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Supplemental Material

Conodont systematic paleontology.

SYSTEMATIC PALEONTOLOGY

Genus ***Neognathodus*** Dunn, 1970

Type Species. *Polygnathus bassleri* Harris and Hollingsworth, 1933

Remarks. Many Early Pennsylvanian species of *Neognathodus* are poorly characterized and species ranges are not well constrained. A few names have been applied to wide variety of morphotypes often in an inconsistent manner. Through time, the shape and extent of the margins of the platforms of Early Pennsylvanian *Neognathodu*s P_1 elements have varied from entire margins that enclose the platform to forms in which one or both margins have retreated from the dorsal tip and have assumed different shapes. The patterns of evolution and ancestor-descendent lineages are not well known.

The older species, *Neognathodus symmetricus* (Stibane) and *N. bassleri,* appear near the base of the Pennsylvanian and characterize Morrowan faunas. The P_1 elements possess high, entire margins that wrap around the dorsal tip of the element and a carina that lies close to the rostral platform margin. *Neognathodus symmetricus* has a long slender platform with nearly parallel margins, whereas in *N. bassleri* the ventral platform margin flare outward giving the platform a rounded triangular shape. The dorsal termination of the carina generally ends before reaching the dorsal margin, but may extend as a few nodes to near the dorsal margin or as a narrow ridge that joins the dorsal margin. The upper ranges of these two species are not well known because workers may have incorrectly assigned younger Pennsylvanian morphotypes with entire margins to these species.

In contrast, a series of early to middle Atokan species of *Neognathodus* have P_1 elements that possess a platform in which one or both margins have retreated from the dorsal tip of the element and the carina forms the dorsal tip: *N. nataliae, N. uralicus, and N. atokaensis,* and some unnamed morphotypes. *Neognathodus nataliae* Alekseev and Gerelzezeg and *N. atokaensis* have similar platform outlines, but in *N. nataliae* the more complete caudal platform margin is higher than the restricted rostral margin and in *N. atokaensis* the two margins are similar in height and the platform has a more heart shaped outline (Thompson and Lambert, 2017).

In late Atokan to early Desmoinesian strata, *Neognathodus* species in which the platform margins are reduced in size disappear and forms with entire margins reappear. *Neognathodus darcyae* Barrick and *N. bothrops* both have biconvex platform outlines (Barrick et al. 2023). In *N. darcyae* the carina does not reach the dorsal platform margin whereas in the slightly younger *N. bothrops* the carina does reach the dorsal platform margin. *Neognathodus colombiensis* has a distinctly triangular platform shape and a well-developed carina that extends to dorsal tip. In all of these species the outer edges of the wide platform margins slope gently down to the medial carina, unlike the deep adcarinal troughs formed by the steep margins of the older Morrowan species, *N. symmetricus* and *N. bassleri,* in which the carina also lies nearer to one side of the margin. Barrick et al. (2013, 2022) showed *N. colombiensis* as appearing in the latest Atokan, and *N. bothrops* appearing slight later, near the beginning of the Desmoinesian. According to Alekseev and Goreva (2013), *N. colombiensis* and *N. bothrops* originated simultaneously, with *N. atokaensis* as common ancestor. Moore (2017) considered that a morphotype called *N.* "*pre-colombiensis*" was most likely derived from *N. atokaensis* due to their similarity in platform shape, representing a transitional form between *N. atokaensis* and *N. colombiensis*. Wang and Qi (2022) illustrated a similar pattern of *Neognathodus* evolution based on material from South China.

Neognathodus colombiensis (Stibane, 1967)

Fig. 3: 1-5, 10, 13-14

1967. *Streptognathodus colombiensis* Stibane, p. 336, pl. 36, figs. 1-10.

1971. *Neognathodus* n. sp. A, Merrill and King, p. 659-660, pl. 76, fig. 7 (only).

2004. *Neognathodus colombiensis* Stibane, Barrick et al., pl. 1, fig. 1 (reillustrated in Barrick et al., 2013)

2017. *Neognathodus colombiensis* Stibane, Moore, p. 82-83, fig. 24: 13-17, 24, 25.

Material: 7 illustrated elements (CEGH-UNC 27639 to 27645)

Description: The P_1 element of *Neognathodus colombiensis* is characterized by a triangular, arrow-shaped outline with entire margins and a straight, medial carina that reaches the dorsal tip of the platform. It is sub-symmetrical, with the rostral margin slightly narrower and less prominent than the caudal margin. The surface of the platform is relatively flat, with shallow adcarinal troughs. The basal cavity is asymmetrical and extends anteriorly under the blade as a groove.

Remarks: *Neognathodus colombiensis* is similar to *N. bothrops*, but the latter has a more almond-shaped platform, the ventral adcarinal ridges are generally more developed, and the carina may be fused along much of its entire length. The distinctly triangular platform shape and wide ventral margins that slope gently into the shallow adcarinal troughs distinguish *N. colombiensis* from the Morrowan species, *N. asymmetricus* and *N. bassleri.*

The name *Neognathodus colombiensis* has been ignored, synonomized, or inconsistently applied to variety of different morphotypes. Stibane (1967) described *Neognathodus colombiensis* based on 18 specimens from two samples at Río Nevado, Santander Department, Colombia. Stibane and Forero (1969) interpreted this faunal assemblage to be likely Desmoinesian in age. Merrill and King (1971) considered the holotype (Stibane, 1967, pl. 36, figs. 1, 2) and one other specimen (figs. 9, 10) to be examples of *N. bassleri bassleri,* suggesting that the carina did not reach the posterior tip. They placed Stibane's other specimens into their *N.* n. sp. A apparently because in some specimens the carina more clearly reached the dorsal tip (figs. 6-8) or their *N.* n. sp. B because the carina appeared to be shifted to one side (figs. 3-5). Merrill (1972) proposed a series of new names for *Neognathodus* species, of which the new species *N. bothrops* was erected for Merrill and King's (1971) *N.* sp. A. The diagnosis of *N. bothrops* emphasized that the carina extended to the dorsal tip of the platform to distinguish it from *N. bassleri bassleri*, and the outline was called "lanceolate, with the greatest width in the anterior one-third" (Merrill, 1972, p. 823). The holotype (OSU 28243) from the Lower Mercer of Ohio has a clearly ovate to biconvex outline, unlike the triangular shape of the holotype of *N. colombiensis.* Merrill (1972) retained the placement of the holotype of *N. colombiensis* in *N. bassleri bassleri.* Unlike Merrill and King (1971), our interpretation of the illustrations of Stibane (1967) is that the carina reaches the dorsal tip of the platform in the holotype and paratypes. Rabe (1977) assigned all of Stibane's material to *N. bassleri* n. subsp. A, which was based on Merrill and Kings (1971) *N.* sp. A. Because Rabe had access to Stibane's material at Giessen, this species assignment supports the interpretation of the carina reaching the dorsal tip. This leaves two alternatives. One is that *N. colombiensis* and *N. bothrops* are the same species and the platform outline is not significant, in which case *N. colombiensis* is the appropriate name. Grayson (1984, p. 52) and Grubs (1984) synonymized *N. colombiensis* with *N. bothrops,* but for some unknown reason used the younger name *N. bothrops.* Lambert et al. (2001) pointed out that *N. colombiensis* has priority. We prefer the second alternative, that the outline of the platform is a species-diagnostic feature and that both names are valid. We recognize, though, that the diagnostic platform outlines are best seen in larger specimens, and that small specimens cannot always be confidently assigned to one species or the other.

Subsequent identifications of *Neognathodus* specimens as *N. colombiensis* have not always followed these criteria. A full synonymy will require reexamination of specimens reported as *N. colombiensis,* but we can make a few observations here. Good examples of *N. colombiensis* from the Seville Limestone were illustrated by Merrill and King (1971) and Barrick et al. (2004, 2013). The illustrated specimens of Rabe (1977, pl. 1 figs. 28-30) from Bucaramanga, Santander Department, Colombia, possess a biconvex outline and are more likely examples of *N. bothrops.* Bender (1980) assigned three specimens from the Hare Fiord Formation, Arctic Canada, to *N. colombiensis,* but these species have incomplete platform margins and appear to be closer to *N. atokaensis.* The specimens identified as *N. colombiensis* in Cardoso et al. (2017, fig. 7: 10-12) appear to be examples of *N. "pre-colombiensis"* because the rostral platform margin is not complete (see below). Rojas Mantilla et al. (2022, fig. 3C) reillustrated a specimen from Nascimento et al. (2010) as *N. bassleri* that appears to be *N. colombiensis.* Some specimens shown as *N. bothrops* and *N. colombiensis* from South China (Wang and Qi, 2022, figs. 3-5) include shapes that are not typical of either species.

Neognathodus "pre-colombiensis" Moore, 2017

Fig. 3: 6, 8-9

2017. *Neognathodus "pre-colombiensis"* Moore, p. 80-82, fig. 24: 13-17, 24, 25.

Material: 3 illustrated elements (CEGH-UNC 27646 to 27648)

Description: *Neognathodus "pre-colombiensis"* has a slightly asymmetrical triangular P_1 element with weak ridges and a medial carina that extends to the dorsal tip of the platform. The carina is straight, fused ventrally, and replaced by nodes dorsally. The rostral margin is narrow and extends as far ventrally than the caudal margin and is composed of nodes separated by gaps dorsally. The caudal margin is wider, continuous, and nodose where it meets the carina.

Remarks: The morphotype designated here as *Neognathodus "pre-colombiensis"* differs from *N. colombiensis* by a narrower rostral margin that is not continuous, but is composed of nodes and gaps dorsally. Moore (2017) suggested that this morphotype represented a transitional form from *N. atokaensis* to *N. colombiensis*, but included a couple of different morphotypes in this group. When Grayson (1984) erected *N. atokaensis* he included a wide variety of morphotypes that included basically all middle Atokan forms with restricted platform margins. He interpreted *N. atokaensis* to be a precursor species to his interpretation of *N. bothrops.* Unfortunately, two different specimens were listed by Grayson as being the holotype specimen OU10027 (pl. 1 fig. 8; reillustrated as the holotype by Barrick et al., 2004; 2013) and specimen OU10051 (p. 52, pl. 3 fig. 1). OU10027 could be considered to an example of *N. uralicus* Nemirovskaya and Alekseev 1995, but we believe that OU10051 is the actual holotype. Three features characterize *N. atokaensis* as used by most workers: 1) the rostral and caudal margins lie at about the same height, 2) the ventral end of the rostral margin is shorter than the caudal margin, and 3) the dorsal end of the rostral margin is shorter than the carina and a distinct indentation lies between the end of the rostral margin and the end of the element. In the transition from *N. atokaensis* to *N. colombiensis*, the rostral margin lengthens ventrally to extend at least as far as the end of the caudal margin and the rostral margin lengthens dorsally to the dorsal end of the platform, losing the indentation. In the forms we call *N. "pre-colombiensis",* both the ventral and rostral margins have reached the full extent of the platform and the dorsal rostral indentation is gone, but the dorsal rostral margin is incomplete with nodes separated by gaps.

Specimens in the transition from *N. atokaensis* to *N. colombiensis* have been commonly assigned incorrectly to *N. medadultimus* Merrill 1972 (e.g., Grubbs, 1984, pl. 3 figs. 10-13; see discussion in Barrick et al., 2023) or included in *N. colombiensis* (e.g., Cardoso et al., 2017, fig. 7:10-12). Alekseev and Goreva (2013, fig. 4) illustrated a range of *Neognathodus* morphotypes, encompassing a succession of forms transitioning from *N. atokaensis* to *N. colombiensis.* Additional work is needed to better characterize the details of the *N. atokaensis* to *N. colombiensis* transition.

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