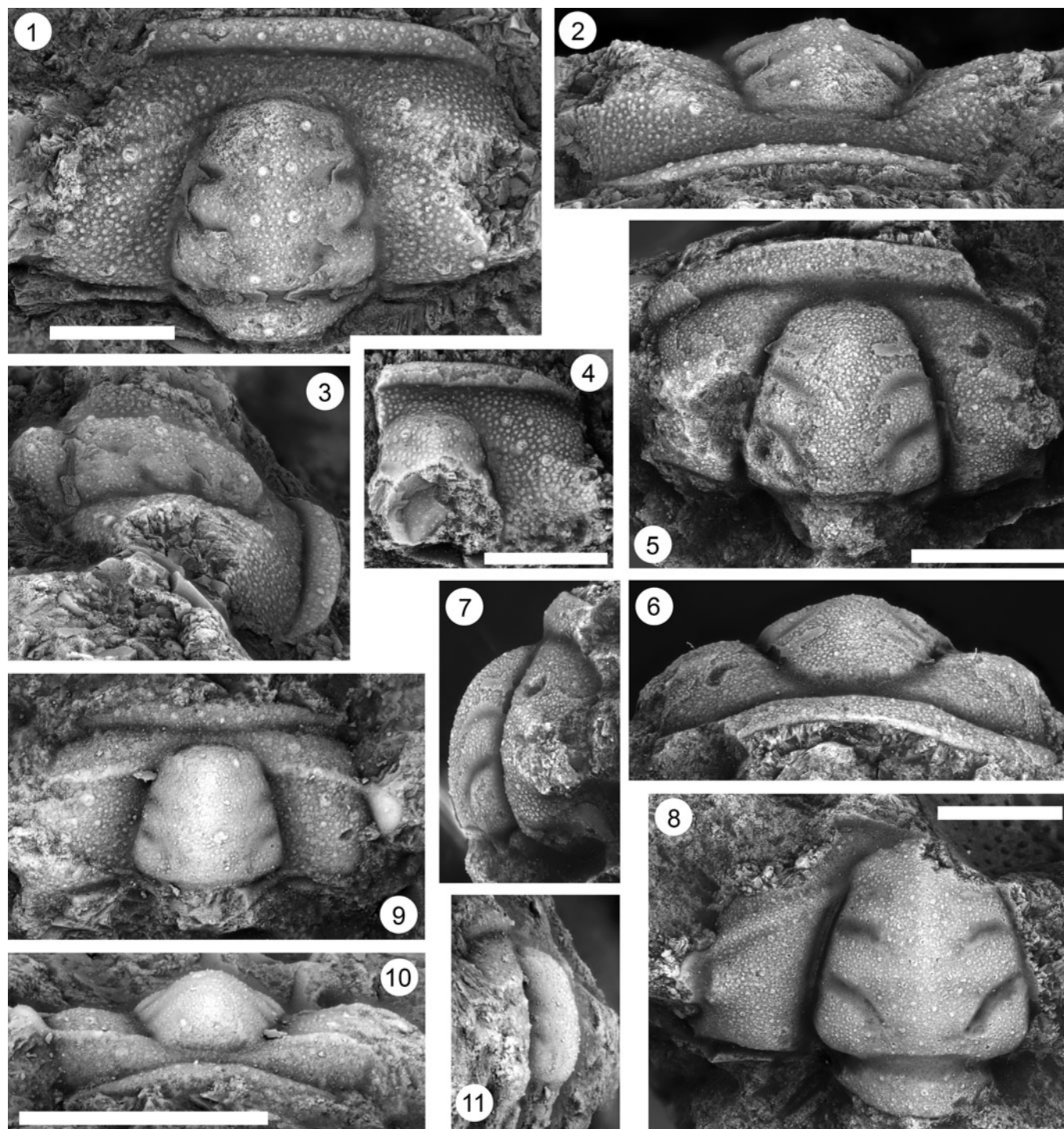
1965 Genus and species undetermined 3; Palmer, p. 92, pl. 3, fig. 17.

**Occurrence.**—Dunderberg Formation, Barton Canyon, Cherry Creek Range (CHC-2-138.5); Bastian Peak, Nevada, USGS collection 3009–CO (Palmer, 1965).

**Description.**—Cranidium subrectangular in outline; width across palpebral lobes approximately twice cranial length (excluding LO). Axial and preglabellar furrows well defined. Glabella convex, tapered, bluntly rounded anteriorly. Glabella

occupying ~80% of cranial length. SO as shallow groove; LO incompletely preserved but curving backward. Oblique S1 and S2 glabellar furrows present, deepest abaxially. S1 extending farther inward than S2, curving toward SO. Very faint S3 expressed as slight indentation of glabellar margin. Palpebral area of fixed cheeks nearly flat, lying well below crest of glabella; width ~70% of glabellar width at anterior tip of L2. Palpebral lobe semicircular in outline, upturned, situated opposite L2; length ~40% of glabellar length. Palpebral furrow as narrow, deeply etched groove. Palpebral ridge extending obliquely forward, reaching axial furrow opposite S3. Frontal area short, ~22% of cranial length, 28% of glabellar length. Weakly convex, gently sloping preglabellar field occupying approximately one-third of frontal area length. Border furrow distinct, nearly transverse, bending toward glabella medially. Anterior border convex, widest (sag.) medially, tapering abaxially, nearly transverse. Anterior branches of facial suture directed slightly inward anteriorly. Posterior border flexed downward; posterolateral projection not preserved. Fixed cheeks evenly coated with small granules and scattered larger granules. Smaller granules present on glabella, except for furrows. Granules on anterior border more prominent than those on fixed cheeks and glabella.

**Remarks.**—Palmer (1965, p. 92, pl. 3, fig. 18) described a single cranidium from the *Dunderbergia* Zone at Bastian Peak, Nevada, that he compared to *Deckera*. He recognized that all previously described species of *Deckera* had elevated palpebral lobes located far back on the cranidia at the crests of tall, strongly upsloping fixed cheeks, whereas his specimen



**Figure 9.** Cranidia of *Deckera* spp. from Newfoundland and Nevada: (1–4) *Deckera* n. sp. 2 from the Downes Point Member, Shallow Bay Formation, Hickey Cove, Newfoundland, boulder HC 166: (1–3) GSC 143344, dorsal, anterior, and lateral views; (4) GSC 143345, dorsal view; (5–8) *Deckera* n. sp. 3 from the Downes Point Member, Shallow Bay Formation, Hickey Cove, Newfoundland, boulder HC 202: (5–7) GSC 143346, dorsal, anterior, and lateral views; (8) GSC 143347, dorsal view; (9–11) *Deckera* n. sp. 1, cranium, OU 89896, dorsal, anterior, and lateral views, from the Dunderberg Formation, Barton Canyon, Nevada, collection, CHC-2-138.5. Scale bars (each pertaining to set from same catalog number)=2 mm.

had more anteriorly placed palpebral lobes set on weakly inflated, nearly flat fixed cheeks. An additional cranium of what appears to be the same species was recovered from the *Dunderbergia* Zone at Barton Canyon (Fig. 9.9–9.11). It shares several characters with other species of *Deckera*, including a wide, subrectangular cranium, with maximum

width twice the sagittal length (excluding LO); the palpebral area of the fixed cheeks is broad. The anterior border is short but slightly longer than the preglabellar field. The tapered, anteriorly rounded glabella with relatively shallow S1 and S2 furrows resembles those of *Deckera completa* and *Deckera aldenensis*. The palpebral lobe is situated opposite L2 with

length equal to ~40% of glabellar length. The oblique palpebral ridge is conspicuous and reaches the axial furrow opposite S3. The external surface of the cranium is granulose. The cranidia from the *Dunderbergia* Zone are interpreted as a basal species of *Deckera*, which possesses some, but not all of the characters of the genus. The diagnosis of the genus is revised above.

*Deckera* new species 2

Figure 9.1–9.4

*Occurrence.*—Shallow Bay Formation, Cow Head Group, Hickey Cove, western Newfoundland, boulder HC 166, *Acmahachis kindlei* Fauna (Westrop and Eoff, 2012).

*Remarks.*—Among Paibian species, *Deckera* n. sp. 2 is most like younger members of the genus, e.g., *Deckera aldenensis* and *Deckera completa*. In particular, it possesses upsloping palpebral areas of the fixed cheeks and, although the slope is noticeably lower than in the latter two species, they do rise to the level of the crest of the glabella (e.g., compare Fig. 9.2 with Figs. 3.7, 5.3). As a result, the palpebral lobe is elevated, although less so than in *Deckera aldenensis* and *Deckera completa*. The proportions of the cranium of *Deckera* n. sp. 2 are similar to those of *Deckera* n. sp. 1 (Fig. 9.9–9.11), with width (tr.) across the palpebral areas equal to at least 1.45 times cranial length. However, *Deckera* n. sp. 1 has weakly inflated, nearly flat fixed cheeks. In other respects, *Deckera* n. sp. 1 and *Deckera* n. sp. 2 are similar, sharing bluntly rounded glabellae and incised lateral glabellar furrows. The preglabellar field is longer than in *Deckera* n. sp. 1, equal to ~60% of frontal area length; frontal area occupies approximately one-quarter of cranial length. In these respects, *Deckera* n. sp. 2 is more like *Deckera aldenensis* (e.g., Fig. 3.6), and the relatively short anterior cranial border is also comparable, although it is more transverse. The sculpture of *Deckera* n. sp. 2, which comprises closely spaced large granules and scattered fine tubercles, is unique.

*Deckera* new species 3

Figure 9.5–9.8

*Occurrence.*—Shallow Bay Formation, Cow Head Group, Hickey Cove, western Newfoundland, collection HC 202, *Acmahachis kindlei* Fauna (Westrop and Eoff, 2012).

*Remarks.*—A second species from Hickey Cove (boulder HC 202) is represented by two broad cranidia with widths exceeding sagittal lengths. On this basis, it is interpreted as a new, basal species of *Deckera*. It will not be named formally because of the incomplete nature of the specimens and is simply designated *Deckera* n. sp. 3. In terms of fixed cheek anatomy, *Deckera* n. sp. 3 is farthest morphologically from the type species, *Deckera aldenensis*. The palpebral area is gently inflated and does not slope upward from the axial furrow (Fig. 9.6). The well-incised lateral glabellar furrows also set it apart from *Deckera aldenensis*, although they are shared with *Deckera* n. sp. 2 (e.g., Fig. 9.1–9.3). The palpebral lobe is short (exsag.) and centered opposite the S1

lateral glabellar furrow; the oblique palpebral ridge is well defined. The preglabellar field is barely expressed.

*Deckera* n. sp. 2 differs from *Deckera* n. sp. 3 in having a much longer preglabellar field, and fixed cheeks that are upsloping, rather than strongly inflated and flexing gently downward near the palpebral lobe (compare Fig. 9.1, 9.2 with Fig. 9.5, 9.6). To some extent, the anatomy of *Deckera* n. sp. 1 (Fig. 9.9–9.11) bridges the gap in morphology between these species, in that it has a short but clearly defined preglabellar field and gently inflated, nearly flat fixed cheeks. The upsloping cheeks and longer preglabellar field of *Deckera* n. sp. 2 are, in turn, gradational with more derived species, e.g., *Deckera aldenensis* (compare Fig. 9.2 with Fig. 3.7, 3.9). This apparent gradation is, in our view, a strong argument for including all three Paibian species in *Deckera*.

*Deckera* sp. indet. 1

Figure 6.1–6.5

*Occurrence.*—Sneakover Limestone Member, Orr Formation, Orr Ridge, northern House Range (ORR 59.4).

*Remarks.*—An incomplete cranium and pygidium from ORR 59.4 resemble *Deckera completa* from Pennsylvania (Figs. 4.4–4.6, 5). In particular, the cranidia share a long anterior border, which separates them from *Deckera aldenensis* (Fig. 3). However, the cranium of *Deckera* sp. indet. 1 has well-incised glabellar furrows that distinguish it from both *Deckera completa* (e.g., Fig. 5.1, 5.5, 5.10) and *Deckera aldenensis* (e.g., Fig. 3.6, 3.8). *Deckera* sp. indet. 1 and *Deckera completa* are clearly different in the pygidial anatomy. The pygidium of the latter species (Fig. 4.4–4.6) is widest posteriorly, opposite the fourth axial ring, whereas the widest portion of *Deckera* sp. indet. 1 (Fig. 6.4, 6.5) is situated anteriorly, opposite the second ring furrow. Additionally, in posterior view, the pygidium of *Deckera* sp. indet. 1 is not as strongly flexed downward in the axial region. The pygidial sculpture of the *Deckera* sp. indet. 1 consists of closely packed fine granules augmented by scattered coarser granules, whereas the pygidium of *Deckera completa* lacks the coarser granules. *Deckera* sp. indet. 1 almost certainly represents a new species, but more specimens are needed to name it.

A single cranium from the Wind River Mountains of Wyoming was described by Lochman and Hu (1960) as cf. *Deckera completa*. Lochman and Hu (1960) stated that the Wyoming specimen has a preglabellar field to anterior border ratio of 1:1; the ratio seen in the Orr Ridge specimen is slightly < 2:3. Additionally, it appears that the glabellar furrows of the Wyoming specimen are not as deep.

*Deckera* sp. indet. 2.

Figure 4.1–4.3

1975 *Deckera* cf. *D. aldenensis*; Kurtz, p. 1025, pl. 2, fig. 23.

*Occurrence.*—Units B and C, Davis Formation, St. Francois County, Missouri, collections 977.67-2, 977.67-3, and 977.67-6 (Kurtz, 1975).

**Remarks.**—Kurtz (1975) identified cranidia from the Davis Formation of Missouri as *Deckera* cf. *D. aldenensis*, but they are treated as an indeterminate species here, albeit one that is probably new. Like *Deckera aldenensis* (Fig. 3), the only specimen that Kurtz (1975) figured (Fig. 4.1–4.3) has upsloping fixed cheeks, and the proportions of the anterior border and preglabellar field are similar. However, the anterior border furrow of this specimen is nearly transverse and, as noted by Kurtz (1975), the anterior border tapers abaxially to produce roughly triangular or nasute outline. In contrast, the anterior border and border furrow of *Deckera aldenensis* are distinctly curved. In addition, the cranidium from Missouri has a distinct anterior arch (Fig. 4.2) that is absent in *Deckera aldenensis* (Fig. 3.7, 3.9). The palpebral furrow is preserved on the left side of the cranidium and terminates opposite S2 (Fig. 4.1). This indicates that the palpebral lobe is longer (exsag.) than in *Deckera aldenensis*. The palpebral lobe of the Missouri specimen is similar in size and position to *Deckera* cf. *D. completa* from Oklahoma (Fig. 8.1, 8.5), but the latter has a relatively shorter preglabellar field, a curved anterior border and border furrow, and lacks an anterior arch (Fig. 8.2, 8.3).

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## Declaration of competing interests

The authors declare none.

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