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SHORT COMMUNICATION

THE AGE AND PROVENANCE OF "*ESCHRICHTIUS*" *CEPHALUS* COPE (MAMMALIA: CETACEA)

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A fossil balaenopterid whale, '*Eschrichtius*' *cephalus*, was described by Edward D. Cope in 1867. He itemized the original material as consisting of "a considerable portion of both premaxillary bones," the mandibular rami, the atlas, third, fourth, fifth, and seventh cervical vertebrae, a caudal vertebra, humerus, radius (initially identified as an ulna in Cope, 1867a), two carpals, and one phalanx (Cope, 1867b). Later, Cope (1890) figured a number of individual elements purportedly from this same specimen, including an auditory bulla not previously described, and offered a largely speculative skeletal restoration of the species that indicated by shading which elements of the skeleton were actually known from the type material. These shaded elements included an additional phalanx (not among the type material at the Academy of Natural Sciences of Philadelphia at the present time) and some portions of the skull not enumerated in the earlier description (part of the vomer and part of the right squamosal). Curiously, the shaded elements do not include the atlas vertebra or caudal vertebra listed earlier among the type material. The shaded cervicals are the fourth through seventh, rather than the third, fourth, fifth, and seventh as initially reported, which indicates that Cope had changed his mind by 1890 about the third cervical being present and the sixth cervical being absent. More than 20 years after his initial description of this species, Cope transferred '*E.*' *cephalus* to the genus *Cetotherium* (Cope, 1890, 1896). This generic assignment subsequently was followed by Hay (1902, 1930) and Case (1904).

The type material received Academy of Natural Sciences of Philadelphia catalog numbers ANSP 12691 and ANSP 12692 on 13 August 1914, 17 years after Cope's death. It was probably submitted to the Academy many years earlier, but no precise information about this transaction is known. The next day, 14 August, an additional cervical vertebra was added to the type material without explanation and given catalogue number ANSP 12693. About six weeks thereafter, on 24 September 1914, nine more vertebrae (not labeled as type) were added to the Academy's collection of '*E.*' *cephalus* under catalogue number ANSP 12941.

The material languished for many decades until Kellogg (1968a), in a synopsis of Calvert Formation baleen whales, discussed it again under its original nomenclatural combination of *Eschrichtius cephalus* Cope. Kellogg stated that the species almost certainly did not pertain to the genus *Eschrichtius*; instead, it belonged to *Balaenoptera* or an extinct genus very close to *Balaenoptera*. Despite this statement, Kellogg did not choose to change the generic assignment of the species. Kellogg (1968a) considered the following material to constitute the type specimen: ANSP 12691, right and left mandibles with posterior ends destroyed behind level of coronoid processes, both incomplete premaxillary bones, a portion of the maxillary, a portion of the vomerine trough, portions of both squamosals, left humerus, left radius, two carpals, and one phalanx; ANSP 12692, the fourth through seventh cervical vertebrae (Spamer et al., 1995:267 list these as the third through the sixth cervicals); and ANSP 12941, one half of an atlas vertebra, three lumbar vertebrae, and two caudal vertebrae (Spamer et al., 1995:267 state that this lot originally included nine vertebrae). Although the Academy of Natural Sciences of Philadelphia in 1914 catalogued an axis vertebra (ANSP 12693) as part of the type of *E. cephalus* Cope, Kellogg (1968a) recognized that this specimen instead was the type of *Eschrichtius leptocentrus* Cope (1867b:147); it is now listed as missing (Spamer et al., 1995:267). The left humerus figured by Kellogg (1968a), which was part of lot ANSP 12691, also now is listed as missing (Spamer et al., 1995).

Kellogg (1968a) stated that the tympanic bulla figured by Cope (1890) and assigned by him to '*E.*' *cephalus* is a specimen reposited in the American Museum of Natural History (AMNH 9846), but he gave no reason for making this assertion. The catalogue card for AMNH 9846 states that the specimen came from the Cope collection (acquired by AMNH in 1895) and cites the figure in Cope (1890) illustrating the alleged bulla of '*E.*' *cephalus* (Christopher A. Norris, American Museum of Natural History, pers. comm., May, 2006). Apparently this catalogue card was the source of Kellogg's information. Since the original material of '*E.*' *cephalus* at the Academy of Natural Sciences does not include a tympanic bulla (Spamer et al., 1995:266), there is no reason to doubt that the figured specimen is AMNH 9846.

Kellogg considered this bulla to be too small to belong to the type specimen of '*E.*' *cephalus* and thus excluded it from that taxon. He based this opinion on the fact that a much smaller cetothere, *Diorocetus hiatus*, had tympanic bullae as wide and as long as AMNH 9846. In his subsequent description of *Diorocetus hiatus*, however, Kellogg (1968b:142) noted that the skull of *Pelocetus calvertensis*, a cetothere with a skull considerably larger than that of *Diorocetus hiatus*, has much smaller tympanic bullae. Thus there is no simple allometric relationship between the tympanic bulla length and skull length in cetotheres. For this reason, Cope's referral of this specimen to '*Eschrichtius*' *cephalus* cannot be dismissed summarily. Nevertheless, the fact that this bulla was neither mentioned in the original descriptions nor accessioned with the original material at the Academy of Natural Sciences of Philadelphia makes its association with '*E.*' *cephalus* dubious.

Although the ANSP catalogue lists lot 12691, lot 12692, and (incorrectly) specimen 12693 as the type material for *E. cephalus*, the catalogue does not state that the nine vertebrae in lot 12941 are part of the type (Spamer et al., 1995:267). Besides the four posterior cervicals catalogued as ANSP 12692, Cope (1867b) de-

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scribed only two other vertebrae as part of the type material: an atlas and a caudal. Thus, at most only two of these nine vertebrae could pertain to Cope's original description of this species, and the fragmentary atlas in this lot is not an obvious match for the type atlas. Cope (1867b:148) gave a total width measurement for the atlas of the type (slightly over 8 inches or about 21 cm), so he evidently made this measurement on an essentially complete vertebra and not half of one. Therefore, unless the atlas subsequently was broken and half of it lost, the atlas fragment in lot ANSP 12941 is not the atlas vertebra described by Cope (1867b). Cope (1867a) did mention cervical and dorsal vertebrae among supplementary material for '*E.*' *cephalus* collected from the Pliocene Yorktown Formation at Yorktown, Virginia, and Tarboro, North Carolina. He referred these specimens to '*E.*' *cephalus*, but they were not part of the type material. Lot ANSP 12941 thus probably represents some or all of this material and is not part of the type specimen at all. Similarly, specimen USNM 23749, which Kellogg (1968a) referred to '*E.*' *cephalus* partly in the belief that it was found in diatomaceous beds of the Calvert Formation at Petersburg, Virginia, actually comes from the Pliocene Yorktown Formation, which at Petersburg includes some very diatomaceous beds that in the past were confused with the Calvert (Andrews, 1980). Consequently, only the material catalogued as ANSP 12691 and ANSP 12692 can be assigned with confidence to '*Eschrichtius*' *cephalus* Cope.

According to the ANSP accession data, the unequivocal type material was collected in the bed and opposite bank of a small run, not far from the home of James T. Thomas near the Patuxent River (38.5412° N, 76.7308° W; NAD27), about one mile east of the site marked Patuxent on the Benedict U.S. Geological Survey 7.5-minute topographic map and 2 miles east of Hughesville in Charles County, Maryland (Kellogg, 1968a). The locality indicated is in a north-facing gulley that feeds into an unnamed branch of Swanson Creek. The stratum in the bottom of this gulley has been mapped as belonging to the upper part of the Calvert Formation (Mathews and Mendenhall, 1939), which is middle Miocene in age, so the horizon listed for the specimen by Kellogg (1968a) is in accord with the stratigraphic position assigned to beds in that area.

Kellogg (1968a) noted that '*Eschrichtius*' *cephalus* was a uniquely large and evolutionarily advanced whale from the Calvert Formation, and that no other material referable to this species had been collected from the Calvert since the original specimen was discovered and described. Gottfried and colleagues (1994) later reiterated this point and, in view of the clear affinity of this species with the living family Balaenopteridae rather than with the extinct family Cetotheriidae (to which other then known Calvert baleen whales belonged), they argued strongly that the type material probably came from a stratigraphic unit younger than the Calvert. At that time, in the absence of any other unequivocal balaenopterid whale material known from the Calvert (or any other middle Miocene formation), it seemed most plausible to assume either that some unrecognized stratum younger than the Calvert was at the type locality for '*Eschrichtius*' *cephalus*, or else that the material had been mislabeled and had come from some other locality.

Recently, Dooley and colleagues (2004) described a new balaenopterid whale from the Carmel Church quarry near Ruther Glen in Caroline County, Virginia. The specimen came from a bone bed at the base of the middle Miocene Calvert Beach Member of the Calvert Formation (Fig. 1), which is equivalent to Shattuck beds 14–16 in the Calvert Cliffs of Maryland. Dooley and colleagues (2004) make no mention of '*Eschrichtius*' *cephalus*, although they do cite Gottfried and colleagues (1994) in their bibliography. Dooley and colleagues (2004) claimed that their specimen represented the oldest known occurrence of a member of the rorqual–gray whale clade. This claim is true, however, only if '*Eschrichtius*' *cephalus* Cope came from a horizon younger than the Calvert Formation as asserted by Gottfried and colleagues (1994).

Because the age and provenance of '*E.*' *cephalus* have been debated but not tested, one of the authors (RW) visited the Philadelphia Academy of Natural Sciences to assess the possibility of determining the age of the type specimen using microfossils that might remain in matrix still attached to the bones. With the aid of Ned Gilmore and Ted Daeschler of the Philadelphia Academy, the bones of the type specimen were examined for matrix that could be removed for study. The friable, silty sand matrix was sparse, but a useful quantity was gleaned from cracks, marrow cavities, and foramina in bones from the type specimen lot ANSP 12691. A sub-sample of this matrix was processed for nannofossils, but none were seen. Microscopic calcite rhombs in the right size-range were present, however, that may have been derived from dissolution and recrystallization of nannofossils (Jean M. Self-Trail, pers. comm., June, 2004).

The remaining matrix sample yielded a well preserved dinoflagellate flora of moderate diversity. No single species dominates the assemblage, indicating that the burial site of the type specimen was offshore away from coastal, reduced salinity depositional settings. The following taxa were recognized:

Batiacasphaera sphaerica Stover, 1977
Cleistosphaeridium placacanthum (Deflandre et Cookson, 1955) Eaton et al., 2001
Cyclopsiella lusatica (Krutzsch, 1970) Strauss et Lund, 1992 [acritarch]
Dapsilidinium pseudocolligerum Stover, 1977
Habibacysta tectata Head et al., 1989
Hystrichosphaeropsis obscura Habib, 1972
Labyrinthodinium truncatum Piasecki, 1980 subsp. *truncatum*
Lingulodinium machaerophorum (Deflandre et Cookson, 1955) Wall, 1967
Operculodinium centrocarpum (Deflandre et Cookson, 1955) Wall, 1967
Operculodinium piaseckii Strauss et Lund, 1992
Palaeocystodinium golzowense Alberti, 1961
Pentadinium sp. cf. *P. laticinctum granulatum* Gocht, 1969
Reticulatosphaera actinocoronata (Benedek, 1972) Bujak et Matsuoka, 1986
Spiniferites mirabilis (Rossignol, 1964) Sarjeant, 1970
Spiniferites Mantell, 1850 (assorted spp.)
Sumatradinium druggii Lentin et al., 1994
Tectatodinium pellitum Wall, 1967
Tuberculodinium vancampoae (Rossignol, 1962) Wall, 1967

This assemblage can be assigned to the upper part of dinoflagellate zone DN5 of de Verteuil and Norris (1996) (Fig. 1), based on the co-occurrence (overlap) of *Habibacysta tectata* Head et al., 1989 (whose lowest occurrence is midway through DN5) and *Cleistosphaeridium placacanthum* (Deflandre et Cookson, 1955) Eaton et al., 2001 (whose highest occurrence defines the top of DN5).

Assignment of this assemblage to upper DN5 confirms a middle Miocene (Serravallian) age, and also unequivocally restricts the stratigraphic horizon of the type specimen of '*Eschrichtius*' *cephalus* to the Calvert Beach Member of the Calvert Formation (equivalent to Shattuck beds 14–16) (de Verteuil and Norris, 1996). Because the sparse matrix within the specimen was quite sandy and contained recognizable small shell fragments, the specimen most likely came from Shattuck bed 14, which is the most sandy and shelly bed within the Calvert Beach Member. This stratigraphic horizon is fully in accord with the upper Calvert Formation assignment of strata in the vicinity of the Thomas farm in Charles County, Maryland (Mathews and Mendenhall, 1939), which is the area from which the type specimen was alleged to have come. As all pertinent data and records are consistent and reinforcing, this removes all reasonable grounds for

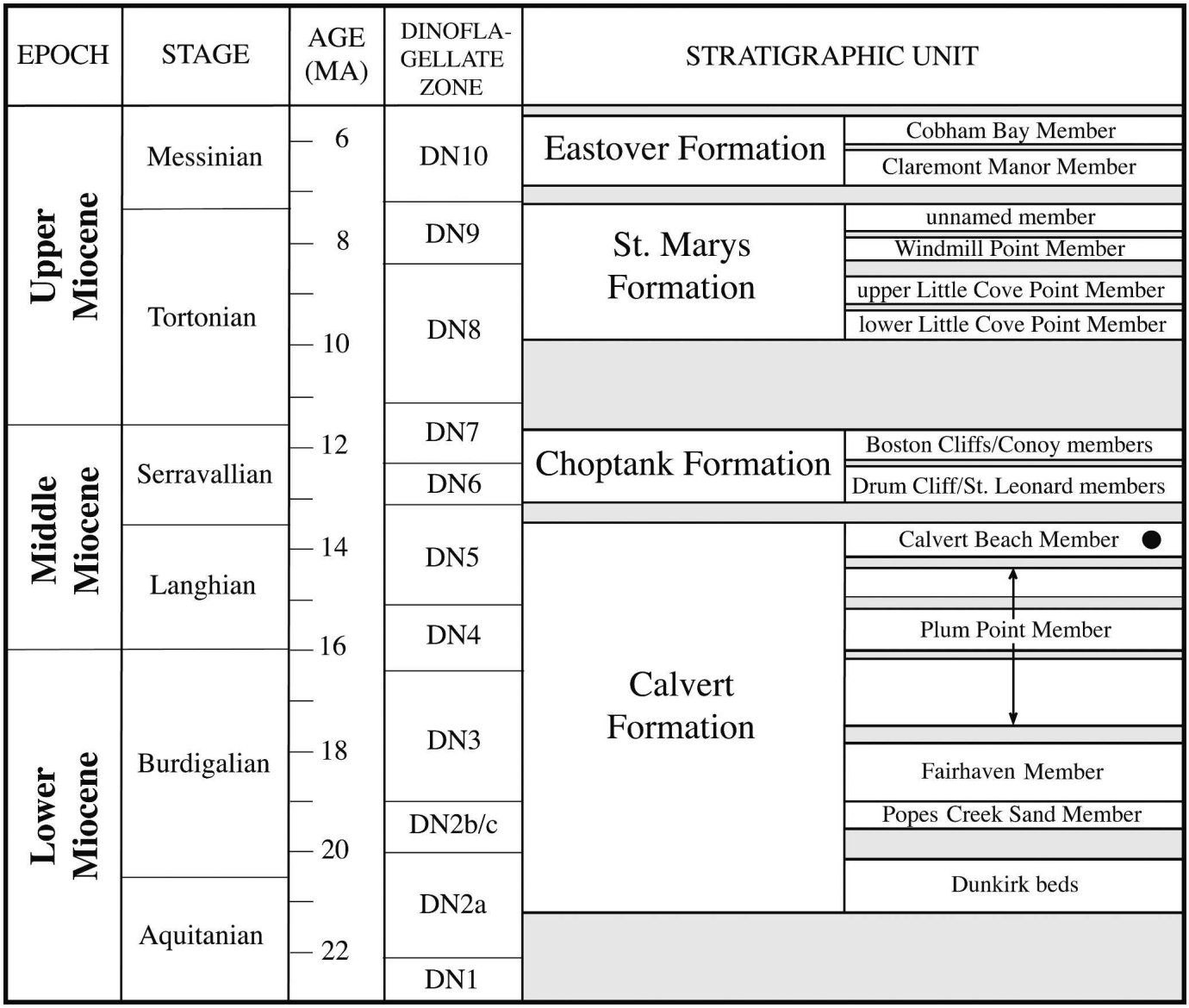

FIGURE 1. The dinoflagellate zonation of de Verteuil and Norris (1996) as modified by de Verteuil (1997), with updated age datums from Gradstein and colleagues (2004). The stratigraphic horizon of the type specimens of *Eobalaenoptera harrisoni* and '*Eschrichtius*' *cephalus* is indicated by a black circle.

questioning whether the locality and stratigraphic data for the type specimen of '*Eschrichtius*' *cephalus* are correct.

As the type specimen of '*Eschrichtius*' *cephalus* Cope came from the same stratigraphic unit (Calvert Beach Member) as did the type specimen of the recently described taxon *Eobalaenoptera harrisoni* (Dooley et al., 2004), a question then arises if the two taxa are conspecific. Unfortunately, this question cannot be answered definitively at the present time. The most diagnostic portions of '*Eschrichtius*' *cephalus* Cope are the mandibular rami and the anterior skull fragments, neither of which are preserved in the type specimen of *Eobalaenoptera harrisoni*. Conversely, the most diagnostic portions of *Eobalaenoptera harrisoni* are bones of the basicranial region, which are not preserved in the type specimen of '*Eschrichtius*' *cephalus*. The atlas and axis for *Eobalaenoptera harrisoni* are figured (Dooley et al., 2004), but the atlas for '*Eschrichtius*' *cephalus* was not figured (and is now probably lost) and the axis was never recovered. The centra of posterior cervicals four through seven of '*Eschrichtius*' *cephalus* have been figured (Cope, 1890; Case, 1904; Kellogg, 1968a) but these elements of *Eobalaenoptera harrisoni* were not figured by Dooley and colleagues (2004). This means that there are only two common elements of the two type specimens that can be compared without direct examination.

Only the tympanic bulla and the humerus purportedly have been figured for both species. The tympanic bulla is a taxonomically useful element, and the figured specimens are quite different in appearance, but Kellogg (1968a) has stated firmly that the bulla that Cope (1890) assigned to '*Eschrichtius*' *cephalus* does not belong to that species. The bulla of *Eobalaenoptera harrisoni* is proportionately much longer and narrower than the bulla Cope ascribed to '*Eschrichtius*' *cephalus*, which is much more similar in width-length proportions and inflation to the bullae of such cetotheres as *Diorocetus*, *Aglaocetus*, and *Parietobalaena* (Kellogg, 1968b,c,d). Such a strong contrast in appearance is unexpected between two taxa that should be close to a common branching point. Thus there is little reason to doubt Kellogg's

conclusion that the proper tympanic bulla of '*Eschrichtius*' *cephalus* Cope remains unknown. The humeri (Fig. 2A, B) are similar in size but not particularly similar in their detailed morphology. The published figures indicate that, compared to '*Eschrichtius*' *cephalus*, the shaft of the humerus of *Eobalaenoptera harrisoni* is somewhat stockier and its humeral head is less inflated. This strongly suggests a difference between these two taxa, although this cannot be stated with certainty in the absence of a sense of the range of variability of the humeral proportions in primitive balaenopterids.

As discussed previously, the vertebrae in ANSP lot 12941 cannot be assigned with confidence to '*Eschrichtius*' *cephalus*. Therefore, the fragmentary atlas and lumbar vertebrae in this lot cannot be meaningfully compared to the atlas and lumbar elements of *Eobalaenoptera harrisoni*. Although the originally described atlas of '*Eschrichtius*' *cephalus* was not figured, Cope (1867b:148) did give a rather detailed verbal description of it: "The atlas is notable for the want of a neural spinous crest, and in the inferior position and obliquity of the cotyloid cavity. The latter are separated by an inch below; in the same interval behind there is a transverse, very obtuse *tuberculum atlantis*. The inferior portion of the perforation, or *foramen dentati*, is much narrower than the neural arch." This description is similar to that of the atlas vertebra of *Eobalaenoptera harrisoni* (Fig. 2C, D), and thus provides a link between the two taxa. Even so, in view of Kellogg's (1968a:106) statement that '*Eschrichtius*' *cephalus* has "a close affinity if not identity with *Balaenoptera*," the similarity between the description of the atlas of '*Eschrichtius*' *cephalus* and the atlas of *Eobalaenoptera harrisoni* hardly is surprising. While this similarity strongly supports a familial association between these taxa, it is far from compelling evidence for synonymizing them.

The only other unexplored avenue for distinguishing the two species would be direct comparison of the centrum proportions of the posterior cervicals of '*Eschrichtius*' *cephalus* (ANSP 12692) with the unfigured posterior cervicals of the type specimen of *Eobalaenoptera harrisoni*. However, most likely a definitive comparison of these two taxa will have to await the discovery of a balaenopterid skull from the Calvert Beach Member of the Calvert Formation that contains cranial elements in common with both the type specimen of '*Eschrichtius*' *cephalus* and the type specimen of *Eobalaenoptera harrisoni*. On the basis of the

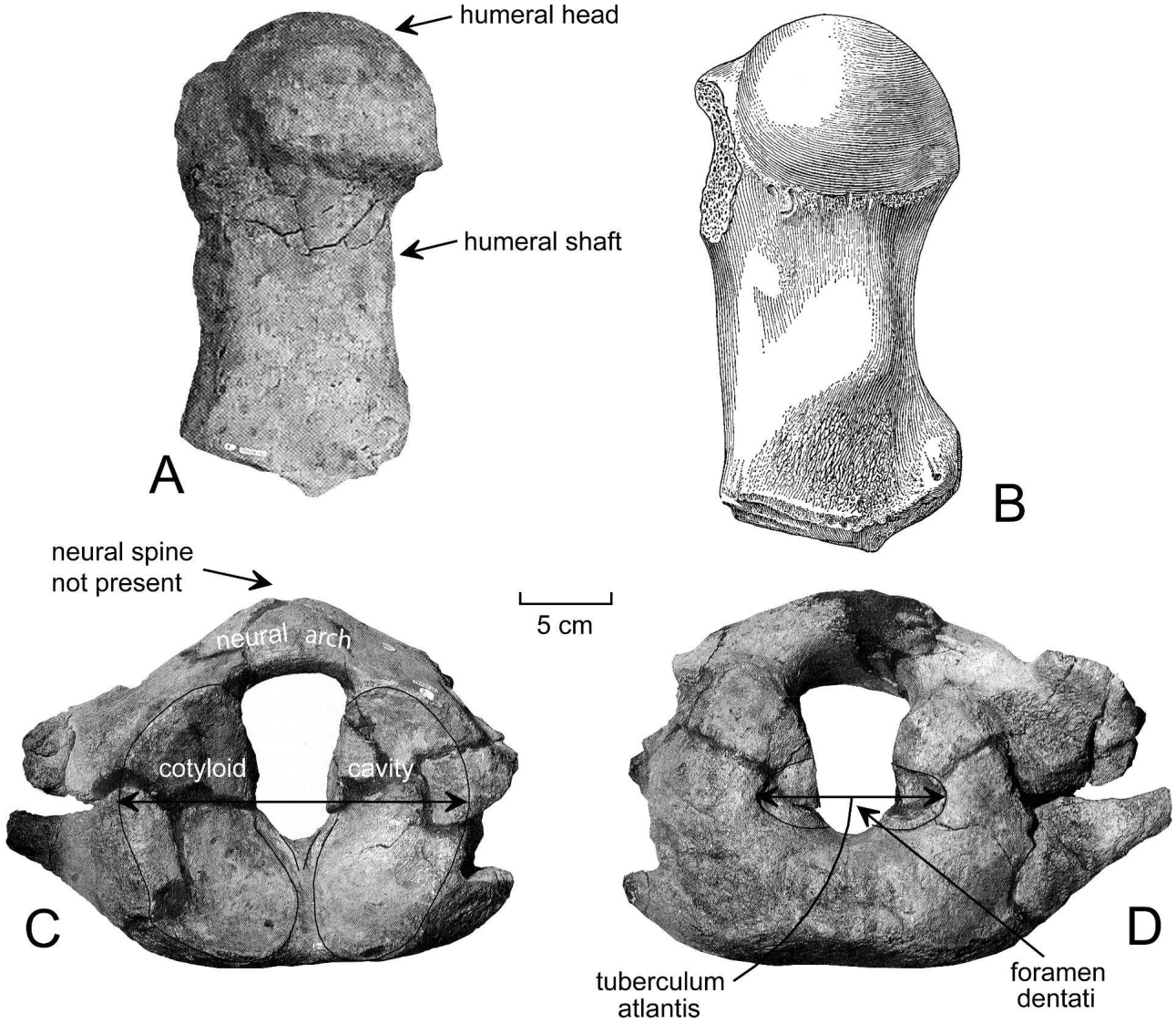

FIGURE 2. **A**, Left humerus of *Eobalaenoptera harrisoni* in external view (from Dooley et al., 2004:fig. 8B) and **B**, left humerus of "*Eschrichtius*" *cephalus* in external view (from Kellogg, 1968a:fig. 46). **C**, Anterior and **D**, posterior views of the atlas of *Eobalaenoptera harrisoni* (from Dooley et al., 2004:fig. 6A–B).

limited evidence that is available, however, it seems most likely that the two taxa are distinct.

As *cephalus* is a valid species of balaenopterid whale that clearly does not belong within the genus *Eschrichtius*, but cannot be placed with certainty in another genus, we choose for now to associate this species questionably with the genus *Balaenoptera*, with which it has either close affinity or identity (Kellogg, 1968a), under the combination *Balaenoptera? cephalus*. Fossil remains confidently referable to *Balaenoptera* are not known as far back in time as the Miocene, but SINE insertion analysis indicates that the fin whale (*Balaenoptera physalus*) and the minke whale (*Balaenoptera acutorostrata*) diverged from a common ancestor 19.8 ± 4.7 million years ago (Nikaido et al., 2001). Even at the younger end of this range for divergence (15.1 Ma), the branching time is 1–2 Ma earlier than the time interval of DN5 (Fig. 1). This strongly suggests that, by the Serravallian Stage of the middle Miocene, at least two and perhaps more early species of *Balaenoptera* already existed. Thus, although remains of whales referable to the rorqual-gray whale clade are very rare in the Calvert Formation, the radiation of this clade apparently was well under way by the time the upper part of the Calvert Formation was deposited. In view of this, the scarcity of their remains in the Calvert seems best explained either by a local environmental bias against their preservation or by their normal middle Miocene range being in some other part of the world, so that only occasional stragglers then visited the northwestern Atlantic coastal region.

The taxonomic history of *Balaenoptera? cephalus* is summarized as follows:

SYSTEMATIC PALEONTOLOGY

Family BALAENOPTERIDAE Lacépède, 1804
BALAENOPTERA Lacépède, 1804
BALAENOPTERA? CEPHALUS (Cope, 1867)
(Fig. 2)

Eschrichtius cephalus Cope, 1867a:131.
Cetotherium cephalus (Cope): Cope, 1890:612, figs. 7–8, pl. 22.
Cetotherium cephalum (Cope): Hay, 1902:599 (emended spelling).
Eschrichtius cephalus Cope: Kellogg, 1968a:10, figs. 40–47.
Balaenoptera? cephalus (Cope): Weems and Edwards (this paper; new combination).

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