PROCEEDINGS OF THE UNITED STATES NATIONAL MUSEUM

issued by the

SMITHSONIAN INSTITUTION
U. S. NATIONAL MUSEUM

Vol. 107 Washington: 1957 No. 3387

TWO ADDITIONAL MIOCENE PORPOISES FROM THE CALVERT CLIFFS, MARYLAND

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I. Rediscovery of *Phocageneus venustus* Leidy

In his article on vertebrate remains from Richmond, Va.,published in 1850, Jeffries Wyman mentioned that among the specimens he had received from Dr. Martin Burton, a resident of Richmond, was a tooth which Professor Louis Agassiz identified as belonging to his genus *Phocodon*. The type of this genus is *Phocodon scillae* Agassiz, now generally recognized as a species of *Squalodon*. Professor Wyman figured and described the tooth received from Dr. Burton, but he did not give it a specific name. Prior to 1869 Leidy received from Professor Wyman what was supposed to be the same tooth, but remarked: "Having requested Prof. Wyman to allow me to inspect the tooth, he sent me a specimen which he observed was either the original of the figure (1850, fig. 4) or pertained to the same animal. If such is the case, the figure is an unfaithful representation of it." This comment is unquestionably correct, for while Wyman's figure represents what appears to be a tooth with a small tubercle or cusp at the base of the crown posteriorly, a vestigial tubercle on the anterior cutting edge, and a flattened root of which the terminal end is missing, Leidy's figure (1869, pl. 29, fig. 10) shows a tooth of a somewhat different appearance.

The tooth (No. 11227) in the collection of the Academy of Natural Sciences of Philadelphia bearing the name *Phocageneus venustus* is, as Leidy has commented, not accurately portrayed in the illustration published by Wyman. Nevertheless it should be noted that the essential structural features are shown, although somewhat exaggerated. After examining this tooth, however, I am of the opinion that it is actually Wyman's original specimen, and that his illustration represents an unsuccessful attempt to draw a rather difficult object. One reason for this conclusion is that the length of Wyman's tooth as illustrated corresponds rather closely to that of Leidy's type specimen. Wyman stated that his tooth measured 1.2 inches, that is, 30.48 mm. Furthermore, Wyman's description applies very exactly to the tooth (No. 11227) in the collection of the Academy of Natural Sciences of Philadelphia. Leidy also accurately described this tooth, and his illustration is of exactly the right size, though the ornamentation of the enamel crown is not accurately depicted. Notwithstanding the observed inaccuracies in the illustrations, the descriptions given by both Wyman and Leidy clearly pertain to the tooth in the collection of the Academy of Natural Sciences of Philadelphia and it is the type of *Phocageneus venustus*.

Wyman's description (1850, p. 231) is as follows:

> This tooth (fig. 4) is 1⅞₀ inch in length, having a small portion broken from the end of its root. The crown is conical, compressed on its inner face, with slightly trenchant edges, the posterior of which is provided with a slightly projecting tubercle. The enamel over its whole surface is roughened by small irregular ridges, the general direction of which is from the base towards the apex of the crown, those at the apex being the most minute. This tooth must have been placed at the anterior part of the jaw; all those of the posterior lateral portions being deeply indented.

Wyman obviously was influenced by the assumption that this odontocete was a relative of *Squalodon*, whose posterior teeth have serrated cutting edges. This tooth, however, came from the posterior end of the tooth row and probably from the maxillary.

Leidy (1869, pp. 426–427) described the tooth as follows:

> The crown is conical, compressed, oval in section at base, and moderately curved. It forms an acute ridge before and behind, and has an acute point. The base is conspicuously swollen internally, and contracts all around toward the neck. The anterior acute border of the crown expands in a triangular surface of the swollen base. The posterior border is embraced by an attempt to form a basal cingulum. The enamel of the crown is nearly uniformly corrugated, and the wrinkles are much interrupted. The fang, broken at its point, has been about twice the length of the crown, is conical, slightly curved, and feebly gibbous.

The dimensions of the type tooth of *Phocageneus venustus* are as follows: Maximum length as preserved, 30.4 mm.; maximum height of crown, 13.5 mm.; maximum anteroposterior diameter of base of

crown, 10.7 mm.; maximum transverse diameter of base of crown, 8.8 mm.; maximum diameter of root, 9.5 mm.; maximum diameter of root at broken-off extremity, 8.0 mm.; least diameter at same point, 5.5 mm.

The specimen hereinafter described apparently represents the second recorded occurrence of this extinct porpoise in the Calvert formation. The symphyseal portion of the mandibles was discovered by Roland A. Fowler on May 15, 1955, protruding from the face of the cliff south of Fairhaven, Md., and it was brought to the U. S. National Museum for identification. Subsequently, on May 21, Franklin L. Pearce accompanied Mr. Fowler to the site and excavated the posterior portions of the mandibles as well as six vertebrae. Later, on September 17, Mr. Fowler, Mr. Pearce, G. Donald Guadagni, and I made a deeper excavation at the site and recovered ten additional vertebrae.

Phocageneus Leidy

Phocageneus Leidy, Journ. Acad. Nat. Sci. Philadelphia, ser. 2, vol. 7, p. 426, 1869.

Genotype: *Phocageneus venustus* Leidy.

Diagnosis: Mandibles with symphysis united but not firmly ankylosed; width of symphysis greater than depth; opposite free posterior portions of mandibles come together at a 30° angle at symphysis; coronoid process robust; distance from apex of coronoid process to posterior margin of hindmost alveola equivalent to approximately one half of distance from posterior face of condyle to posterior end of symphysis; flange-like internal dorsal border of mandible posterior to coronoid process prolonged backward internal to and beyond condyle; condyle large, directed downward and backward, and projecting externally conspicuously beyond outer face of mandible.

Seven teeth located behind posterior end of symphysis on each mandible; alveolae separated by intervals of 4.5 to 11.5 mm.; circular depressions for reception of apices of teeth in upper jaws present between teeth on symphysis; roots of teeth elongated, curved, and slightly expanded proximally; crowns of teeth somewhat compressed transversely on distal half of their height and bent inward toward apex, ovoidal in cross section at base, constricted around circumference at base, and with a vertically directed blunt carina on anterior and posterior faces of at least the nine hindmost teeth; enamel on basal half of crowns of posterior mandibular teeth coarsely corrugated or wrinkled; enamel on crowns of anterior mandibular teeth less noticeably wrinkled, the striae being least conspicuous on external face, and a vertically directed carina more noticeably developed on posterior than on the anterior face.

Periotic with unusually large elliptical fenestra rotunda, relatively small internal acoustic meatus, and elongated anterior process. Cervical vertebrae robust, with relatively thick centra; atlas with reduced lower transverse processes, enlarged upper transverse processes and elongated hypapophysial process; ventroexternal angles of broad transverse processes of third and fifth cervicals project forward and outward; lateral arterial canals large. Neural spines narrow on anterior dorsals and broad on posterior dorsals; first to sixth dorsals have facets for articulation with capitula of corresponding ribs situated at the upper anteroexternal and upper posteroexternal angles of the centra; eighth dorsal with short diapophysis and short parapophysis (transverse process) closely approximated.

Phocageneus venustus Leidy

Phocageneus venustus Leidy, Journ. Acad. Nat. Sci. Philadelphia, ser. 2, vol. 7, p. 426, pl. 29, fig. 10, 1869. (See Wyman, Amer. Journ. Sci., ser. 2, vol. 10, 1850, p. 230, fig. 4.)

Type specimen: One tooth. Cat. No. 11227, Academy of Natural Sciences of Philadelphia. Collector, Dr. Martin Burton (1850?).

Horizon and locality: Richmond, Henrico County, Va. Presumably from the diatomaceous deposits, Calvert formation, upper Miocene.

Referred Specimen

USNM 21039: Mandibles, lacking anterior portion of symphysis; right and left tympanic bulla; right and left periotic; right and left malleus; right incus; left stapes; 16 detached teeth; atlas and 3 cervical vertebrae; 10 dorsal vertebrae; 2 lumbar vertebrae; 4 caudal vertebrae; 2 chevron bones; 1 sternal segment; and portions of 5 ribs. Collector, Roland A. Fowler, May 15, 1955.

Horizon and locality: Diatomaceous earth, one-quarter mile south of wharf at Fairhaven, Fairhaven Cliffs, Anne Arundel County, Md., about 8 feet above base of cliff. Calvert formation, upper Miocene.

Mandibles

The anterior portion of the symphysis (pl. 1) was broken off and lost prior to the discovery of these mandibles protruding from the face of the cliff. A short section of the right mandible between the level of the third tooth behind the posterior end of the symphysis and the anterior border of the orifice of the internal dental canal was destroyed accidentally when the specimen was discovered; this region has been restored. The posterior portions of both mandibles are somewhat crushed in a dorsoventral direction but are otherwise

essentially complete. The mandibles were united but not firmly ankylosed at the posterior end of the symphysis. On the ventral face (pl. 2) the line of contact of the opposite mandibles is indicated by a continuous narrow groove which extends medially the full length of this portion of the symphysis.

The symphyseal portion of the united mandibles apparently tapered toward the anterior extremity, since the transverse diameter diminishes from 45 mm. at the level of the posterior end to 28± mm. at the level of the 11th alveola counting forward from the hindmost alveola in the left mandible, although the dorsoventral reduction is less noticeable.

Between the tooth rows the dorsal surface of the symphysis is concave or depressed. Pits for the reception of the apices of the teeth in the upper jaws are present between the teeth on the symphysis.

The distance (107 mm.) from the posterior end of the symphysis to the posterior margin of the hindmost alveola in the left mandible is greater than the interval (60± mm.) between opposite tooth rows at the level of this tooth. The opposite free posterior portions of the mandibles come together at an angle of 30° at the symphysis.

More than 11 alveolae were present in the left mandible when complete. Since there is no known closely related odontocete it is inadvisable to estimate the number of teeth originally present in each mandible. The teeth on the posterior portion of the symphysis were not implanted opposite one another and the alveolae are separated by intervals of 7 to 9 mm. from preceding and succeeding alveolae. The minimum interval between alveolae in either mandible behind the symphysis is about 4.5 mm. The septa between the alveolae are complete. The largest alveola (sixth counting forward from the hindmost) in the left mandible measures 9 mm. anteroposteriorly and 8 mm. transversely, and the smallest (ninth counting forward from the hindmost) 8 mm. anteroposteriorly and 7 mm. transversely. The alveolae located behind the symphysis are larger than those located anterior to the posterior end of the symphysis. The seven alveolae located behind the symphysis on the left mandible are spaced at intervals of 4.5 to 11.5 mm. The distance from the posterior margin of the hindmost alveola to the anterior margin of the 7th alveola in the left mandible is 101.5 mm. The distance between opposite alveolae immediately in front of the posterior end of the symphysis is 22 mm., and at the level of the 11th tooth counting forward from the hindmost in the left mandible it is 18.5 mm. The presence of 7 teeth in the left mandible behind the level of the posterior end of the symphysis readily distinguishes these mandibles from those of *Pelodelphis gracilis* (Kellogg, 1955, pl. 13, fig. 1), which have 12 teeth on this portion of the mandibles.

The extremities of the long roots of at least two teeth posterior to the posterior end of the symphysis curve backward below the tooth immediately behind.

From a lateral view the ventral profile of the proximal portion of the symphysis suggests that the anterior portion was bent slightly upward. The external face of the symphyseal portion of the left mandible is convex along the dorsal border, but then slopes obliquely from the dorsal border to the midline of the ventral surface. A cross section of the symphysis at the level of the 11th tooth counting forward from the hindmost in the left mandible resembles an open U.

The largest nutrient foramen is located on the outer surface of the left mandible 15 mm. below the rim of the second alveola counting forward from the hindmost. A second foramen opens 17 mm. below the rim of the sixth alveola and a third foramen 16 mm. below the rim of the eighth alveola counting forward from the hindmost. Short grooves extend forward from the first and second of these foramina, and a somewhat longer groove extends forward from the third foramen at least beyond the level of the 11th alveola counting forward from the hindmost.

The depth of the left mandible in its present condition at the posteriormost alveola is 32 mm., although crushing has distorted the posterior portion of each mandible to some extent. It is also possible that the posterior portions of the mandibles have been spread apart more than originally existed.

The dorsal edge of each mandible ascends gradually to the apex of the coronoid process which has a thickened dorsal border. Each coronoid process is bent outward and the opposite processes are separated by an interval of 132 mm. The distance (173 mm.) from the apex of the coronoid process to the posterior margin of the hindmost alveola on the left mandible is equivalent to about 53 percent of the distance (324 mm.) from the posterior face of the condyle to the posterior end of the symphysis.

About 52 mm. behind the posteriormost alveola on the inner face of each mandible there is a large orifice for the dental canal. Posterior to this orifice, the inner wall is reduced to a low thin strip along the ventral border of the mandible. The outer wall of the posterior portion of each mandible consists of a thin shell of bone which, judging from the curvature of the crushed areas, was originally somewhat convex. Unlike other odontocetes the dorsal border of the mandible posterior to the coronoid process forms an internal flange-like ledge which is prolonged backward internal to and beyond the condyle. Unfortunately no comparisons can be made with the posterior portions of the mandibles of *Squalodelphis fabianii* (Dal Piaz, 1916) which are concealed by matrix. The ventral margin of the left mandible is

continued backward from the symphysis in a shallow curve toward the angle.

The dorsoventral axis (35 mm.) of the left condyle is directed downward and backward and its external border projects conspicuously beyond the outer face of the mandible. The maximum transverse diameter of the left condyle is 32.8 mm. In outline, the left condyle is almost subscutate in outline and is directed more outward than backward. The right condyle has been restored.

Measurements of mandibles (in millimeters)

	Right	Left
Length of mandible, condyle to broken anterior end	395. 0±	386. 0
Greatest length of ankylosed symphyseal portion of rami	62. 5	62. 5
Transverse diameter of mandibular symphysis at level of posterior end	45. 0	
Vertical diameter of mandibular symphysis at level of posterior end	29. 0	
Transverse diameter of mandibular symphysis at level of 11th tooth counting forward from hindmost tooth in mandible	28. 0±	
Vertical diameter of mandibular symphysis at level of 11th tooth counting forward from hindmost tooth in mandible	23. 5	
Height of mandible through coronoid process	85. 0+	87. 0+
Greatest dorsoventral diameter of condyle		35. 0
Greatest transverse diameter of condyle		32. 8
11 alveolae in an interval of		164. 0
7 posterior alveolae (first to seventh) in an interval of		101. 5
4 anterior alveolae (eighth to 11th) in an interval of		56. 0
Condyle to posterior end of symphysis	330. 0±	324. 0
Apex of coronoid process to posterior end of symphysis		282. 0

Teeth

Both mandibles were broken off 62.5 mm. in front of the posterior end of the symphysis. Eleven alveolae are now preserved in the left mandible and presumably the same number were present in the corresponding portion of the right mandible. Seven teeth were implanted in the left mandible behind the level of the posterior end of the symphysis. Four teeth are preserved in place in the right mandible; eight teeth and three alveolae are present in the left mandible. The alveolae for the tenth and eleventh teeth in the left mandible counting forward from the hindmost were completely filled with diatomaceous earth. Two of the detached teeth have been allocated to these alveolae. On the right mandible, the alveolae for the ninth, tenth, and eleventh teeth counting forward from the hindmost lack the outer walls since a section of the external shell of this mandible 70 mm. in length and 18 to 20 mm. in width was destroyed.

The teeth of *Phocageneus venustus* resemble most closely those of *Squalodelphis fabianii* (Dal Piaz, 1916, p. 24, figs. 5–8, and pl. 5, figs. 3–18) from the lower Miocene, upper Langhian stage of Belluno, Italy, not only in size but also in the configuration of the crown and the wrinkling of the enamel. Dal Piaz (1916, p. 32) proposed the family Squalodelphidae to include the Italian *Squalodelphis* and the Argentine *Argyrodelphis* [=*Diochotichus*], while others have regarded *Squalodelphis* as either an offshoot of primitive Squalodontidae (Slijper, 1936, pp. 545, 549) or a transitional form between the Squalodontidae and the Ziphiidae. Although the family allocation of *Phocageneus* will await discovery of a skull, the structural characteristics of the teeth nevertheless indicate some relationship with *Squalodelphis*.

Fifteen teeth were present in each mandible and on each side of the rostrum of *Squalodelphis fabianii*, a total of 60 teeth. The alveolae on the symphysis of *Squalodelphis fabianii* are separated by intervals that progressively increase from 15 mm. at the level of the posterior end to about 23 mm. at the anterior end. On the basis of the illustrations of the skull and mandibles of *Squalodelphis fabianii* published by Dal Piaz (1916, pl. 1, fig. 2; pl. 2, fig. 2) it would appear that eight teeth were located on the symphyseal portion of each mandible and seven on the free portion behind the symphysis. Consequently the eight teeth implanted on the symphyseal portion of each mandible occupied an interval of about 246 mm. Since the four alveolae on the posterior symphyseal portion of each mandible of *Phocageneus venustus* occupy an interval of 62.5 mm., it is obvious that either the symphysis of *Phocageneus* was shorter than that of *Squalodelphis* or a greater number of teeth were present.

The ornamentation of the enamel crowns of the teeth of *Phocageneus venustus* is quite unlike those of either *Delphinodon dividum* (True, 1912, pl. 26, figs. 1–20) or *Tretosphys gabbii* (Kellogg, 1955, pls. 20, 21). Furthermore the teeth of *Phocageneus venustus* are larger than the corresponding teeth of either *D. dividum* or *T. gabbii*. The teeth of *P. venustus* differ from the corresponding teeth of *D. dividum* and *T. gabbii* in that the base of the crown is constricted around its circumference to conform to the shape of the neck of the root and in that the wrinkles or vertical striae on the corrugated enamel surface are more or less complicated by a varying number of short oblique grooves. The enamel on the crown is black.

It should be pointed out that the genotype of the genus *Delphinodon* was fixed by Hay (1902, p. 591) as *Delphinodon mento* (Leidy, 1869, pl. 30, figs. 7, 8). The type tooth of *Delphinodon mento* (No. 11228, Acad. Nat. Sci. Philadelphia) is much larger than those of either *Delphinodon dividum* or *D. leidyi* (Leidy, 1869, pl. 30, fig. 12) and

presents several important peculiarities not shared by the smaller species. When either a skull or mandible with teeth that match the type tooth of *Delphinodon mento* is found, it is quite probable that it will be necessary to separate *D. dividum* generically from *D. mento*.

The ornamentation of the enamel on the inner surface of the crown is rugose to a varying degree, the corrugation or wrinkling of the enamel being most pronounced on the teeth situated behind the symphysis and progressively diminishing anteriorly. The rugosities on the external face of the crown of some of the posterior teeth, although rather coarse, are less prominent as compared to the internal face and are best developed on the basal one-half of this face. The apical one-third of the external face is much less noticeably wrinkled. On the basal half, the internal face of the crown of the first to ninth teeth (counting forward from hindmost) is noticeably roughened by the presence of more or less vertically directed coarse irregular wrinkles. The distal third of the internal face of the crown is less noticeably corrugated. The crown of each of the above-mentioned teeth is somewhat compressed transversely on the distal half of its height and bent inward toward the apex, ovoidal in cross section at the base, and characterized by a vertically directed blunt carina on the anterior and posterior cutting edges. These teeth (pl. 3, figs. 4–6; pl. 4, figs. 1–6) are larger than the corresponding teeth of *Delphinodon dividum* (True, 1912, pp. 171–174, pl. 19, figs. 1–2; pl. 26, figs. 1–20), the sculpturing of the internal enamel surface is relatively coarse (corrugated or wrinkled) on the basal half of their height, no denticulated carina is developed on either the anterior or the posterior faces, and no discernible accessory tubercle is present near the base of the posterior face on any of the mandibular teeth. No minute tubercle is present at the base of the crown either anteriorly or posteriorly on the nine mandibular teeth counting forward from the hindmost. The anterior vertically directed carina extends from the triangular basal area to the apex of the crown. The posterior vertically directed carina is more noticeably developed on the teeth situated behind the level of the posterior end of the symphysis than on the teeth situated anterior to this end of the symphysis. The anterior and posterior faces of first to fourth teeth (counting forward from the hindmost) in the left mandible and the posterior face of the fifth and sixth in the right mandible were worn by occlusion with the teeth in the maxillaries. The presence of circular depressions between the alveolae for the sixth to eleventh teeth in the left mandible indicates rather conclusively that the points of the corresponding maxillary teeth were thrust into these pits.

By "basal cingulum" Leidy (1869, p. 426) apparently referred to the inwardly projecting irregular rugose area (pl. 3, fig. 2) approximately

4 to 5 mm. above the base of the crown on the type specimen of *Phocageneus venustus*. The enamel in this area is corrugated and the more or less vertically directed wrinkles are not in each instance continuous. In describing this tooth Wyman (1850, p. 231) mentions "a slightly projecting tubercle." Wyman seems to have applied this term to a minute tubercle situated near the basal end of the posterior carina on the crown (pl. 3, fig. 2). Since the wrinkles on the enamel surface of the crown of the type tooth are less pronounced than on the posterior mandibular teeth of USNM 21039, this type tooth is tentatively identified as a posterior tooth from the right maxillary.

The following detailed descriptions of 10 of the 16 detached teeth, which were recovered from the matrix enveloping the mandibles, are given to indicate the extent of variation in the ornamentation of the enamel on the crowns. The allocations are based on comparison with teeth implanted in the mandibles.

A posterior tooth (pl. 4, fig. 2), identified as the second counting forward from the hindmost on the right mandible, which lacks the distal portion of the root, has the enamel on all faces of the crown coarsely corrugated on the basal half, the apical half of the crown is compressed transversely, the edge of the vertical carina on the anterior face is blunt and slightly nodular, and the base of the crown is constricted around its circumference.

Another posterior tooth (pl. 3, fig. 6), identified as the fourth counting forward on the right mandible, has carinae on the anterior and posterior faces, the apical half of the crown is bent inward and somewhat compressed transversely, the enamel on the basal half of the crown is corrugated or wrinkled, and the base of the crown is constricted around its circumference. The greatest diameter of the proximal portion of the elongated curved root exceeds slightly the greatest diameter of the basal portion of the crown.

The sixth tooth (pl. 3, fig. 5), counting forward from the hindmost on the left mandible, has the enamel on the crown ornamented similarly to that of the preceding tooth but differs in having two carina on the anterior face, the bifurcation commencing approximately 3 mm. below the point.

An anterior tooth (pl. 4, fig. 1), presumably the 10th in the left mandible counting forward from the hindmost, is quite similar to the 11th (28.2+ mm.) as regards ornamentation of the enamel on the crown, although the anteroposterior diameter of the crown is greater and a vertical carina is present on both the anterior and posterior faces.

The anterior tooth (pl. 4, fig. 6) identified as the 11th counting forward from the hindmost in the left mandible has the enamel on the internal face somewhat wrinkled, especially at the base of the crown, but possesses a carina on the anterior edge which bifurcates

ventrally to bound a rather smooth triangular basal area. The posterior face of the crown is worn.

Another anterior tooth (pl. 3, fig. 4) from the right mandible which seems referable to the 11th counting forward from the hindmost has an ornamentation on the internal face of the crown similar to the corresponding tooth from the left mandible.

Another detached tooth (pl. 4, fig. 5) apparently was located anterior to the 11th alveola and may be either the 12th or the 13th in the tooth row of the right mandible. It has an inwardly curved crown which is tapered toward the point. The side to side compression of the upper half of the crown is much less noticeable than on the 10th tooth. On the internal face of the crown the enamel is faintly wrinkled, the striae extending in a more or less vertical direction to the point. As contrasted with the internal face, the enamel on the external face is less noticeably wrinkled and relatively smooth. A slight vertical carina is present on the posterior face but not on the anterior face. The elongated and curved root is swollen on the internal face below the crown, and slightly flattened transversely at the extremity.

A rather small tooth (pl. 4, figs. 3, 4) with shortened and malformed root unquestionably represents the posteriormost tooth in either the upper or lower tooth rows. No alveola for such a tooth is discernible on the left mandible, but since this portion of the right mandible was destroyed, it may possibly have been present in the right tooth row. In that case, eight teeth were present in the right mandible behind the posterior end of the symphysis. The crown is low—the height being equivalent to about two-thirds of the anteroposterior diameter—and is constricted at the base, the apex of the crown is blunt and a coarsely corrugated pseudocingulum, broader internally than externally, sets off the somewhat triangular apical half of the crown. The short root is transversely flattened, nodular on the distal half, and irregularly bifurcated at the extremity.

Of these 16 detached teeth, the longest one is complete and undoubtedly belongs in the anterior part of the tooth row of either the upper or lower jaws. The measurements of this slender tooth are as follows: Greatest length, 39 mm.; greatest length of root, 29 mm.; greatest diameter of root, 8 mm.; height of crown, 12 mm.; greatest anteroposterior diameter of crown, 7 mm. If this tooth was included in a lower tooth row it was dislodged from the symphyseal portion of the right mandible. The inwardly curved crown is ornamented with rather coarse vertical wrinkles on the inner surface, although the outer surface is relatively smooth. The base of the crown is not constricted around its circumference. The terminal end of the backwardly curved and tapering root is very slender.

MEASUREMENTS OF THE DETACHED TEETH (IN MILLIMETERS)

	L. 6 (pl. 3, fig. 5)	R. 4 (pl. 3, fig. 6)	R. 11 (pl. 3, fig. 4)	R. 12 or 13 (pl. 4, fig. 5)	L. 11 (pl. 4, fig. 6)	R. 2 (pl. 4, fig. 2)	L. 10 (pl. 4, fig. 1)	R. P. (pl. 4, fig. 3)
Greatest length, as preserved	36. 8	34. 5	32. 8	30. 8	28. 2	26. 0+	24. 5+	11. 5
Greatest length of root	28. 7	25. 2	25. 6	23. 0	16. 8	17. 7+	15. 8+	5. 8
Greatest diameter of root	8. 3	8. 8	7. 2	7. 0	7. 0	8. 0	7. 8	4. 0
Height of crown externally	10. 3	11. 4	10. 6+	12. 0	11. 5	10. 5	11. 0	4. 2
Greatest anteroposterior diameter of crown	8. 6	8. 7	6. 8	6. 9	7. 2	9. 4	7. 7	6. 5
Greatest transverse diameter of crown	7. 7	7. 3	5. 8	6. 6	6. 3	9. 7	7. 2	5. 0

MEASUREMENTS OF THE TEETH IN MANDIBLES (IN MILLIMETERS)

	R. 5	R. 6	R. 7	R. 8	L. 1	L. 2	L. 3	L. 4	L. 5	L. 7	L. 8	L. 9
Greatest length in a straight line	32. 5					32. 0			32. 5			
Greatest length of root in a straight line	22. 0					21. 0			22. 0			
Height of crown externally	11. 5	11. 5	11. 0	10. 5	8. 5	10. 0	11. 7	11. 4	11. 0	11. 0	11. 2	11. 4
Greatest anteroposterior diameter of crown	9. 4	9. 4	8. 5	7. 9	8. 8	9. 35	8. 8+	9. 2	9. 4	8. 2	7. 9	7. 3
Greatest transverse diameter of crown	8. 3	7. 6	7. 4	6. 7	8. 3	8. 3	8. 3	8. 35	8. 1	7. 0	6. 5	6. 4

Another slender detached anterior tooth of similar shape, which lacks most of the crown, measures 37 mm. in its present condition and may, when complete, have exceeded the length of the previously described tooth.

The left mandible was broken subsequent to preparation, revealing the roots of the second and third teeth counting forward from the hindmost. The distal half of the root of the second tooth is bent backward almost at right angles to the axis of the crown and the proximal portion of the root and extends backward below the root of the posteriormost tooth. The distal portion of the root of the third tooth is not bent backward as abruptly as that of the second tooth and its extremity does not extend posterior to the level of the anterior margin of the alveola of the second tooth. In the right mandible the root of the third tooth situated behind the posterior end of the symphysis (presumably the fifth tooth counting forward from the hindmost) is strongly curved backward toward the extremity and slightly expanded below the base of the crown and its extremity extends backward below the root of the tooth behind it.

Periotic

The left periotic (pl. 5, fig. 7), which was detached from the corresponding tympanic bulla, does not differ in its external features from the right periotic. Both periotics are characterized by dorsoventral compression of the pars cochlearis, unusually large orifices of the fenestra rotunda and the aquaeductus cochleae, and a relatively small internal acoustic meatus.

One characteristic feature of the ventral surface of the periotic (pl. 5, fig. 6) is the shape of the articular facet on the posterior process for the corresponding process of the tympanic bulla. This articular facet curves concavely from end to end, and slopes from the posteroexternal angle to the anterointernal angle. Faint shallow grooves directed externally are visible on the internal portion of this facet. The ventrointernal border of the posterior process projects inward and the free edge contributes the floor for the facial canal. The anterior face, except for the short internal portion, and the dorsal face of the posterior process form a continuous sloping surface which terminates in the dorsally prolonged posterodorsal free edge of this process; the posterior face of this process is shallowly concave and the external end is emarginate.

As regards the ventral aspect of the pars cochlearis, there is a much closer resemblance to *Zarhachis flagellator* (Kellogg, 1924, pl. 7, fig. 6) than to other Calvert Miocene porpoises, although the free posterior and internal and anterior faces of this region are thicker and more

noticeably rounded. The large fenestra rotunda (pl. 6, fig. 3) is elliptical in outline and noticeably larger than the fenestra ovalis. The posterior face of the periotic is noticeably excavated above the fenestra rotunda, forming a broad dorsally directed groove. The foot plate of the stapes is lodged tightly in the ovoidal fenestra ovalis and is held in position by a pair of narrow internal ledges which extend across the anterior and posterior walls, respectively. Within the vestibule are the orifices of the three small canals, the two largest of which are situated opposite the epitympanic orifice of the aquaeductus Fallopii and lead to the semicircular canals; the other, a minute orifice, is situated at the posterointernal angle and is the terminus of the aquaeduct leading from the foramen singulare. On the internal wall there is a small passage which leads into the scala vestibuli. The epitympanic orifice of the aquaeductus Fallopii is small and opens into a narrow slit formed by the rim of the fenestra ovalis and the thin inwardly projecting ledge of the external portion of the periotic. The groove for the facial nerve, which leads from this aquaeduct, is sharply delimited externally and internally, and is markedly widened and deepened external to the fossa for the stapedial muscle and then extends backward along the dorsointernal face of the posterior process to and along the posterior face of the same process. A thin-edged rim separates the fenestra ovalis on the outside from the groove for the facial nerve and on the rear from the fossa for the stapedial muscle. The ovoidal fossa for the stapedial muscle is rather deep, concave from side to side, and extends downward on the external face of the pars cochlearis.

Along the internal margin of this fossa the thin-edged crest developed on the ventroexternal angle of the pars cochlearis extends backward to the posterior limit of the latter. The depth of the posterior face of this fossil periotic (9.8 mm.), as measured from the hindmost margin of the stapedial fossa to the fossa for the cerebral orifice of the aquaeductus vestibuli, is greater than the corresponding measurement of *Zarhachis flagellator*.

Between the irregular tuberosity or swelling on the basal portion of the anterior process and the anterior margin of the articular facet on the posterior process the ventral surface of the external denser portion of the periotic is narrowly depressed or excavated. The fossa incudis is reduced to a flattened oval area about 2 mm. in diameter and is located adjacent to the external rim of the groove leading from the aquaeductus Fallopii. This fossa incudis, which receives the crus breve of the incus, is shorter than that of *Zarhachis flagellator*, being prolonged farther posteriorly on the periotic of the latter.

The fossa for the reception of the head of the malleus is circular in outline, rather deeply concave, and is located on the internal face of

the irregular tuberosity on the basal portion of the anterior process. This fossa extends forward for the most part beyond the level of the epitympanic orifice of the aquaeductus Fallopii. The anterior process is elongated, obliquely truncated anteriorly, and directed obliquely inward. The main articular surface for the accessory ossicle or uncinate process of the tympanic bulla is an elongated concave depression which occupies the distal three-fourths of the ventral surface of the anterior process.

In its general features the confirmation of the cerebral face readily distinguishes this periotic (pl. 5, fig. 7) from those of other Calvert Miocene porpoises.

The internal acoustic meatus (pl. 6, fig. 2) is relatively small when contrasted with the orifice for the aquaeductus Fallopii through which passes the facial nerve. The channel for this aquaeduct is separated posteriorly by a low thin partition from the internal acoustic meatus. The minute orifice of the foramen singulare is located on the edge of this partition. The tractus spiralis foraminosus is well defined and terminates in the minute foramen centrale at the anterior end.

Outside the internal acoustic meatus and external to the unusually large cerebral orifice of the aquaeductus cochleae is the small orifice of the aquaeductus vestibuli which opens into a slit-like depression.

Measurements of the periotics (in millimeters)

	Right	Left
Breadth of periotic at level of fenestra ovalis (as measured from external face above groove to internal face of pars cochlearis)	20. 0	20. 0
Greatest length of periotic (tip of anterior process to tip of posterior process)	37. 5	40. 0
Greatest dorsoventral depth of periotic (as measured from most inflated portion of tympanic face of pars cochlearis and groove to most projecting point on cerebral face)		14. 2
Distance between fenestra rotunda and tip of anterior process	28. 0	28. 0
Distance between fenestra rotunda and anteroexternal angle of posterior process	16. 0	16. 4
Distance between epitympanic orifice of aquaeductus Fallopii and tip of anterior process		21. 0

Tympanic Bullae

Both of the tympanic bullae are unusually well preserved. The left tympanic bulla was detached from the periotic while the right one has been left in its normal relationship. These tympanic bullae are somewhat larger than those of either *Eurhinodelphis bossi* or *Rhabdosteus latiradix* and slightly smaller than those of *Zarhachis flagellator* (Kellogg, 1924, pl. 7, figs. 2, 4).

From a dorsal view (pl. 5, fig. 1) the inferior margin of the outer lip of the bulla is seen to be bent abruptly inward, forming a thin shelf to which the uncinate process is attached. The uncinate process which articulates with the elongate depression on the ventral face of the anterior process of the periotic is missing from the left bulla, but it is preserved in its normal position on the right bulla (pl. 6, fig. 1). This uncinate process is rather large, laterally compressed, and prolonged dorsally. The anterior end of the bulla is drawn out into a narrow projection which is directed forward and slightly downward, and constitutes the anterior outlet or tympanic aperture of the eustachian canal. The tympanic cavity is bounded by the overarching outer lip and by the involucrum. The thick involuted portion of the tympanic bulla is unevenly depressed below the level of the inwardly bent outer lip and rapidly diminishes in depth anterior to the middle of its length. The thick posterior portion of the involucrum is depressed dorsally and internally opposite the sigmoid process.

The posterior border and extremity of the sigmoid process are noticeably thickened; this process is twisted at a right angle to the long axis of the bulla. The posterior conical apophysis is somewhat flattened on its dorsal face, but otherwise the relations between the apophysis and the closely approximated sigmoid process are normal.

The elongated posterior process (pl. 5, fig. 3) is dorsoventrally compressed, emarginate distally, and is borne on a short slender neck; the articular facet for the posterior process of the periotic occupies less than half of the dorsal surface.

Measurements of tympanic bullae (in millimeters)

	Right	Left
Greatest length of bulla	50. 0	49. 5
Greatest depth of bulla on internal side (ventral face to dorsal face of involucrum)	18. 0	18. 5
Greatest depth of bulla on external side (ventral face to extremity of sigmoid process)	33. 0	34. 0
Greatest width of involucrum in epitympanic cavity		18. 0
Length of posterior process	21. 5	21. 0
Greatest width of bulla	30. 5	31. 5

The ventral surface of the tympanic bulla (pl. 5, fig. 2) is characterized by a rather broad and deep longitudinal groove, the depression becoming more pronounced anterior to the middle of its length. When viewed from the ventral side the outer contour of the bulla is biconvex and the inner contour exhibits a concave curvature. The bulla is much broader posteriorly than anteriorly.

When viewed from the external side (pl. 6, fig. 1), the posterior contour is seen to be convex, the ventral contour slightly convex posterior to the anterior projection, the posterior conical apophysis

partially concealed, and the sigmoid process directed more upward than backward.

Malleus

The malleus differs in several respects from that of *Kentriodon pernix* (Kellogg, 1927, figs. 8–13). The facets for articulation with the incus occupy more than one-third of the head of malleus and are located at the anterior end in a depressed area. The opposite facets meet medially at a right angle. The anterior end of the head is prolonged and forms a projecting conical point, and from it on the external side arises the minute tubercle or processus muscularis for insertion of the tensor tympani tendon.

The head of the malleus is borne on a slender stalk, the processus anterior (longus, gracilis, or folianus of authors), which becomes narrower as it approaches the outer lip of the tympanic bulla, fusing with the latter in the narrow groove between the sigmoid process and the uncinate process.

The longitudinal groove on the internal face of the tubercle at the anterior end of the head of the malleus may mark the area of attachment of the fleshy process (the "triangular ligament" of authors) of the membrana tympani. The malleus, including the anterior tubercle, measures 8.4 mm. in length and 4.3 mm. in width.

Incus

Two distinct facets comprise the surfaces by which the incus articulates with the corresponding facets on the malleus. The largest of these two facets is shallowly concave, subcrescentic in outline, and coextensive with the external face or base of the body of the incus; the smallest facet is deeply concave and is situated at the base on the ventral side. These two facets are separated from one another by a sharp ridge. From the body of the incus projects the crus longum, which is bent inward distally in a dorsointernal direction. On the dorsal end of the apical portion of the short conical crus breve is a small facet which rests in the fossa incudis. From the apex of the crus longum to the base of the body the incus measures 4 mm.; the greatest diameter of the base is 3.5 mm.

Stapes

The footplate of the slender stapes is closely fitted to the rim of the fenestra ovalis, although some slight side-to-side movement may have been possible. On the vestibular face of the footplate of the stapes is a distinct umbo or large oval concavity. The intercrural aperture is very minute and connects the concavities on the opposite sides of the stapes. A minute tubercle in the center of a small circular scar on the posterointernal angle of the head presumably marks the area for the

attachment of the stapedius muscle. The ovoidal concave facet on the slightly expanded distal end of the head constitutes the area of contact with the corresponding facet on the head of the crus longum of the incus.

Cervical Vertebrae

Four cervical vertebrae were associated with the mandibles. By a rather unusual modification, the ventroexternal angle of the broad transverse process of the third and fifth and presumably of the fourth cervical projects forward and outward. In this feature as well as the large size of the lateral arterial canals, these cervicals resemble the corresponding vertebrae of *Basilosaurus cetoides* and *Zygorhiza kochii* (Kellogg, 1936, fig. 10 and pl. 1) and differ in these respects from other known Calvert Miocene odontocetes. There is no indication, however, of any future tendency toward ankylosis of the individual cervical vertebrae. The sixth cervical has elongated and laterally compressed ventral transverse processes which are directed downward and outward. The third, fifth, and sixth cervicals have a rather broad longitudinal ridge on the ventral surface of the centrum.

Atlas: This vertebra (pl. 7, fig. 3) resembles the atlas of *Eurhinodelphis cocheteuxii* (Abel, 1931, pl. 19, fig. 2) in having robust upper transverse processes but differs in a number of other respects. The reduction of the lower transverse processes, the enlargement of the upper transverse processes, the elongation of the hypapophysial process, the height of the neural canal, and the anteroposterior diameter of the roof of the neural arch characterize this atlas.

The upper transverse processes are widened vertically, somewhat compressed in an anteroposterior direction, and project more outward than backward. The lower transverse processes are short and nodular. The facets for articulation with the occipital condyles are concave, widest near the middle of their height, and separated ventrally by an interval of 22 mm. The roof of the neural arch is not elevated medially—the anteroposterior diameter at center measuring 30 mm.—and is pierced on each side by a large vertebrarterial canal. The neural spine is low, broad, and blunt. The posterior facets for articulation with the axis are not identical in conformation. The left facet is somewhat elliptical and the right facet ovoidal in outline. Both facets are set off from the posterior face of the centrum externally, ventrally, and internally by projecting edges. The hypapophysial process is elongated, flattened dorsally, and somewhat rounded ventrally. Between the posterior facets and at the base of the rather broad neural canal is a narrow upwardly curving surface for articulation with the odontoid process of the axis which extends upward along the internal border of each lateral facet for at least half of the height of the latter.

Third cervical: This cervical vertebra (pl. 7, fig. 2) differs from the corresponding vertebra of both *Eurhinodelphis bossii* and *Rhabdosteus latiradix* by having much broader and shorter transverse processes, which have ventroexternal angles bent forward instead of backward, and by having large lateral arterial canals. The right prezygapophysial facet is ovoidal in outline and slopes steeply from external to internal margin. The right postzygapophysial facet is slightly convex, and slopes downward from external to internal margin. The neural canal is considerably wider (38 mm.) than high (18 mm.). The robust neural spine is short and is inclined backward. The anterior and posterior faces of the centrum are somewhat convex although depressed at the center. The median anteroposterior ridge on the ventral face of the centrum is rather broad (about 11 mm.) and separates deep lateral depressions. On both transverse processes the large arterial canal has a vertical diameter greater than the horizontal. Each transverse process is continuous dorsally with the pedicle of the neural arch; the dorsoexternal angle of each projects backward and the ventroexternal angle projects forward. Near the base of the anterior border of each transverse process a blunt tuberosity projects forward.

Fifth cervical: In many respects this cervical (pl. 7, fig. 4) is quite similar to the third cervical. Each transverse process is somewhat compressed anteroposteriorly, perforated at the base by a large rounded arterial canal, and connected dorsally with the lateral face of the pedicle of the neural arch by a thin plate. The dorsoexternal angle of each transverse process projects backward and the ventroexternal angle projects forward, resulting in the concave curvature of the anterior face distally. A small process similar to that of the third cervical projects forward near the base of the anterior border of the transverse process. The roof of the neural arch is narrow, although wider anteroposteriorly than that of the third cervical; the neural spine is short. The neural canal is wider (43 mm.) than high (34 mm.). The right prezygapophysial facet is subpyriform in outline, although flat, and slopes steeply from external to internal margin. The rather flat postzygapophysial facets are less elongated than the prezygapophysial facets and slope steeply downward from external to internal margins. The anterior and posterior facets project beyond the corresponding faces of the centrum. The anterior and posterior faces of the centrum are somewhat convex although depressed at the center. A broad median anteroposterior ridge on the ventral face of the centrum projects conspicuously below the lateral depressions.

Sixth cervical: Except for larger size and more robust build, this cervical (pl. 7, fig. 1) is quite similar in general conformation to the corresponding vertebra of *Rhabdosteus* and *Eurhinodelphis*. The transverse processes are directed downward, outward, and backward.

The broad ventral projection of each transverse process is flattened transversely; the upper portion is compressed anteroposteriorly, perforated at the base by a very large arterial canal and connected dorsally with the lateral face of the pedicle of the neural arch by a thin plate. The pedicles of the neural arch are stout and the neural canal is wider (47 mm.) than high (23 mm.). The anteroposterior diameter of the roof of the neural arch exceeds slightly that of the fifth cervical and the neural spine is low. The prezygapophysial facets are large and each slopes steeply from outer to inner margin. The left postzygapophysis is somewhat larger than the corresponding prezygapophysial facet and slopes much less steeply downward from external to internal margins. Both facets project beyond the corresponding faces of the centrum. The anterior face of the centrum is slightly convex but depressed at the center; the posterior face of the centrum is concave. The median anteroposterior ridge on the ventral face of the centrum is noticeably narrower than that of the fifth cervical and the lateral depressions are shallower.

MEASUREMENTS OF CERVICAL VERTEBRAE (IN MILLIMETERS)

	Atlas	C. 3	C. 5	C. 6
Greatest vertical diameter of articular surface for condyle (right)	55. 0			
Greatest transverse diameter of articular surface for condyle (right)	25. 5			
Least anteroposterior diameter of dorsal portion of neural arch	30. 0	13. 5	14. 5	17. 0
Least anteroposterior diameter of pedicle of neural arch		14. 5	14. 5	15. 5
Greatest height (vertically) of vertebra (tip of neural spine to ventral face of centrum)	91. 0	77. 5	86. 5	91. 5
Anteroposterior diameter of centrum	58. 0	31. 5	33. 5	39. 5
Distance across vertebra between tips of lower angles of transverse processes	94. 0	100. 0	108. 0	146. 0
Distance across vertebra between tips of upper angles of transverse processes (diapophyses)	108. 0	105. 0		130. 0
Distance between tip of prezygapophysis and tip of postzygapophysis		44. 0	50. 0	50. 0
Transverse diameter of neural (spinal) canal anteriorly	48. 0	38. 0	43. 0	47. 0
Maximum height of neural (spinal) canal anteriorly	46. 0	18. 0	34. 0	23. 0
Greatest distance across vertebra between outside margins of anterior articular facets	87. 0			
Greatest distance across vertebra between outside margins of posterior articular facets	87. 5			

Dorsal Vertebrae

The centra increase in length progressively from the first to the tenth in the dorsal series, and are broader than high. The width exceeds the length of the centrum of the first dorsal; the four posterior dorsals, seventh to tenth, have centra that are longer than wide. On each side of the centrum of the six anterior dorsals articular facets for the heads of the corresponding and succeeding ribs are situated at the upper anteroexternal and the upper posteroexternal angles; the upper anteroexternal facet alone is retained on the seventh dorsal. The pedicles of the neural arches are strong and occupy more than half the length of the centrum. On the five anterior dorsals the neck of the diapophysis is constricted dorsoventrally between the distal articular facet and the neural arch. The facets on the distal ends of the diapophyses for articulation with the tubercula of the ribs increase in width from the first to the sixth dorsals. On the second to fifth dorsals, inclusive, this facet projects forward beyond the level of the anterior face. On the eighth dorsal the diapophysis projects outward from near the base of the pedicle of the neural arch.

As will be noted from an examination of the illustrations, the backwardly projecting dorsal portion of the neural arch becomes progressively narrower toward the posterior end of the dorsal series. The anteroposterior diameter of the neural spine at the base increases from the anterior to the posterior end of the series. On the three anterior dorsals the anteroposterior diameter of the neural spine at the distal end is somewhat less than at the base, this difference being especially noticeable on the first dorsal. The neural spines of the two posterior dorsals have approximately the same anteroposterior diameter above the base. The prezygapophysial articular facets on the first dorsal are separated by a greater interval than on succeeding dorsals. Between the third and the ninth dorsals the width of the interval separating the prezygapophysial facets becomes markedly reduced. Each prezygapophysial facet is characterized by an upturned inner margin. The postzygapophysial facets of the six anterior dorsals project backward beyond the level of the posterior face of the centrum. The metapophyses of the ninth and tenth dorsals project forward beyond the level of the anterior face of the centrum.

First dorsal: On this vertebra (pl. 12, fig. 1) the diapophysis projects farther laterally than on the vertebrae that follow and the distal facet for articulation with the tuberculum of the first rib is situated behind the level of the anterior face of the centrum. A large facet for the capitulum of the first rib is located at the upper anteroexternal angle of the centrum (pl. 8, fig. 1) and a smaller facet for the capitulum of the second rib at the upper posteroexternal angle of the centrum.

The pedicles of the neural arch are strong and the neural canal is triangular in outline. As compared with the following vertebrae, the neural spine is relatively slender and slightly inclined forward. The prezygapophysial facets are large, deeply depressed posteriorly, and are separated by an interval of 41 mm. posteriorly. The postzygapophysial facets are large and slope obliquely from external to internal margins. The roof of the neural arch is narrow anteroposteriorly, the minimum diameter being 29 mm. The anterior and posterior faces of the centrum are shallowly depressed medially and the dorsal surface of the centrum is depressed on each side of the low median anteroposterior ridge. The centrum of this vertebra is the smallest of the dorsal series.

Second dorsal: The centrum of this vertebra (pl. 8, fig. 2) is longer than that of the first, the neural canal is smaller, and the minimum anteroposterior diameter (38 mm.) of the roof of the neural arch is greater. The neural spine is nearly vertical. The pedicles of the neural arch are low and robust. Each diapophysis projects upward, outward, and forward, and extends beyond the level of the anterior face of the centrum. The ovoidal lateral facet on the diapophysis for articulation with the tuberculum of the second rib is somewhat rugose, concave from end to end, and the anteroposterior diameter (28 mm.) is greater than the vertical diameter (21 mm.). The right prezygapophysial facet (pl. 12, fig. 2) is nearly flat, and slopes less steeply from external to internal margin than on the first dorsal; these facets are separated by an interval of 33 mm. posteriorly. The postzygapophysial facets are smaller than the anterior facets and somewhat rugose. The anterior and posterior faces of the centrum are depressed medially. The upper anteroexternal facet on the centrum for the capitulum of the second rib is smaller than the corresponding facet on the first dorsal, but slightly larger than the upper posteroexternal facet.

Third dorsal: Compared with the second dorsal, this vertebra (pl. 12. fig. 3) has shorter diapophyses, narrower neural canal, and broader neural spine. The backwardly projecting dorsal portion of the neural arch has a narrower transverse width than on the preceding dorsal. The prezygapophysial facets are large, concave, deeply depressed, and separated posteriorly by a relatively narrow interval (25± mm.). The right postzygapophysial facet is slightly convex, roughened, and slopes from external to internal margin. Each diapophysis projects outward, upward, and forward from the pedicle of the neural arch and projects forward beyond the level of the anterior face of the centrum; the ovoidal lateral facet for articulation with the

tuberculum of the third rib is rugose, deeply concave, and the anteroposterior diameter (21 mm.) exceeds slightly the vertical diameter (20 mm.). The lateral faces of the centrum (pl. 8, fig. 3) are depressed and curve concavely from anterior to posterior margins; the maximum width of the posterior face slightly exceeds that of the anterior face. The upper anteroexternal facet on the lateral surface of the centrum is elongated vertically and narrower anteroposteriorly than on the second dorsal; the upper posteroexternal facet is reduced in size.

Fourth dorsal: The length of the centrum is less than the width of the anterior face and the vertical diameter is about two-thirds the greatest width posteriorly; the anterior epiphysis is missing. This vertebra (pl. 12, fig. 4) is characterized by a rather low and wide neural canal; the backwardly projecting dorsal portion of the neural arch is noticeably contracted transversely posteriorly, as contrasted with the third dorsal. The neural spine is relatively narrow. The diapophyses project upward and outward and the concave rugose articular facet for the tuberculum of the fourth rib slopes obliquely downward and inward, the vertical diameter (21 mm.) being approximately equal to the anteroposterior diameter (22 mm.). The deeply depressed prezygapophysial facets are separated anteriorly by an interval of 17 mm. and project forward beyond the level of the anterior face of the centrum. The postzygapophysial facets have been broken off. The lateral (pl. 8, fig. 4) and ventral surfaces of the centrum are depressed and curve concavely from anterior to posterior margins. The upper anteroexternal and posteroexternal facets for articulation with the heads of the corresponding ribs are approximately the same size.

Fifth dorsal: In general appearance this vertebra (pl. 9, fig. 1) is quite similar to the fourth dorsal, with the exception of the more anterior position of the articular facet for the tuberculum of the fifth rib, the shorter pedicle of the neural arch, and the longer anteroposterior diameter of the neural spine. The robust diapophysis projects upward, outward, and forward at a lower level than on the fourth dorsal; the rugose subtriangular facet for the tuberculum of the fifth rib is concave, slopes downward and inward, and projects forward beyond the level of the anterior face of the centrum; the anteroposterior diameter (25 mm.) of the right facet exceeds slightly the vertical diameter (22 mm.). The concave prezygapophysial facets (pl. 12, fig. 5) are broad, and deeply depressed; the interval separating these facets can not be determined with certainty because of distortion resulting from crushing. The postzygapophysial facets are elongated, almost twice as long (23 mm.) as broad (12 mm.), and

slope obliquely from external to internal margins. The upper anterior and posterior facets for heads of the corresponding ribs are present on the lateral surface of the centrum. The transverse and vertical diameters of the posterior face of the centrum exceed the corresponding measurements of the anterior face; the ventral and lateral surfaces of the centrum curve concavely from anterior to posterior margins.

Sixth dorsal: Compared with the fifth dorsal, the backwardly projecting dorsal portion of the neural arch is narrower, the facet on the diapophysis for articulation with the tuberculum of the corresponding rib is smaller, the metapophyses project farther forward, the neural canal is reduced in width and height, and the pedicles of the neural arch are wider anteroposteriorly. The robust diapophysis (pl. 13, fig. 4) projects more outward than either upward or forward, and the concave distal facet for articulation with the tuberculum of the sixth rib is somewhat reniform in outline and is situated behind the level of the anterior face of the centrum. The concave prezygapophysial facets slope steeply from external to internal margins and are separated by an interval of less than 10 mm. Both postzygapophysial facets are eroded. The ventral and lateral faces of the centrum curve concavely from anterior to posterior margins, and the transverse width of the posterior face exceeds that of the anterior face. The anterior facet on the upper lateral surface of the centrum (pl. 9, fig. 2) for articulation with the capitulum of the sixth rib is larger than the corresponding posterior facet for the capitulum of the seventh rib.

Seventh dorsal: This vertebra (pl. 12, fig. 6) was badly damaged while the mandibles were being excavated. It lacks portions of both epiphyses, the pre- and postzygapophyses, the diapophyses, the dorsal portion of the neural arch, and the neural spine. Nevertheless, it should be noted that the height and width of the neural canal is less than on the preceding dorsal, the centrum is longer, and the diapophysis projects outward from the pedicle of the neural arch at a slightly lower level. The upper anteroexternal facet on the centrum (pl. 9, fig. 3) for articulation with the capitulum of the seventh rib is located on the anterior face of a protruding 3-sided tuberosity, foreshadowing the development of the rudimentary transverse process on the eighth dorsal. No posteroexternal facet for articulation with the eighth rib is developed on the centrum.

Eighth dorsal: On this vertebra (pl. 13, fig. 1) the neural spine, the backwardly projecting dorsal portion of the neural arch including the postzygapophyses, the right metapophysis and its prezygapophysial facet, and the left transverse process were destroyed during excavation. The elongated left prezygapophysial facet occupies

most of the internal surface of the metapophysis and slopes steeply downward from external to internal margins. The short dorsoventrally compressed left diapophysis projects outward from the pedicle of the neural arch. The distal facet on the diapophysis for articulation with the tuberculum of the eighth rib is elongated and is separated from the facet on the short transverse process for the capitulum of the same rib by an elongated groove measuring less than 10 mm. in vertical diameter. This dorsoventrally compressed transverse process (pl. 9, fig. 4) is situated at least 10 mm. behind the level of the anterior face of the centrum. The vertical and transverse diameters of the neural canal are less than on the preceding dorsal, the pedicles of the neural arch are noticeably reduced in height, and the left metapophysis projects forward beyond the level of the anterior face of the centrum.

Ninth dorsal: This vertebra (pl. 13, fig. 3) is characterized by short robust transverse processes (parapophyses), large markedly elevated and laterally compressed metapophyses, neural canal reduced and triangular in cross section, and broad neural spine. The centrum is longer than the preceding dorsal, and the width of the posterior face (62.8 mm.) exceeds the width (58 mm.) of the anterior face. Each parapophysis projects outward below the level of the dorsal face of the centrum and the distal facet for articulation with the single-headed ninth rib is deeply concave and rugose. The laterally compressed pedicles of the neural arch occupy more than half the length of the centrum; the vertical and transverse diameters (26 mm.) of the neural canal anteriorly are equivalent. The broad neural spine (pl. 10, fig. 1) is directed nearly vertically and is incomplete distally; the posterobasal portion of the spine is eroded in the region of the postzygapophyses. Narrow prezygapophysial facets separated by an interval of 10 mm. are present at the base and on the inside of each metapophysis.

Tenth dorsal: Longer transverse processes (parapophyses), longer centrum, and larger neural spine distinguish this dorsal (pl. 13, fig. 2) from the preceding vertebra. Each dorsoventrally compressed parapophysis projects outward from near the middle of the height of the lateral surface of the centrum and is narrowed slightly toward the distal end; the distal facet for articulation with the tenth rib is reduced in size. The laterally compressed pedicles of the neural arch resemble rather closely those of the ninth dorsal. No distinct prezygapophysial facets are retained at the base on the internal face of the large laterally compressed metapophyses. The large metapophyses (pl. 10, fig. 2) project anteriorly beyond the level of the anterior face of the centrum. The neural canal is triangular in cross section and similar in size to that on the preceding dorsal.

MEASUREMENTS OF DORSAL VERTEBRAE (IN MILLIMETERS)

	D. 1	D. 2	D. 3	D. 4	D. 5	D. 6	D. 7	D. 8	D. 9	D. 10
Greatest vertical height of vertebra, ventral face of centrum to tip of neural spine	149.0			171.0					164.0+	178.0+
Vertical height of neural spine, dorsal surface of neural canal to tip of neural spine	70.5			100.0					93.5	102.5
Greatest anteroposterior diameter of centrum	44.0	51.0	51.2	52.5+	54.5	59.0	63.5	66.5	71.5	74.5
Greatest vertical diameter of anterior face of centrum	43.3	41.5	42.5	42.5	41.5	44.6	46.0	49.0	52.0	54.0
Greatest transverse diameter of anterior face of centrum	49.5	51.0	55.5	58.5	58.2	55.0		55.0	58.0	64.0
Greatest vertical diameter of posterior face of centrum	42.2	43.5	41.2	44.5	42.4	45.2	48.2	51.0	52.5	56.5
Greatest transverse diameter of posterior face of centrum	52.5	57.0	58.8	63.5	61.0	61.8	57.0+	57.5	62.8	64.5
Greatest vertical diameter of neural (spinal) canal anteriorly	44.5	40.0	38.8	28.0	34.0	24.0		24.0	26.0	26.0
Greatest transverse diameter of neural (spinal) canal anteriorly	44.5	40.0	31.0	36.0	27.0+	32.5		28.0	26.0	26.0
Least anteroposterior diameter of pedicle of neural arch	21.0	23.5	24.0	26.0	23.5	30.0	32.0	33.0	39.0	40.5
Distance across vertebra between outer ends of diapophyses	130.5	108.0	85.5	94.5	78.5	89.5		77.5		
Distance across vertebra between outer ends of parapophyses									118.8	
Anteroposterior diameter of diapophysis at extremity	24.5	28.8	27.5	34.5	33.5	26.5		22.5		
Anteroposterior diameter of parapophysis at extremity									37.5	
Greatest distance between outer margins of prezygapophysial facets	94.0	75.0	57.0	55.5	42.5+	44.0			28.0	
Greatest distance between outer margins of postzygapophysial facets	72.8	58.8			36.5	28.5				
Anteroposterior diameter of neural spine horizontally at base	31.5	36.5	44.0	48.0	52.5	49.0			59.0	67.0
Distance from inner surface of pedicle of neural arch to extremity of diapophysis	43.5	38.5	33.5	37.0	34.0	33.0		26.0		

Lumbar Vertebrae

Two lumbar vertebrae were associated with the dorsal vertebrae, one of which is partially destroyed and lacks not only the right side of the centrum but all processes as well. The anteroposterior diameter of the centrum is 86.5 mm., which, on the basis of the length (74.5 mm.) of the posteriormost dorsal, would indicate an anterior location in the lumbar series. The transverse diameter (64 mm.) of the centrum is approximately the same as the vertical diameter (63.5 mm.). The median longitudinal keel is best developed near the middle of the centrum. The remnant of the left transverse process indicates that it was broad at the base.

The other lumbar vertebra (pl. 10, fig. 3) is fairly well preserved but lacks the anterior portion of both metapophyses and the distal end of the neural spine. The centrum is longer (91 mm.) than the preceding and the lateral depressions on the ventral face are separated medially by the thin longitudinal ridge. No marked differences in the vertical and transverse diameters of the anterior and posterior faces of the centrum are observable.

The transverse processes (pl. 14, fig. 1) are elongated, broad at the base, and apparently truncated obliquely at the extremity. The height (17 mm.) of the neural canal anteriorly is less than the transverse diameter (21.5 mm.). On each side the pedicle of the neural arch occupies more than half the length of the centrum. The metapophyses were bent upward and directed outward and forward; they project anteriorly beyond tht level of the anterior face of the centrum. The neural spine is broad at the base with concavely curved anterior and posterior margins, but it should be noted that the posterobasal portion of the neural spine is eroded.

Caudal Vertebrae

The mingling of cervical, dorsal, lumbar, and caudal vertebrae in a horizontal space of less than three feet shows that the carcass either was in an advanced stage of decay or was torn apart before the bones were covered by sediments. It would appear that the bones were washed about by water action before they settled in a soft diatomaceous ooze. Four caudal vertebrae were found. Three are regarded as belonging to the anterior part of the caudal series and one is unquestionably from the terminal end. The caudal series of Recent odontocetes ranges from 18 in *Inia*, 18 in *Hyperodon*, and 19 in *Berardius* to 45 in *Lagenorhynchus*. In view of this variation it does not appear advisable to estimate the number of caudal vertebrae.

The largest of these four vertebrae probably represents the second or third in the caudal series. The distal end of the neural spine is missing and a portion of the left transverse process is destroyed.

Otherwise this caudal (pl. 11, fig. 1) is essentially complete. The pedicles of the neural arch occupy more than half the length of the centrum and the ovoidal neural canal diminishes in diameter from the anterior to the posterior end. The neural spine is broad at the base; the anterior and posterior edges of the neural spine are eroded. The metapophyses are strong, projecting upward and outward, and extend forward beyond the level of the anterior face of the centrum; their dorsal edges are at least 46 mm. above the level of the top of the centrum. The centrum is large, its transverse diameter posteriorly being greater than the corresponding measurement anteriorly, and its lateral surfaces deeply depressed between the pedicle of the neural arch and the transverse process. The posterior paired plate-like descending processes for the chevron are longer than the anterior pair; these processes contribute the lateral boundaries of the rather deep longitudinal groove on the ventral surface of the centrum. The dorsoventrally compressed transverse processes (pl. 13, fig. 5) were expanded anteroposteriorly distally, but truncated obliquely toward anterior and posterior distal angles.

The second largest caudal (pl. 11, fig. 2) of those excavated is slightly twisted from crushing, the neural spine is destroyed, the dorsal edges of the metapophyses are slightly worn, and a portion of the left transverse process is broken off. The length of the centrum is approximately the same as the more anterior caudal, but the transverse and vertical diameters of the anterior and posterior faces are reduced. The lateral face of the centrum between the pedicle of the neural arch and the transverse process is not only depressed but is divided by a longitudinal ridge. The posterior pair of plate-like descending processes on the ventral face for articulation with the chevrons are much longer than the anterior pair; these processes constitute the lateral boundaries of the longitudinal ventral groove which is somewhat deeper than on the anterior caudal. The pedicles of the neural arch are reduced in height and length; the neural canal is small, not more than 10 mm. in diameter. The metapophyses are robust, and project more outward than upward; they apparently projected forward barely beyond the level of the anterior face of the centrum. The transverse processes (pl. 14, fig. 2) are short and broad, and both are perforated at the base by an arterial canal. The transverse process on the right side is truncated obliquely distally from anterior to posterior angle.

The caudal (pl. 11, fig. 3) with a slightly shortened centrum was somewhat damaged during excavation and now lacks a portion of the posterior epiphysis and the adjoining region of the centrum, the hinder end of the neural arch, and major portions of the plate-like descending processes on the ventral face of the centrum. This caudal is characterized by a very short neural spine, a very small neural

canal (pl. 14, fig. 3), low neural arch, and short transverse processes perforated at the base by an arterial canal. The metapophyses project outward and do not extend forward to the level of the anterior face of the centrum. The longitudinal groove between the descending processes for articulation with the chevrons was wider and not depressed to the same extent as on the preceding caudal.

The caudal (pl. 15, fig. 1) from near the terminal end of this series is pierced dorsoventrally by two fairly large arterial canals, the dorsal orifices being separated by a wider interval than the ventral orifices. The anterior and posterior faces of the centrum are slightly concave.

Measurements of lumbar and caudal vertebrae (in millimeters)

	L	L	Ca	Ca	Ca	Ca
Greatest vertical height of vertebra, ventral face of centrum to tip of neural spine	209. 0+		155. 0+			
Ventral face centrum anteriorly to dorsal edge of metapophyses	111. 0		118. 0	105. 0	88. 0	
Vertical height of neural spine, dorsal surface of neural canal to tip of neural spine	128. 0+		66. 0+			
Greatest anteroposterior diameter of centrum	92. 0	88. 0	97. 5	97. 0	88. 0	42. 0
Greatest vertical diameter of anterior face of centrum	66. 0		70. 5	69. 0	71. 0	43. 0
Greatest transverse diameter of anterior face of centrum	70. 0		76. 0	73. 0	68. 0	54. 0
Greatest vertical diameter of posterior face of centrum	65. 0	64. 0	71. 8	67. 0		
Greatest transverse diameter of posterior face of centrum	69. 0	64. 0	78. 5	73. 8		
Greatest vertical diameter of neural canal anteriorly	18. 0		16. 5	12. 0	9. 0	
Greatest transverse diameter of neural canal anteriorly	22. 0		15. 0	10. 0	11. 0	
Least anteroposterior diameter of pedicle of neural arch	45. 0		53. 5	51. 0		
Distance across vertebra between outer ends of parapophyses	230. 0		164. 0	135. 0+	80. 5	
Anteroposterior diameter of parapophysis at extremity			56. 0			
Anteroposterior diameter of neural spine horizontally at base	68. 0		61. 0			
Distance from inner surface of pedicle of neural arch to extremity of parapophysis	130. 0		101. 0	86. 5		

Chevron Bones

Two chevron bones (pl. 15, figs. 2, 3) were found in the matrix surrounding the vertebrae. These chevrons have elongated, ovoidal, rugose surfaces for articulation with the corresponding facets of the caudals. The laterally compressed ventral blade is prolonged backward.

II. An apparently unrecognized odontocete in the Calvert Miocene of Maryland

Further studies of the Calvert Miocene odontocetes reveal a previously unrecognized porpoise. The materials on which this study are based were collected in 1914 and 1940, but were laid aside until some of the more perplexing problems involved in the determination of the identity of some of Cope's type specimens could be resolved, at least tentatively. In view of the presently available series of odontocete skeletal materials recovered during the past 40 years from the Calvert Miocene deposits of Maryland, it seems desirable to review briefly the status of our knowledge of the components of this marine fauna.

At least 13 genera of toothed whales were represented by one or more species in the Calvert Miocene fauna. The physeterid *Orycterocetus*, although of small size in comparison to the living sperm whale, was the largest of all the Calvert toothed whales. This small sperm whale possessed functional teeth in the upper jaws although they were lodged in an open continuous alveolar groove. Presumably 20 to 22 teeth were present in each upper jaw and 20 to 24 in each mandible. One skull, which may possibly represent an immature individual, measures approximately three feet in length. The adipose cushion or reservoir for spermaceti had spread backward behind the narial passages and, as a result of this enlargement, the relative proportions and relations of the bones forming the dorsal surface of the skull have been altered to conform to this large supracranial basin. The basin is bounded behind by the dorsal border of the supraoccipital and the right premaxillary (which overlies the frontal) and laterally by the elevated borders of the maxillaries. The vertex of the skull has been entirely eliminated, one of the nasal bones has either been lost or greatly reduced and the other flattened against the frontal behind the greatly enlarged left narial passage, and the rostrum has been expanded laterally at the proximal end. In contrast to skulls of other odontocetes, the roof of the braincase has been depressed below the normal position, seemingly as the result of the additional weight and presure of the developing spermaceti reservoir.

Shark-toothed whales of the family Squalodontidae were represented by the genus *Squalodon* (Kellogg, 1923). The skull of this porpoise measured at least three feet in length and the rostrum was nearly twice

as long as the braincase. In some respects the skull is less modified than those of other contemporary odontocetes since the mesethmoid divides the fontanelle between the frontals on the forewall of the braincase into two large foramina through which the olfactory nerves pass. Unlike other Calvert Miocene odontocetes, the dentition of *Squalodon* is heterodont and is regarded as consisting of 3 incisors, 1 canine, 4 or 5 premolars and 6 or 7 molars. There were 16 teeth present in each upper jaw and 14 in each mandible. The crowns of the cheek teeth (molars and premolars) have the anterior and posterior cutting edges serrated by well-defined accessory cusps. Comparative measurements indicate a skeletal length of 10 feet.

Another porpoise, *Phocageneus*, on the basis of available materials seems to be related to the lower Miocene Italian *Squalodelphis*, which has been regarded as either an offshoot of primitive Squalodontidae or a transitional form between the Squalodontidae and the Ziphiidae. The lower Miocene *Squalodelphis* has 15 teeth on each side in the upper and lower jaws that are regarded by Dal Piaz (1916, p. 23) as representing 3 incisors, 1 canine, and 11 premolars and molars. Unlike the genus *Squalodon*, the posterior teeth of both *Squalodelphis* and *Phocageneus* lack serrations on the anterior and posterior cutting edges. The enamel on the crowns of the teeth of *Phocageneus* and also those of *Squalodelphis* is coarsely corrugated or wrinkled, the crowns are somewhat compressed transversely on the distal half of their height, and a vertically directed carina is present on the anterior and posterior faces of at least the nine posterior mandibular teeth.

Most of the other types of Calvert porpoises possessed a somewhat homodont dentition and a considerably greater number of teeth than *Squalodon*. Of the four genera of unusually long-beaked porpoises, *Zarhachis* (Kellogg, 1924) was the largest. It appears to be an aberrant type with no known counterparts in the Miocene of either Europe or South America. The skull of *Zarhachis* was nearly 4 feet long and illustrates an extreme stage in the lengthening of the rostrum and the symphysis as well as reduplication of the teeth. As regards the number of teeth, 86 to 87 were located on each side of the rostrum and 70 to 72 in each mandible. A dorsoventral flattening of both the rostrum and the symphysis characterize *Zarhachis*. Furthermore, the terminal teeth on the symphysis occlude with the anteriormost pair of teeth on the rostrum. On the braincase the outer end of each supraorbital process of the frontal is bent upward to form a thickened longitudinal crest. Two crescentic orifices (Kellogg, 1926, pl. 2) enclosed by involuted ectethmoid bones for passage of olfactory nerves are present on the posterior wall of the nasal passages. The length of the skeleton of this long-beaked porpoise was approximately 16 feet.

Eurhinodelphis (Kellogg, 1925) also is characterized by an elongated rostrum which constitutes four-fifths of the total length of the skull. The distal one-third of the rostrum of the skull of old individuals is either edentulous or a cartilaginous ligament may have lodged small teeth in an uninterrupted narrow groove, which on each side extends from anteriormost alveola to extremity. The alveolae are closely spaced on the middle portion of the rostrum. The mandible is certainly abnormally shortened and does not extend forward to extremity of rostrum. Although some variation in the number of teeth may be anticipated, the type skull of *Eurhinodelphis bossi* has 59 teeth on the right side of the rostrum and 60 teeth on the left side. The full complement of teeth in the lower jaws may have approached the number lodged in alveolae in the upper jaws. Unfortunately the distal end of the symphysis of the above type specimen is missing, but in the present condition 50 teeth were present in the right mandible and 51 teeth in the left mandible. The alveolae are rather closely approximated on the mandibles. The length of this skull is 42 inches (1066 mm.), and the estimated length of the skeleton is 12 feet.

On the basis of recovered specimens *Rhabdosteus* (Cope, 1867) was far more numerous in the Calvert fauna than the other genera. The largest skull measures about 41 inches (1055 mm.) in length and the anterior one-third of the slender tapering rostrum projects at least 10 inches beyond the anterior extremity of the symphyseal portion of the mandibles. Four-fifths of the total length of the skull is constituted by the rostrum. Like *Eurhinodelphis*, the distal one-third of the rostrum on skulls of old individuals is seemingly edentulous, but on skulls of immature individuals the alveolae are distinct on this portion of the rostrum and closely spaced to or nearly to the extremity of the rostrum. On each side of the rostrum of a mature individual at least 39 teeth were present, and, although no alveolae persist on the anterior one-third of the rostrum, the presence of continuous alveolar grooves extending to the extremity suggest a condition similar to that described for *Eurhinodelphis*. Along the middle portion of the rostrum the alveolae are rather widely spaced and are separated by porous or spongy bone which fills the alveolar gutter between the roots of the teeth. Teeth are implanted the full length of the symphyseal portion of the mandibles. At least 36 teeth were present in each mandible. The teeth in the upper and lower jaws are characterized by a slender crown and a root markedly compressed from side to side and conspicuously widened toward the extremity as well as more or less prolonged at one basal angle. Comparative measurements suggest that the skeletal length of this porpoise may have been slightly shorter than that attributed to *Eurhinodelphis*.

Another long-beaked porpoise, *Schizodelphis* (True, 1908), occurs less frequently in Calvert Miocene. The dorsoventrally flattened rostrum and symphysis as well as the presence of a long longitudinal groove on the outer face of the symphyseal portion of each mandible and the flattened palatal surface of the rostrum readily distinguish this genus. Unlike either *Eurhinodelphis* or *Rhabdosteus*, the anterior end of the symphysis extends forward to the level of the anterior end of the rostrum. The estimated length of the type skull of *Schizodelphis crassangulum* is less than 30 inches (735 mm.). A count of the alveolae reveals 65 on each side of the rostrum and 67 in each mandible. The skeleton is not sufficiently well known from vertebrae to estimate the total length of this porpoise.

One occurrence has been reported for *Pelodelphis* (Kellogg, 1955, pp. 130–143, pls. 12–16), and, although thus far known only from the mandibles, this genus unquestionably possessed a skull with a shorter rostrum than either *Eurhinodelphis*, *Rhabdosteus*, or *Schizodelphis*, as well as fewer and somewhat larger teeth. Alveolae for 33 teeth are present on each mandible and when complete the full complement was probably 36 teeth. The skull undoubtedly was more lightly constructed than that of *Lophocetus*, but approximately the same length. The symphysis constituted slightly more than two-fifths of the length of either mandible.

The *Lophocetus* skull (Kellogg, 1955, pls. 1–3) is approximately 2 feet in length. It possessed 24 teeth on each side of the rostrum and 26 teeth in each mandible. The ankylosed symphysis constituted one-third the length of either mandible. The large and well worn teeth of the type specimen of *Lophocetus pappus* suggest a coarser type of food than that sought by porpoises with a markedly elongated rostrum. The skull is strongly constructed and is characterized by having the vertex of the braincase elevated, the posterior end of each premaxillary bent upward, forming an oblique crest adjacent to the longitudinally elongated nasal bone, and a rostrum equivalent to not more than three-fifths of the length of the skull.

Kentriodon (Kellogg, 1927) resembles in many respects the living *Sotalia* of South American fresh-water streams. The length of the skull varied from 12 to 13 inches and the rostrum comprised three-fifths of the total length of the skull. The symphysis did not quite equal one-third the length of either mandible. The teeth are small and closely spaced in the jaws; 40 teeth are present on each side of the rostrum and 38 in each mandible. A reconstruction of the skeleton indicates a total length of 5½ feet.

The rather broad braincase, the relatively short rostrum, and short symphysis of *Delphinodon* (True, 1912; Barwick, 1939) as well as the

peculiarities of the teeth readily distinguish this genus from other small Calvert porpoises. The type skull of *Delphinodon dividum* has 27 teeth on each side of the rostrum and 26 in each mandible, and the largest skull measures slightly more than 16 inches in length. The symphysis equals one-fifth the length of either mandible and the rostrum comprises 45 to 51 percent of the total length of the skull. The estimated length of this porpoise is about 6 feet.

Our present knowledge of *Tretosphys* (Kellogg, 1955, pp. 143–153, pls. 17–21) is limited to portions of the skull and mandibles, teeth, hyoid bones, an incomplete forelimb, and a few vertebrae. *Tretosphys gabbii* was a small porpoise whose ankylosed symphysis measured 147 mm. in length. There are 14 rather closely approximated alveolae located on each side of the symphysis. Anterior detached teeth have relatively smooth enamel on anteroposteriorly flattened crowns; teeth from near the middle of the tooth row have the enamel on the outer surface of the crown ornamented with fine striae; and the posterior teeth have either a fairly large accessory cusp with a denticulated cutting edge, or several small tubercles one above the other, or a rugose coarsely sculptured internal face of the crown.

In all probability the skull of the slender-beaked porpoise hereinafter described as *Araeodelphis* did not exceed 19 inches in length. More than 45 teeth were originally present on each side of the rostrum, and at least 46 and not more than 50 teeth were implanted in each mandible. Assuming that the number of caudal vertebrae of *Araeodelphis* did not exceed 20, the dimensions of the dorsal and lumbar vertebrae tentatively referred to this species suggest a skeletal length of 7 feet.

In the above review of the odontocete genera represented in the Calvert fauna, one notes that the reduplication of the teeth in the jaws has progressed at a variable rate. The full complement of teeth in each of these genera is summarized as follows:

Squalodon	60
Phocageneus	?60
Lophocetus	100
Delphinodon	106
Tretosphys	110±
Pelodelphis	144±
Rhabdocetus	150
Kentriodon	156
Araeodelphis	190+
Eurhinodelphis	210
Schizodelphis	264
Zarhachis	315

Araeodelphis,[1] new genus

GENOTYPE: *Araeodelphis natator*, new species.

DIAGNOSIS: Rostrum slender, attenuated toward anterior extremity; mesorostral trough roofed over by close approximation of premaxillaries; narrow median longitudinal groove on palatal surface extends forward from 45th tooth (counting backward from anteriormost alveola) to extremity; more than 45 teeth located on each side of rostrum.

Mandibles slender with symphysis firmly ankylosed, elongated, and tapered toward anterior extremity; width of symphysis greater than depth; median longitudinal groove on dorsal surface of symphysis indistinctly divided longitudinally for about two-thirds its length by the raised thin ridge formed at line of contact of mandibles; opposite free posterior portions of mandibles come together at a blunt angle (55°) at symphysis; external surface of each mandible convex dorsally above the deep channel or groove which commences about 20 mm. behind level of posterior end of symphysis and extends forward almost to anterior end; these channels or grooves on the opposite rami bound the median and somewhat convex longitudinal strip on ventral surface of symphysis; 36 to 37 teeth located on each side of symphysis.

Roots of teeth implanted in alveolae which slope more inward than backward; roots of teeth noticeably swollen below base of crown and attenuated near extremity; crowns of most of the teeth on symphysis and rostrum slender, pointed, and curved inward; enamel on crowns of majority of the teeth indistinctly wrinkled in a vertical direction on internal surface, but posterior teeth on symphysis have enamel more coarsely sculptured internally and possess a small tubercle on posterior margin of internal face; posterior teeth (41st to 45th) on rostrum possess one small tubercle on the posterior surface about half way of height of crown and a varying number of minute rugosities on internal surface; interval between teeth at base of crowns varies from 3 to 6 mm.

Araeodelphis natator, new species

TYPE SPECIMEN (USNM 10478): Essentially complete rostrum except for portion immediately in front of antorbital notches, symphyseal portion of mandibles, and 12 detached teeth. Collector, Norman H. Boss, July 1914.

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[1] From the Greek, "araios," thin, slender, and "delphis," dolphin, in allusion to slender rostrum and symphyseal region of mandibles.

HORIZON AND LOCALITY: Sandy clay of Calvert Cliffs, 1 mile south of Chesapeake Beach, Calvert County, Md. Calvert formation, upper Miocene.

ROSTRUM

This slender attenuated rostrum is characterized by a somewhat greater length than that of *Kentriodon pernix* (Kellogg, 1927, pls. 2, 6, 7), by closely approximated premaxillaries on the dorsal surface, by a narrow median longitudinal groove on the ventral surface which extends forward from the 45th tooth (counting backward from the anteriormost alveola) to the extremity, and by a greater number of teeth. The length of the rostrum of the largest known skull of *Kentriodon pernix* is 199 mm., while this rostrum, although incomplete, measures 337 mm.

At the hinder end of this rostral fragment (pl. 17, fig. 1) the maxillaries and the premaxillaries are approximately equal in width, but near the anterior extremity the width of the maxillary is greater than that of the premaxillary. Commencing at the level of the 38th tooth (counting backward from the anteriormost alveola) on the right side and continuing to the extremity of the rostrum, the inner borders of the premaxillaries are in contact, completely roofing over the mesorostral trough.

The conformation of the hinder end of the right premaxillary indicates that the premaxillaries are more or less flattened out and almost horizontal at the base of the rostrum, but anterior to the level of the 40th tooth (counting backward from the anteriormost alveola) these bones become rather strongly convex and slope from the inner to the outer margin, although they are less noticeably elevated above the maxillaries on the distal 80 mm. of the rostrum. Both premaxillaries decrease in breadth toward the extremity of the rostrum. Several nutrient foramina from which narrow grooves extend forward are located on the lateral surfaces of the premaxillaries. The premaxillaries and maxillaries are so firmly ankylosed that the line of contact is not clearly discernible on the anterior half of this incomplete rostrum. The slope of the maxillaries from the inner to the outer margin progressively diminishes toward the anterior extremity.

On the ventral side of the rostrum (pl. 16, fig. 2) the palatal surfaces of the maxillaries become progressively flattened in the direction of the antorbital notches and more noticeably convex anterior to the 35th tooth (counting backward from anteriormost alveola). The median longitudinal groove on the palatal surface diminishes in depth toward the anterior extremity. The ventral ridge of the vomer is visible on the palatal surface of the rostrum as far forward as the 35th tooth

(counting backward from the anteriormost alveola) and is thrust between the opposite maxillaries. More than 45 teeth were originally present on each side of the rostrum.

Measurements of rostrum (in millimeters)

Length of rostral fragment, as preserved	337. 0
Transverse diameter of rostrum at level of 39th alveola counting backward from anteriormost alveola of right maxillary	42. 0
Transverse diameter of rostrum at level of 5th alveola counting backward from anteriormost alveola of right maxillary	18. 5
Distance between alveolae of opposite tooth rows at level of 39th alveola counting backward from anteriormost alveola of right maxillary	30. 0
Distance between alveolae of opposite tooth rows at level of 30th alveola counting backward from anteriormost alveola of right maxillary	16. 0
Distance between alveolae of opposite tooth rows at level of 10th alveola counting backward from anteriormost alveola of right maxillary	10. 0
45 alveolae on right side of rostrum in an interval of	319. 0
38 alveolae on left side of rostrum in an interval of	277. 0

Mandibles

Both mandibular rami are broken off a short distance behind the posterior end of the symphysis. The symphysis is attenuated toward the anterior extremity, the transverse diameter diminishing from 50 mm. at the level of the posterior end to 11 mm. at the anterior end. The vertical diameter of the symphysis at the anterior end is slightly more than one-third the depth at the posterior end. The anterior extremity of the symphysis may lack only the anterior walls of the anteriormost alveolae.

The mandibles (pl. 16, fig. 3) are firmly ankylosed throughout the length of the symphysis; the line of ankylosis is indicated by the raised thin longitudinal ridge on the posterior 190 mm. of the median longitudinal groove on the dorsal surface of the symphysis. The dorsal surface of the symphysis is not flattened and is characterized chiefly by this rather deep median longitudinal groove measuring about 8 mm. in width at a point 40 mm. anterior to the posterior end of the symphysis and narrowing anteriorly to a width of about 1 mm. at a point about 40 mm. posterior to the anterior extremity. On each side of this median longitudinal groove and inside the tooth rows, the dorsal surface of each mandible comprising the symphysis is convex from side to side. On the ventral surface (pl. 17, fig. 2) the line of ankylosis is indicated by a continuous thin groove which extends medially the full length of the symphysis.

The blunt angle (55°) formed by the free hinder portions of the two mandibles of *Araeodelphis natator* where they meet to form the

symphysis is less acute than in *Acrodelphis letochae*. Brandt (1874, p. 22, pl. 3) states that the two mandibles of *Acrodelphis letochae* meet at a 25° angle. The two mandibles of *Champsodelphis lophogenius*, judging from the artist's illustration (Van Beneden and Gervais, 1880, pl. 57, fig. 10), meet at an angle of 35°. The transverse diameter of the symphysis of *Acrodelphis letochae* (Heiligenstadt, No. 15, Wien Mus.) is 20.5 mm., however, as contrasted to 50 mm. for the corresponding measurement of *Araeodelphis natator* and 43.2 mm. for *Champsodelphis lophogenius* (type, No. 11731, Lab. Paléont., Mus. Nat. Hist. Nat., Paris).

From a lateral view (pl. 16, fig. 1) the ventral profile is essentially straight. The external surface of the mandible is characterized by a deep channel or groove, commencing at a vascular foramen about 20 mm. behind the level of the posterior end of the symphysis and extending forward almost to the anterior end although diminishing in depth. No interruptions or breaks in the continuity of this groove are observable. This channel is about 6 mm. wide posteriorly and progressively narrows toward the anterior extremity of the symphysis. Short, anteriorly directed grooves from small vascular or nutrient foramina open into these channels. These longitudinal channels on the lateral surface of the right and left mandibles set off a somewhat convex ventral strip (pl. 17, fig. 2) which measures 15 mm. in width 30 mm. anterior to the posterior end of the symphysis and about 9 mm. in width 50 mm. behind the anterior end.

The mandible of *Acrodelphis letochae* (Abel, 1900, pl. 1, fig. 2), however, is characterized by a longitudinal groove on the lateral surface that originates in a vascular foramen approximately at the level of the posteriormost alveola and extends forward parallel to the alveolar edge at least as far as the posterior end of the symphysis. This longitudinal groove is then replaced at a slightly lower level by another deeper and more sharply defined longitudinal groove which continues forward in the same position to the anterior end of the symphysis as preserved. These grooves on the lateral surfaces of the ankylosed mandibles delimit the median longitudinal convex portion of the ventral surface of the symphysis. The interruptions or breaks in the continuity of these lateral grooves as well as the conformation of the median longitudinal portion of the ventral surface of the symphysis of *Acrodelphis letochae* are regarded as indicating that *Acrodelphis* and *Araeodelphis* are not closely related. Although some variability is expected in structures, such as vascular impressions, no collateral evidence is known which supports Abel's (1900, p. 849) contention that such grooves possess no generic significance. Grooves on mandibles of species of other odontocetes conform to the generic types, as, for instance, *Schizodelphis*.

MEASUREMENTS OF MANDIBLES (IN MILLIMETERS)

	Right	Left
Length of mandible, as preserved	359. 0	320. 0
Greatest length of ankylosed symphyseal portion of mandibles	291. 5	
Transverse diameter of ankylosed symphysis at posterior end	50. 0	
Vertical diameter of ankylosed symphysis at posterior end	24. 5	
Transverse diameter of ankylosed symphysis at anterior end	11. 0	
Vertical diameter of ankylosed symphysis at anterior end	9. 5	
Transverse diameter of ankylosed symphysis 100 mm. anterior to posterior end	26. 5	
Vertical diameter of ankylosed symphysis 100 mm. anterior to posterior end	16. 5	
Distance between alveolae of opposite tooth rows at level of posterior end of symphisis	36. 0	
Distance between alveolae of opposite tooth rows at the level of 35th tooth counting forward from posterior end of symphysis	6. 0	
Least distance between alveolae in tooth row	3. 0	
Maximum distance between alveolae in tooth row	5. 0	
37 alveolae in an interval of	296. 0	305. 0
35 alveolae on symphysis in an interval of	280. 0	288. 0
Anteroposterior diameter of largest alveola	5. 5	
10 teeth at hinder end of symphysis in an interval of	86. 0	88. 0
12 teeth at hinder end of symphysis in an interval of	102. 0	103. 0

TEETH

One tooth inserted near the anterior end of the symphysis of the mandible (seventh counting backward from anteriormost) by the preparator is in all probability misplaced since it possesses three small tubercles on the basal portion of the coarsely sculptured internal surface of the crown. With this exception, the crowns of the teeth (pl. 18, figs. 1–3) located in front of the posterior end of the symphysis are slender, relatively long, and curved inward, with vertically wrinkled or slightly fluted enamel on the internal surface and relatively smooth enamel on the external surface. The teeth have single roots. The roots are swollen or gibbous below base of the crown, abruptly curved backward at the extremity, and attenuated. Intervals between the basal portions of the crowns of the teeth are rather short, varying from 3 mm. anteriorly to 6 mm. posteriorly. Three teeth on the right side, two of which are situated anterior to the posterior end of the symphysis, have the internal surface of the crown coarsely sculptured or wrinkled and one small tubercle on the posterior margin about half way of height of crown.

Three detached teeth (pl. 18, figs. 4–6), apparently dislodged from the posterior free portion of the right mandible while the specimen was being prepared, have two slender pointed tubercles, one above the other on the posterior edge of the internal surface of the crown, as well as tongue-like projections on the enamel extending nearly

vertically from near the basal border of the internal surface. The anterior surface of the crown (pl. 18, fig. 4) of these teeth is characterized by irregular nodosities which contribute to the formation of a ledge about half way of its height. The enamel on the apical portion of the crown is relatively smooth. The crowns of these three teeth are shorter and more robust than the majority of the teeth on the mandible, although the apical portions are likewise curved inward. Immediately below the base of the crown, excrescences on the anterior and posterior surfaces abruptly widen anteroposteriorly the uppermost portions of the roots. On the symphysis, 37 teeth were present on the right side and 36 on the left side.

The crowns of the five posterior teeth on the right side of the rostrum are shorter, somewhat conical, and curved inward. The apices of the crowns are slightly worn. A varying number of minute rugosities are present on the internal surface of the crown and at least one small tubercle on the posterior surface is situated about half way of the height of the crown. The gibbous roots of the posterior teeth have a somewhat roughened surface immediately below the enamel crown. On the major portion of the rostrum the crowns of the teeth (pl. 16, fig. 1) are slender, relatively long, and curved inward, with vertically wrinkled enamel on the internal surface and relatively smooth enamel on the external surface. These teeth have gibbous roots (pl. 18, figs. 1–3).

As regards some of the Calvert Miocene porpoises it should be noted that the number of teeth located on the free portion of each ramus behind the posterior end of the symphysis varies considerably, ranging from 11 to 12 in *Pelodelphis*, 14 to 15 in *Delphinodon*, and 18 to 19 in *Kentriodon*. Other fossil porpoises known from the Helvetian deposits of the Department of Landes, France, as, for instance, *Champsodelphis lophogenius* (Valenciennes, 1862) and *C. dationum* (referred mandible, Van Beneden and Gervais, 1880, p. 488, pl. 57, fig. 11) have 10 to 11 teeth on the free portion of each mandible. In view of the length of the symphysis one might anticipate that the minimum number of teeth in each mandible of *Araeodelphis natator* would be 46 and the maximum 49 or 50.

All of the teeth on the type mandible of *Champsodelphis lophogenius* have rather smooth enamel on the outer surface of the crown. The shelf on the inner side at the base of the crown does not resemble a cingulum, but nevertheless it is quite prominent; the enamel on this basal region of some of these teeth is characterized by faint striae and minor vertical grooves. Valenciennes (1862, pp. 788–789) refers to an excessively small vestige of a tubercle at the base of the crown, although I failed to observe it at the time the type specimen was examined. The apices of the teeth are pointed and curved inward

and backward. The neck of the root is slightly constricted below the enlargement of the base of the crown. The measurements of these teeth are as follows: height of enamel crown, 5.9 to 7.4 mm.; anteroposterior diameter of crown at base, 4.9 to 5.5 mm.; transverse diameter of crown at base, 5.4 to 5.8 mm. On the left mandible 10 alveolae occupy an interval of 114 mm. These teeth of *Champsodelphis lophogenius* are, however, more robust than those of *Araeodelphis natator*, the base of the crown being more noticeably enlarged, and the root slightly constructed immediately below the base of the crown. The roots of the teeth of *Araeodelphis natator*, however, are conspicuously swollen below the base of the crown and the measurements are as follows: height of enamel crown, 6 to 8.2 mm.; anteroposterior diameter of base of crown, 2.9 to 3.0 mm.; and transverse diameter of base of crown, 2.7 to 3.8 mm.

The teeth of *Acrodelphis letochae* (Pia, 1937, p. 363) that are located in the free portion of the mandible behind the posterior end of the symphysis have crowns that are curved distally, are approximately circular in cross section, and lack any trace of tubercles, granulations (rugosities), or edges. Pia (1937, p. 363) has also commented that the teeth of *Acrodelphis letochae* do not agree with those of "*Champsodelphis*" *ombonii* (Longhi, 1898) and that these two species are not generically related as Abel (1905, pp. 130–132) assumed. The type mandible of *Acrodelphis letochae* has 14 teeth in an interval of 64 mm. There are 14 teeth on the posterior portion of the symphysis of *Araeodelphis natator* in an interval of 123 mm.

The teeth on the mandible referred to *Champsodelphis dationum* by Gervais (Van Beneden and Gervais, 1880, p. 488, pl. 57, fig. 11) approximate more closely in dimensions the teeth of *Araeodelphis natator*. The teeth are described by Gervais (1859, p. 306) as having pointed crowns that curve inward and that have smooth enamel, a constricted neck, and a slightly swollen root. The measurements of the largest of these small teeth are as follows: height of enamel crown, 6 mm.; greatest width of crown, nearly 3 mm. Twelve alveolae occupy an interval of 110 mm. on the left mandible; height of mandible at last tooth, 35 mm.; and height of posterior end of symphysis, 28 mm.

MEASUREMENTS OF THE TEETH (IN MILLIMETERS)

	Antero-median (pl. 18, fig. 1)	Median (pl. 18, fig. 2)	Median (pl. 18, fig. 3)	Median	Pos-terior (pl. 18, fig. 4)	Pos-terior (pl. 18, fig. 6)	Pos-terior (pl. 18, fig. 5)
Greatest length, as preserved	19.7	16.5	16.4	17.0+	15.5	14.4	15.2
Length of root	12.5	8.7	8.5	8.3+	9.6	8.5	9.4
Greatest diameter of root	5.0	5.5	4.4	5.0	5.3	5.7	5.3
Height of crown	7.0	8.2	7.5	8.0	6.0	6.4	6.0
Greatest anteroposterior diameter of crown	3.0	3.0	3.0	3.0	3.0	3.0	2.9
Greatest transverse diameter of crown	2.7	2.8	2.8	3.0	2.9	3.5	3.8

Referred Specimen

USNM 16569: Six cervical (not including atlas), 10 dorsal and 5 lumbar vertebrae; eleven ribs. Collectors, William F. Foshag and Remington Kellogg, Aug. 6, 1940.

Horizon and locality: Compact, sandy, blue clay of Zone 11, about 5 feet above base of cliff, approximately 1.2 miles north of mouth of Parker Creek, William Freeland farm, Calvert County, Md., Calvert formation, upper Miocene.

A consecutive series of vertebrae extending from the axis to and including the fourth lumbar were found embedded in their normal sequence when the specimen was excavated. Following extended comparisons with the vertebrae of other small Calvert odontocetes, and the resultant elimination from further consideration of all forms heretofore recognizable in this fauna, it seemed reasonable to assume at least tentatively that this vertebral series represents *Araeodelphis natator*.

Vertebrae

With the exception of the atlas, all of the vertebrae in the cervical series are preserved. Ten consecutive vertebrae represent the dorsal series. The five lumbar vertebrae belong to the anterior portion of this series.

Cervical Vertebrae

All of the cervical vertebrae were free, the series consisting, when complete, of seven vertebrae. The diagnostic features of this series may be summarized as follows: Axis characterized by a slender and elongated neural spine, short and blunt odontoid process and maximum transverse diameter approximately equal to height; neural spines of third to sixth cervicals short; ventral transverse processes of third to fifth cervicals directed obliquely backward and perforated at the base by an arteri al canal, which increases in size from third to sixth cervical; ventral transverse processes of sixth cervical relatively large and directed downward, outward, and backward; seventh cervical lacks ventral transverse processes and the dorsal transverse processes are blade-like and attenuated distally; pre- and postzygapophyses similar in position and inclination on the third to seventh cervicals, although those of the seventh are somewhat larger than on the preceding vertebrae; axis and third to seventh cervicals exhibit a longitudinal carina on the ventral face of the centrum; there is a slight progressive increase in the thickness of the centra of the third to seventh cervicals.

Axis: In comparison to the axis of *Delphinodon dividum* (True, 1912, pp. 176, 182, pl. 19, figs. 5, 6) this vertebra (pl. 19, fig. 1) is somewhat larger, measuring 89 mm. in height, and its greatest thickness antero-

posteriorly (29.5 mm.) is slightly less than one-half its breadth anteriorly (63 mm.). The neural spine is slender, elongated, and inclined backward; the posterior face of the spine is rugose and a sharp vertically directed carina is developed on the anterior face. This spine differs from that of *D. dividum* in being noticeably elongated and not expanded distally. The ventral transverse processes were relatively slender, elongated, and directed obliquely backward. The height of the neural canal anteriorly is approximately equal to the transverse diameter. The anterior facets (pl. 20, fig. 1) for articulation with the atlas are shallowly concave from side to side—the vertical diameter (27 mm.) of right facet being greater than the maximum transverse diameter (20.5 mm.)—and they are separated ventrally by an interval that barely exceeds the vertical diameter of the right facet. The odontoid process is short, blunt, and somewhat rugose dorsally, and its rather large ventral articular face (transverse diameter, 20.5 mm.; anteroposterior diameter, 20 mm.) is convex in both directions. On the right side the postzygapophysial facet is ovoidal in outline and slopes obliquely downward from external to internal margins. The posterior face of the centrum is deeply concave and considerably wider (40 mm.) than high (26.5 mm.). On each side of the median longitudinal ridge the ventral surface of the centrum is deeply depressed. The dorsal surface of the centrum is also depressed on each side of the median longitudinal ridge.

Third cervical: This vertebra (pl. 19, fig. 2) is characterized by a thin centrum, slender pedicles of the neural arch, a very short neural spine, and slender transverse processes. The right prezygapophysial facet is not only shallowly concave but is depressed posteriorly. Relatively flat and ovoidal postzygapophysial facets slope steeply from the external to the internal margins. The neural canal is considerably wider (21.5 mm.) than high (16 mm.). The centrum has a slightly convex anterior face, a concave posterior face, and a median anteroposterior ridge on the dorsal and ventral faces which separates depressions on each side. On the right transverse process (pl. 20, fig. 2), the arterial canal which perforates the base of this process is large, but on the left transverse process a thin transverse isthmus of bone divides this canal anteriorly. In contrast to *D. dividum* (True, 1912, pl. 19, figs. 7, 8), each slender, elongated, and backwardly curved transverse process projects from the lateral surface of the centrum but is not continuous dorsally with the pedicle of the neural arch.

Fourth cervical: The centrum (pl. 19, fig. 3) is thin, although slightly thicker than the third cervical, the pedicles of the neural arch are wider transversely, and the neural canal is narrower. The roof of the neural arch is narrow anteroposteriorly; the neural spine is very short and obliquely truncated distally. Each transverse process

(pl. 20, fig. 3), although slightly shorter than the process on the third cervical, is attenuated distally, curved outward and backward, and perforated at the base by an arterial canal. The centrum is depressed medially on the anterior face, the posterior face is concave, and the median anteroposterior ridge on the dorsal and ventral faces separates the depressed areas on each side. Shallowly concave and ovoidal prezygapophysial facets slope steeply from external to internal margins. The elongated postzygapophysial facets are twice as long as wide and slope obliquely from external to internal margins. The pre- and postzygapophyses respectively project noticeably beyond the level of the anterior and posterior faces of the centrum.

Fifth cervical: This cervical has a smaller neural canal, the pedicles of the neural arch are narrower transversely, and the centrum is relatively larger than the corresponding vertebra of *D. dividum* (True, 1912, pl. 19, figs. 11, 12). The roof of the neural arch is rather narrow anteroposteriorly and the neural spine is reduced to a low sharp ridge. Each transverse process (pl. 20, fig. 4) is compressed anteroposteriorly, truncated obliquely distally, perforated at the base by a very large arterial canal, and connected dorsally with the lateral face of the pedicle of the neural arch by a thin anteriorly curved plate which is an extension of the lateral face of the centrum.

The anterior face of the centrum is depressed in the center and the posterior face is concave; the median anteroposterior ridge on the depressed dorsal face is reduced; and four depressions separated by low anteroposterior ridges alter the conformation of the ventral face. The prezygapophysial facets are unusually large, shallowly concave, and slope steeply downward from external to internal margins. The postzygapophysial facets are subtriangular in outline, rather flat, and slope obliquely from external to internal margins. All of these facets (pl. 19, fig. 4) project beyond the corresponding faces of the centrum.

Sixth cervical; In contrast to the preceding cervical, the ventral transverse processes (pl. 19, fig. 5) are directed more downward than outward, the large arterial canals extend farther dorsally, and the neural canal is slightly wider. The roof of the neural arch is narrow anteroposteriorly; the neural spine is short and pointed.

The ventral transverse processes (pl. 20, fig. 5) are robust and are directed downward, outward, and backward. On the right side, the outer wall of the arterial canal is thin and compressed anteroposteriorly and is continuous dorsally with the anterior border of the pedicle of the neural arch. The pedicles of the neural arch are compressed from side to side and widened anteroposteriorly. The anterior and posterior faces of the centrum are concave; the median anteroposterior ridge which divides the depressed dorsal face is low in comparison to

the development of the same ridge on the depressed ventral face. The prezygapophysial facets are elongated, almost twice as long (14 mm.) as broad (7.5 mm.), shallowly concave, and slope very steeply from the external to internal margins. The postzygapophysial facets are likewise elongated, but are attenuated anteriorly. This cervical is readily distinguished from the corresponding vertebra of *D. dividum* (True, 1912, pl. 19, fig. 13) by the shape and direction of the transverse processes, by the relatively smaller size of the neural canal, and by the dimensions of the arterial canal.

Seventh cervical: As regards thickness, the centra of the sixth and seventh cervicals are about equal. The anterior and posterior faces of the centrum are shallowly concave; the dorsal face of the centrum is depressed; and the ventral face has two elongate depressions on each side of the median anteroposterior ridge. A vertically elongated posterior facet (pl. 19, fig. 6) for the capitulum of first rib is located on the lateral face of centrum; the blade-like dorsal transverse processes are attenuated toward the extremity, each being broadly united at the base with the pedicle of the neural arch and directed outward. No trace persists of the ventral transverse processes. The neural canal (pl. 20, fig. 6) is much wider (24 mm.) than high (15± mm.) and the roof of the neural arch has increased slightly in anteroposterior diameter. The pedicles of the neural arch resemble those of the sixth cervical, but have a greater anteroposterior diameter. The prezygapophysial facets are elongated, shallowly concave, and slope steeply from external to internal margins. The ovoidal postzygapophysial facets are somewhat longer (13 mm.) than wide (10 mm.) and likewise slope obliquely from external to internal margins.

Dorsal Vertebrae

With the exception of the distal portions of the neural spines of the fifth, seventh, eighth, and ninth dorsals and the right diapophyses of the second and third dorsals, all of these vertebrae are well preserved and little or no distortion from crushing is evident.

The centra progressively increase in length from the anterior to the posterior end of the dorsal series, the centrum of the posterior dorsal being almost three times as long as the first. The shape and size of the neural spine, the width of the interval between the prezygapophysial facets, and the peculiarities of the diapophyses characterize each of the dorsal vertebrae. On these vertebrae as well as those of related fossil porpoises of the Calvert Miocene, a progressive decrease in the width of the interval separating the prezygapophysial facets from the anterior to the posterior dorsal is a normal feature. These facets become increasingly oblique in position toward the posterior end of the dorsal series. On the first four dorsals the facet on the dia-

pophysis for articulation with the tuberculum of the rib is situated in front of the level of the anterior face of the centrum, but on the sixth it is entirely behind the level of the anterior face.

On the six anterior vertebrae in the dorsal series, the vertical diameter of the facet on the diapophysis for articulation with the tuberculum of the rib is greater than the anteroposterior diameter in contrast to the pronounced anteroposterior elongation of these facets on the corresponding vertebrae of *Delphinodon dividum* (True, 1912, pl. 20, figs. 1–9); furthermore, the prezygapophysial facets slope steeply from external to internal margins while those of *D. dividum* are nearly horizontal.

The transverse processes of the transitional vertebra are not perforated by an arterial canal near the base. The slender neural spines of the five anterior dorsals progressively increase in height. Behind these vertebrae the neural spines become wider on the basal half.

A well defined facet for articulation with the capitulum of the rib is located at the upper posteroexternal angle of the centrum of the first to seventh dorsals. On the first dorsal, the diapophyses project farther laterally than on the vertebrae that follow. The relative height of the diapophysial articular facet above the centrum does not change materially on the eight anterior dorsals. On the ninth dorsal the shift to a lower level is rather pronounced since each process projects from the side of the neural arch about midway between centrum and the top of the neural canal. The postzygapophysial facets become progressively reduced (shorter) toward the posterior end of the dorsal series and are barely discernible on the tenth dorsal.

First dorsal: The anterior dorsal (pl. 21, fig. 1) is characterized by a shorter centrum than those that follow in this series—the transverse diameter being more than a third greater than the maximum anteroposterior diameter—by a vertically elongated anterior facet for the capitulum of the first rib on the lateral face, and by a small facet for the capitulum of the second rib at the upper posteroexternal angle of the centrum. The neural spine is relatively slender, rather short, and slightly inclined forward. The neural arch (pl. 22, fig. 1) is low, robust, and with a laterally projecting diapophysis on each side which bears a dorsoventrally prolonged concave articular facet for the tuberculum of the first rib. This facet slopes downward and inward. The postzygapophysial facets are elongated, the anteroposterior diameter (18 mm.) being twice the maximum transverse diameter (9 mm.), and slope obliquely from external to internal margins. The ovoidal prezygapophysial facets are 17 mm. in length and 9.5 mm. in breadth and slope steeply from external to internal margin. The width (22.5 mm.) of the neural canal anteriorly exceeds slightly the vertical diameter (18 mm.), and the prezygapophysial facets are separated by

an interval of 31 mm. posteriorly. The roof of the neural arch is rather narrow anteroposteriorly, the minimum diameter being 12 mm. The centrum has concave anterior and posterior faces, and a low median anteroposterior ridge on the dorsal and ventral faces that separates the depressed areas on each side. A small arterial foramen is located on each side of this ridge on the dorsal face.

Second dorsal: Compared with the first dorsal, the centrum is longer, the neural spine is higher, the neural canal is larger, and the minimum anteroposterior diameter (18 mm.) of the roof of the neural arch is greater. The slender neural spine (pl. 21, fig. 2) is nearly vertical and is obliquely truncated at the extremity. The diapophysis projects upward, forward, and outward. The subpyriform lateral facet on the diapophysis for articulation with the tuberculum of the second rib is concave from side to side, the vertical diameter (19.5 mm.) being greater than the transverse diameter (14.5 mm.).

The left ovoidal prezygapophysial facet measures 14.5 mm. in length and 11 mm. in breadth and slopes steeply from external to internal margin. The left postzygapophysial facet is nearly subquadrate in outline, measuring 12.5 mm. in length and 11 mm. in width, and slopes obliquely from external to internal margins. Anteriorly, the neural canal (pl. 22, fig. 2) is slightly wider (23 mm.) than high (22 mm.). The anterior and posterior faces of the centrum are slightly concave at the center, two arterial foramina of moderate size are present on the depressed dorsal face, and the lateral faces are deeply depressed. The upper posteroexternal facet for the capitulum of the third rib is larger than on the preceding dorsal.

Third dorsal: This vertebra (pl. 21, fig. 3) differs from the corresponding vertebra of *Delphinodon dividum* (True, 1912, pl. 20, fig. 2; pl. 22, fig. 2) in having the diapophyses projecting obliquely upward and outward, the long axis of the articular facet for the tuberculum of the third rib nearly vertical, and prezygapophysial facets steeply sloping. The backwardly projecting dorsal portion of the neural arch has a greater transverse width (38.5 mm.) than on either the preceding or following dorsal. The neural spine has increased in width anteroposteriorly. The maximum width (25 mm.) of the neural canal (pl. 22, fig. 3) anteriorly is slightly greater than the height (23.5 mm.). The left prezygapophysial facet is irregularly depressed, is 17 mm. in length and 13 mm. in breadth, and slopes obliquely downward from external to internal margin. The postzygapophysial facets are ovoidal and likewise slope obliquely. A pair of arterial foramina much larger than those on the second dorsal are present on the depressed dorsal face. The lateral faces of the centrum are depressed and curve concavely from anterior to posterior margins, and the maximum width (37 mm.) of the posterior face exceeds that of the anterior

face (30.7 mm.). A large triangular facet for the capitulum of the fourth rib is located obliquely on the centrum at the upper posteroexternal angle.

Fourth dorsal: The length (30.5 mm.) of the centrum barely exceeds the width (30 mm.) of the anterior face, although the posterior face is somewhat wider (37 mm.). This vertebra (pl. 21, fig. 4) is characterized in part by a high slender neural spine which curves backward toward the extremity. The diapophyses project upward and outward, and the subtriangular articular facet for the tuberculum of the fourth rib slopes obliquely downward and inward, the vertical diameter (17.5 mm.) of the facet being greater than the anteroposterior diameter (15.5 mm.). The steeply sloping prezygapophysial facets are longer (17.5 mm.) than wide (13.5 mm.), concave from side to side, and irregularly depressed. The postzygapophysial facets are elongated and likewise slope obliquely from external to internal margins. The anteroposterior diameter of the backwardly projecting dorsal portion of the neural arch exceeds that of the third dorsal. A pair of large arterial foramina are present on the depressed dorsal face; the lateral and ventral faces of the centrum are depressed and curve concavely from the anterior to posterior margins. The maximum width (25 mm.) of the neural canal (pl. 22, fig. 4) anteriorly is equivalent to the height (25 mm.). The large triangular facet for the capitulum of the fifth rib is located obliquely on the centrum at the upper posteroexternal angle.

Fifth dorsal: In general appearance this vertebra (pl. 21, fig. 5) resembles the fourth, with the exception of the more posterior position of the articular facet for the tuberculum of the rib and an obvious narrowing and elongation of the backwardly projecting dorsal portion of the neural arch. A slight reduction in size of the neural canal (pl. 24, fig. 1), the width and the height being approximately equal, and a narrowing of the minimum interval (16.5 mm.) between the prezygapophysial facets also characterize this dorsal. The centrum is slightly longer than that of the fourth and is more noticeably constricted from side to side between the anterior and posterior faces. The pair of arterial foramina on the dorsal surface of the centrum are as large as those of the fourth dorsal. The neural spine, although lacking the distal end, is similar in conformation and backward inclination to the spine of the fourth dorsal. The diapophyses project upward and outward and the subtriangular articular facet for the tuberculum of the fifth rib slopes less obliquely downward and inward and is placed almost entirely behind the level of the anterior face of the centrum; the anteroposterior diameter (14 mm.) of the left facet is slightly less than the vertical diameter (15.5 mm.). The prezygapophysial facets are concave, longer than wide, and slope obliquely

from external to internal margins. The obliquely sloping elongated postzygapophysial facets are almost twice as long (16.5 mm.) as broad (9 mm.). The large triangular facet for the capitulum of the sixth rib is located obliquely on the centrum at the upper posteroexternal angle.

Sixth dorsal: When the postzygapophysial facets of the fifth dorsal are placed in articular position with the prezygapophysial facets of this vertebra, it will be observed that these paired facets articulate rather loosely in contrast to the more restricted articular relations of the preceding dorsals. The ovoidal prezygapophysial facets are elongated, deeply concave, slope steeply from external to internal margins, the length (18.5 mm.) of the left facet exceeds the maximum transverse diameter (11 mm.), and the minimum interval between these facets posteriorly is reduced to 14 mm. The obliquely sloping postzygapophysial facets measure 13.5 mm. in length and 7 mm. in breadth. Compared with the fifth dorsal the backwardly projecting dorsal portion of the neural arch is noticeably narrower and the anteroposterior diameter (35 mm.) of the neural spine at the base is also greater than the corresponding measurement (30 mm.) of the spine of the preceding vertebra. The diapophyses of this vertebra (pl. 23, fig. 1) are more robust than those of the fifth dorsal and project less noticeably upward; the diapophysial articular facet is slightly smaller, but likewise is located behind the level of the anterior face of the centrum. The height (24 mm.) of the neural canal (pl. 24, fig. 2) anteriorly is equal to the width. The centrum is longer than that of the fifth dorsal, the maximum width (37 mm.) of the posterior face is greater than the anterior width (30.2 mm.), and the strong lateral constriction has reduced the ventral surface to an indistinct ridge. A pair of arterial foramina are present on the dorsal face. The large triangular facet for the capitulum of the seventh rib is located obliquely on the centrum at the upper posteroexternal angle.

Seventh dorsal: This vertebra (pl. 23, fig. 2) differs from the preceding vertebra in having the articular facet on the diapophysis elongated anteroposteriorly, a noticeably narrower backwardly projecting portion of the neural arch, no pronounced widening of the posterior face of the centrum as contrasted with the anterior face, and the absence of an articular facet for the capitulum of the eighth rib at the upper posteroexternal angle of the centrum. The more nearly circular but deeply concave prezygapophysial facets slope steeply from external to internal margins, and the minimum interval between these facets posteriorly does not exceed 10 mm. Each postzygapophysial facet is reduced to an irregular depression located on the external face of the basal portion of the neural spine. Although the major upper portion of the neural spine is broken off, the inclina-

tion of the posterior edge suggests that it was similar in conformation to that of the eighth dorsal; the anteroposterior diameter (35 mm.) of the neural spine at the base is approximately the same as on the sixth dorsal.

The diapophyses project outward but not upward and are located entirely behind the level of the anterior face of the centrum. The height (23 mm.) of the neural canal (pl. 24, fig. 3) anteriorly is slightly less than the transverse diameter (24 mm.). The pedicles of the neural arch are widened anteroposteriorly but lack the lateral depression of the preceding dorsals. The centrum is longer than that of the sixth and the width (32.5 mm.) of the posterior face exceeds very slightly the width (31.8 mm.) of the anterior face; the pronounced lateral constriction of the centrum has reduced the ventral face to a low ridge. The pair of arterial foramina on the dorsal face are large and elongated.

Eighth dorsal: With the exception of the distal portion of the neural spine, this vertebra (pl. 23, fig. 3) is essentially complete. From the preceding dorsal, this vertebra differs in having a pronounced enlargement of the rather thin laterally compressed metapophyses, irregular convex prezygapophysial facets, markedly reduced postzygapophysial facets, and more robust diapophyses located at a lower level. Each diapophysis (or coalesced diapophysis and merapophysis of Abel, 1931) projects outward from the pedicle of the neural arch and bears distally an ovoidal facet for the single-headed rib, the anteroposterior axis (18 mm.) being greater than the vertical (12.5 mm.) diameter; the anterior face of the diapophysis is concave in the dorsoventral direction and the posterior face is convex.

There is a noticeable increase in the length (42.6 mm.) of the centrum, and the width (33.7 mm.) of the posterior face slightly exceeds the width (32.5 mm.) of the anterior face. The pronounced lateral constriction of the centrum also resembles that of the preceding dorsal and the ventral ridge is quite similar. The pair of arterial foramina on the dorsal face are, however, smaller. The height (22 mm.) of the neural canal (pl. 24, fig. 4) anteriorly is equivalent to the width. The anteroposterior diameter of the pedicle of the neural arch exceeds that of the seventh dorsal and the backwardly projecting portion of the neural arch is approximately the same width as the former. The neural spine is relatively broad and inclined backward.

Ninth dorsal: This vertebra (pl. 23, fig. 4) is characterized by a short transverse process (parapophysis) with a distal enlargement to provide an increased surface for articulation with the single-headed ninth rib, a somewhat elevated and laterally compressed metapophysis, reduced neural canal, and broad neural spine.

The centrum is slightly longer (45.5 mm.) than the preceding dorsal,

and the width (34.5 mm.) of the posterior face exceeds the width (32.5 mm.) of the anterior face. The lateral faces of the centrum are strongly depressed and curve concavely from the anterior to the posterior epiphyses, resulting in the development of a sharp thin anteroposterior ventral ridge. The pair of arterial foramina on the dorsal face are smaller than those of the preceding centrum. The laterally compressed pedicles of the neural arch have a minimum anteroposterior length of 26.5 mm. Each parapophysis (pl. 25, fig. 1) projects outward but is situated only partially below the level of the dorsal surface of the centrum. The height (23 mm.) of the neural canal anteriorly exceeds slightly the width (21 mm.). The rather broad neural spine, inclined backward and irregularly thickened below the extremity, measures 40 mm. anteroposteriorly at the base.

Tenth dorsal: Elongated metapophyses, neural canal triangular in cross section, longer transverse processes (parapophyses) with increased distal enlargement, and longer centrum distinguish this dorsal (pl. 26, fig. 1) from the preceding vertebra. Although a perceptible increase in the length (50 mm.) of the centrum is observable, the width (35 mm.) of the posterior face as compared with the width (33.2 mm.) of the anterior face has not been materially changed. The depressed lateral faces of the centrum exhibit the concave end-to-end curvature of the preceding vertebrae, but the thin median ventral ridge is more strongly developed and the pair of arterial foramina on the dorsal face are further reduced in size. Each parapophysis (pl. 25, fig. 2) projects outward from the upper portion of the centrum and is expanded distally to provide a larger surface for articulation with the single-headed tenth rib.

The laterally compressed pedicles of the neural arch resemble more closely those of the following lumbars than of the dorsals. The height (23 mm.) of the neural canal anteriorly is greater than the width (18 mm.). An increase in the anteroposterior diameter (44 mm.) of the neural spine at the base and a slight decrease in the height as compared to the ninth dorsal is conformable to the anticipated transition from the dorsal to the lumbar type of vertebra; it should be noted that the anterior border of the distal end of this spine is eroded and consequently this portion of the spine was probably wider in its original condition.

No distinct prezygapophysial facets are observable and the area occupied by the postzygapophysial facets on the preceding dorsals is reduced to an irregular depression.

Lumbar Vertebrae

Five anterior lumbar vertebrae were found. Of these, one is of no value for comparative purposes, two lack portions of the neural spine,

and, on another, the distal end of the left transverse process is broken off. Four of these lumbar vertebrae appear to represent a consecutive series.

The centra are all longer than broad and progressively increase in length from the first to the fourth. All possess a strongly developed median ventral carina or keel, which increases in prominence from the first to the fourth. The transverse processes are expanded beyond the middle of their length and are rounded distally with the exception of those of the first lumbar which are obliquely truncated. From the first to the fourth lumbars the broad neural spines are nearly vertical and decrease in height. The minimum anteroposterior diameter of either pedicle of the neural arch exceeds one-half the length of the centrum. The neural canals are subtriangular in cross section and decrease in height from the first to the fourth. The thin lamina-like metapophyses are directed obliquely upward and forward and all project beyond the level of the anterior face of the centrum. The prezygapophysial facets are reduced to circular depressions. On these anterior lumbars the backwardly projecting dorsal portion of the neural arch, however, does not extend beyond the level of the posterior face of the centrum.

In contrast to the lumbar vertebrae of *Delphinodon dividum* (True, 1912, pl. 23, figs. 1–6), these vertebrae have more elongated centra, broader neural spines, wider neural canals, and distally expanded transverse processes.

First lumbar: The right metapophyses and the tip of the right transverse process are missing. The centrum is elongated (pl. 26, fig. 2) and the strongly depressed lateral faces are separated ventrally by the thin longitudinal ridge. The pair of arterial foramina on the dorsal face are rather small. The transverse processes are elongated (85 mm.) and exceed in length those of the following lumbars; the distal half of each process is obliquely truncated anteriorly, terminating in an irregular roughened area on the posteroexternal angle. It is quite possible that this rugose surface may have served as an area for the attachment of a floating rib. The height (24 mm.) of the neural canal (pl. 28, fig. 1) anteriorly exceeds the width (18 mm.). On each side the pedicle of the neural arch occupies about two-thirds (37 mm.) the length (56 mm.) of the centrum. The left metapophysis is directed upward and forward, and projects beyond the anterior face of the centrum. The prezygapophysial facets are roughened and are located below the level of the base of the neural spine. The anterior margin of the rather broad neural spine exhibits a more noticeable concave curvature than the posterior margin.

Second lumbar: This vertebra (pl. 26, fig. 3) differs from the first lumbar as follows: the centrum is slightly longer (58.5 mm.) and wider anteriorly (35.5 mm.), the transverse processes are shorter, and the neural spine is broader. The right metapophysis is missing. The left metapophysis does not project as far forward as that of the preceding lumbar, and the prezygapophysial facet, which is located below the level of the base of the neural spine, is reduced to a circular depression. A sharp ventral longitudinal ridge or carina forms the dividing line between the deeply depressed lateral surfaces of the centrum. The pair of arterial foramina on the dorsal face are very small. As compared to the first lumbar the anteroposterior diameter (35 mm.) of the pedicle of the neural arch at the base is slightly shorter, the height (25 mm.) of the neural canal (pl. 28, fig. 2) anteriorly has increased slightly and the width (17.5 mm.) has decreased, and the backwardly projecting dorsal portion of the neural arch may have been shorter since it terminates in its present condition at least 10 mm. anterior to the level of the posterior face of the centrum. The rather broad neural spine is directed almost vertically. It should be noted that the anterior border of the distal portion of the neural spine is slightly eroded, although it is unlikely that this has materially altered the contour. The rather broad transverse processes increase in width beyond the basal constriction, and exhibit a nearly straight posterior edge, a rounded extremity, and an oblique truncation of the anterior border on the distal half of the length.

Third lumbar: On this vertebra (pl. 27, fig. 1) the distal portion of the neural spine is destroyed, the left metapophysis is broken off, and the posteroexternal angle of the left transverse process is missing. As compared to the preceding vertebra, the centrum has increased very slightly in length. In the development of the longitudinal ventral keel and the side-to-side compression this centrum agrees rather closely with that of the preceding lumbar. The width (38 mm.) of the posterior face is slightly greater than the width (36 mm.) of the anterior face and the pair of arterial foramina on the dorsal face are small. The pedicles of the neural arch do not differ materially from the preceding lumbar, and the backwardly projecting dorsal portion of the neural arch does not extend posteriorly to the level of the posterior face of the centrum. The neural spine is not quite so broad anteroposteriorly as the preceding. The elongated and rather slender right metapophysis projects conspicuously beyond the level of the anterior face of the centrum and the prezygapophysial facet is restricted to a small depression located near the posteroventral angle of this process. The transverse processes (pl. 29, fig. 1) are slightly expanded on the distal half and have rounded extremities.

FOURTH LUMBAR: Of this lumbar (pl. 27, fig. 2), the right metapophysis is incomplete, all of the neural spine with the exception of the small basal fragment is missing, and the distal half of the left transverse process is broken off. The centrum is slightly longer (61 mm.) and broader posteriorly (39.5 mm.) than the preceding lumbar, the longitudinal ventral carina or keel is more strongly developed, and the side-to-side compression accentuates the anteroposterior concave curvature of the lateral faces. The neural canal (pl. 29, fig. 2) is reduced in height and breadth. The right transverse process is less noticeably expanded distally than that of the preceding lumbar and is rounded at the extremity. Since a portion of the neural arch is incomplete it is quite possible that the slender elongated metapophysis has been incorrectly placed in the restoration of the missing portions. An irregularly depressed small circular area on the posteroventral border of this metapophysis represents the prezygapophysial facet.

INDETERMINATE LUMBAR: This vertebra (pl. 27, fig. 3) is too incomplete for the determination of its position in the lumbar series. Basal portions of the transverse processes and a small section of the anterior face of the centrum are preserved. The right transverse process does not differ materially from the basal portion of this process on the third lumbar.

MEASUREMENTS OF CERVICAL VERTEBRAE (IN MILLIMETERS)

	Axis	C-3	C-4	C-5	C-6	C-7
Greatest height (vertically) of vertebra (tip of neural spine to ventral face of centrum)	89.0	52.3	53.7	50.2	53.2	
Greatest distance across vertebra between outer margins of anterior articular surfaces	63.0					
Least anteroposterior diameter of dorsal surface of neural arch	17.0	6.5	8.5	6.7	6.6	9.0
Least anteroposterior diameter of pedicle of neural arch	10.0	5.5	5.7	7.4	10.5	14.2
Greatest vertical diameter of anterior face of centrum	26.5*	29.0	29.7	30.8	31.2	30.5
Greatest transverse diameter of anterior face of centrum	40.0*	35.2	35.0	32.4	32.3	31.5
Distance across vertebra between outer ends of diapophyses						72.0
Distance across vertebra between outer ends of transverse processes	87.+			62.8	60.5	
Transverse diameter of neural (spinal) canal anteriorly	23.0	21.5	19.0	19.5	20.7	24.0
Vertical diameter of neural (spinal) canal anteriorly	23.7	16.0	17.0	15.0	16.0	
Greatest distance between outer margins of prezygapophysial facets			36.6	36.7	37.0	42.3
Greatest distance between outer margins of postzygapophysial facets		31.2	34.0	36.2	38.0	48.2
Distance between tip of prezygapophysis and tip of postzygapophysis		18.0	20.7	22.0	23.7	24.5

* Posterior face.

MEASUREMENTS OF DORSAL VERTEBRAE (IN MILLIMETERS)

	D–1	D–2	D–3	D–4	D–5	D–6	D–7	D–8	D–9	D–10
Greatest height (vertically) of vertebra (tip of neural spine to ventral face of centrum)	80. 5	105. 3	103. 5	120. 0	107. 6	88. 0+	83. 0+	111. 0+	125. 0	122. 0
Vertical height of neural spine, dorsal surface of neural canal to tip of neural spine	34. 2	57. 0	55. 5	74. 0	60. 5	43. 0+	44. 7+	71. 5+	83. 5	75. 0
Anteroposterior diameter of centrum	19. 5	23. 4	27. 5	30. 5	32. 2	34. 2	38. 0	42. 6	45. 5	50. 0
Greatest vertical diameter of anterior face of centrum	29. 3	25. 0	24. 5	25. 2	26. 2	27. 8	27. 3	28. 7	29. 0	31. 2
Greatest transverse diameter of anterior face of centrum	32. 0	30. 5	30. 7	30. 0	29. 5	30. 2	31. 8	32. 5	32. 5	33. 2
Greatest vertical diameter of neural (spinal) canal anteriorly	18. 0	22. 0	23. 5	25. 0	24. 8	24. 0	23. 0	22. 0	23. 0	23. 0
Greatest transverse diameter of neural (spinal) canal anteriorly	22. 5	23. 0	25. 0	25. 0	24. 5	24. 3	24. 0	22. 0	21. 0	18. 0
Least anteroposterior diameter of pedicle of neural arch	10. 0	10. 6	13. 0	12. 7	11. 8	13. 7	17. 5	21. 8	26. 5	27. 8
Distance across vertebra between outer ends of diapophyses	74. 5			65. 7	67. 3	67. 0	62. 0+	72. 8		
Distance across vertebra between outer ends of parapophyses									82. 5	103. 5
Greatest distance between outer margins of prezygapophysial facets	52. 3			45. 0	40. 4	34. 0	27. 0	21. 0	16. 0	12. 0
Greatest distance between outer margins of postzygapophysial facets	43. 5	39. 0+	38. 7	36. 8	29. 2	20. 0	15. 0	10. 0		
Distance between anterior edge of prezygapophysial facet and posterior edge of postzygapophysial facet	38. 2	41. 8	44. 8	45. 8	49	54. 2	55			
Distance between tip of metapophysis and posteroventral angle of neural spine								58. 8	61. 0	68. 7

MEASUREMENTS OF LUMBAR VERTEBRAE (IN MILLIMETERS)

	L–1	L–2	L–3	L–4	L–5
Greatest height (vertically) of vertebra (tip of neural spine to ventral face of centrum)	131. 4	127. 0	114. 0+	84. 0+	
Vertical height of neural spine, dorsal surface of neural canal to tip of neural spine	81. 0	73. 5	60. 0+		
Anteroposterior diameter of centrum	56. 0	58. 5	59. 4	61. 0	46. 0
Greatest vertical diameter of anterior face of centrum	35. 0	34. 3	35. 4	37. 0	
Greatest transverse diameter of anterior face of centrum	31. 8	35. 5	36. 0	36. 4	41. 0±
Greatest vertical diameter of neural (spinal) canal anteriorly	24. 0	25. 0	21. 0	16. 0	
Greatest transverse diameter of neural (spinal) canal anteriorly	18. 0	17. 5	16. 4	14. 0	
Least anteroposterior diameter of pedicle of neural arch	34. 8	30. 5	31. 0	34. 0	
Distance across vertebra between outer ends of transverse processes (parapophyses)	195. 0+	179. 5	179. 0	143. 2+	112. 0±
Distance between tip of metapophysis and posteroventral angle of neural spine	75. 0	65. 0	78. 0	58. 0+	

RIBS

Nine identifiable ribs and distal portions of two others were associated with the vertebrae. The ribs were not found in normal relation to the dorsal vertebrae when the bones were excavated and their position was determined by articulations with the vertebrae. Only the first rib (pl. 30, fig. 1) from the left side is essentially complete. As compared with the ribs that follow in the series, this first rib is relatively short, rather broad, and strongly flattened anteroposteriorly. The capitulum is rounded, larger than those of the second to sixth ribs, and its articular surface is rugose. The neck is short and flattened anteroposteriorly. The tuberculum is elongated (22.5 mm.), convex from side to side, with greatest width (12. 5 mm) posteriorly. The greatest width of the shaft (35 mm.) is immediately behind the tuberculum. The shaft is abruptly bent downward behind the angle and its ventral end is slightly twisted inward and enlarged internally to provide the rugose surface for attachment to the sternum.

The right and left second ribs (pl. 30, figs. 2, 5) lack the distal portions of the shafts. On both ribs the small, rounded capitula are borne upon short necks which are bent slightly upward. The tuber-

culum is elongated, subtriangular in outline, and with greatest width (10.5 mm.) posteriorly. The outer surface of the shaft is flattened and transversely widened in the region of the angle, with the protruding edge overhanging the posterior surface. Below the angle the shaft is flattened anteroposteriorly and its inner and outer edges are thin and somewhat irregular. The greatest width (21.5 mm.) of the right rib, as preserved, is near the posterior end of the angle, and its end-to-end curvature is more pronounced than that of the first rib.

The third rib (pl. 30, fig. 6) on the right side lacks the distal portion of the shaft, but is otherwise complete. This rib is characterized in part by a more strongly curved slender shaft, its outer edge being thin and its inner edge somewhat rounded at least on the proximal portion. The outer surface of the shaft is also transversely widened in the region of the angle, with the protruding edge overhanging the posterior surface for a greater distance than on the second rib. The capitulum is elongated, subtriangular in outline, bent upward, and with its articular surface roughened. The neck is narrower and longer than that of the second rib. The elongated tuberculum is subtriangular in outline, concave from end to end, and convex from side to side.

Less than one-third of the fourth rib (pl. 30, fig. 7) on the right side is preserved, and it lacks not only the distal portion of the shaft but the neck and capitulum as well. The fourth rib on the left side lacks the distal portion of the shaft. The shaft is slightly narrower than that of the third rib; the normal widening of the thorax in this region results in a lengthening of the interval between the tuberculum and the angle, and the overhang of the outer edge in this region is less noticeable. The tuberculum is subovoidal in outline and slopes downward from anterior to posterior margins. The neck is slightly longer than that of the third rib and its dorsoventral diameter is reduced. The capitulum is relatively small. The outer edge of the shaft is thin and the inner surface rounded.

The right and left ribs of the sixth pair (pl. 30, figs. 4, 8) are characterized by a slender shaft, an elongated neck, a small capitulum, and a subovoidal tuberculum which slopes downward from anterior to posterior margins. The outer surface of the shaft is transversely widened between the tuberculum and the angle, with the protruding edge overhanging the posterior surface for a greater distance than on any of the preceding ribs. Below the level of the angle the inner surface of the shaft is rounded; the outer edge is thin and irregular.

The proximal portion of the seventh rib (pl. 30, fig. 9) above the angle is missing. The outer surface of the shaft is transversely widened above the angle and the protruding edge overhangs the posterior face as on the preceding rib. The outer edge of the slender

shaft is thin and the inner surface rounded. At some time in the life of this porpoise this rib was broken approximately 125 mm. distal to the angle, and the resulting rugose enlargement of this broken end indicates that the break with the distal portion did not subsequently heal.

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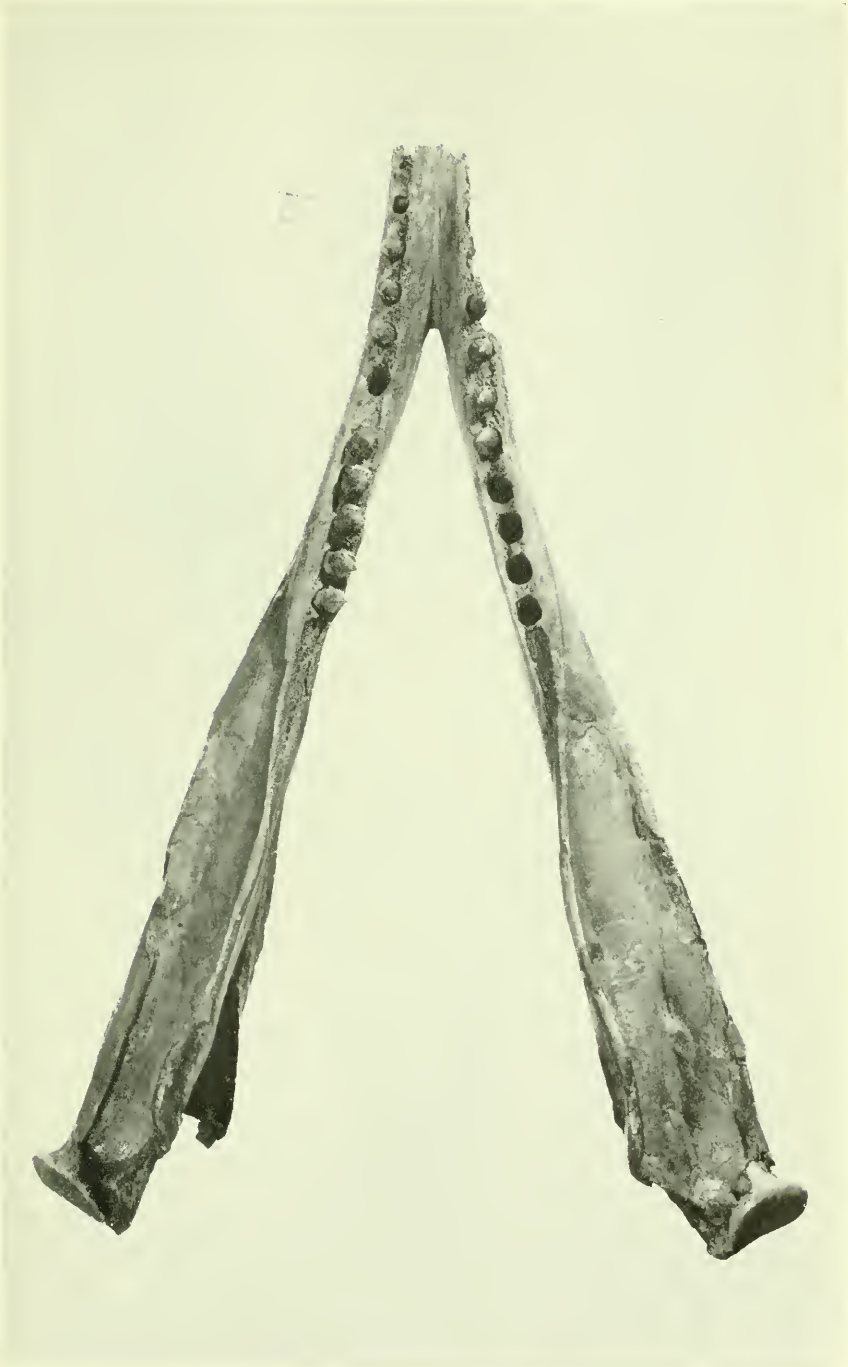
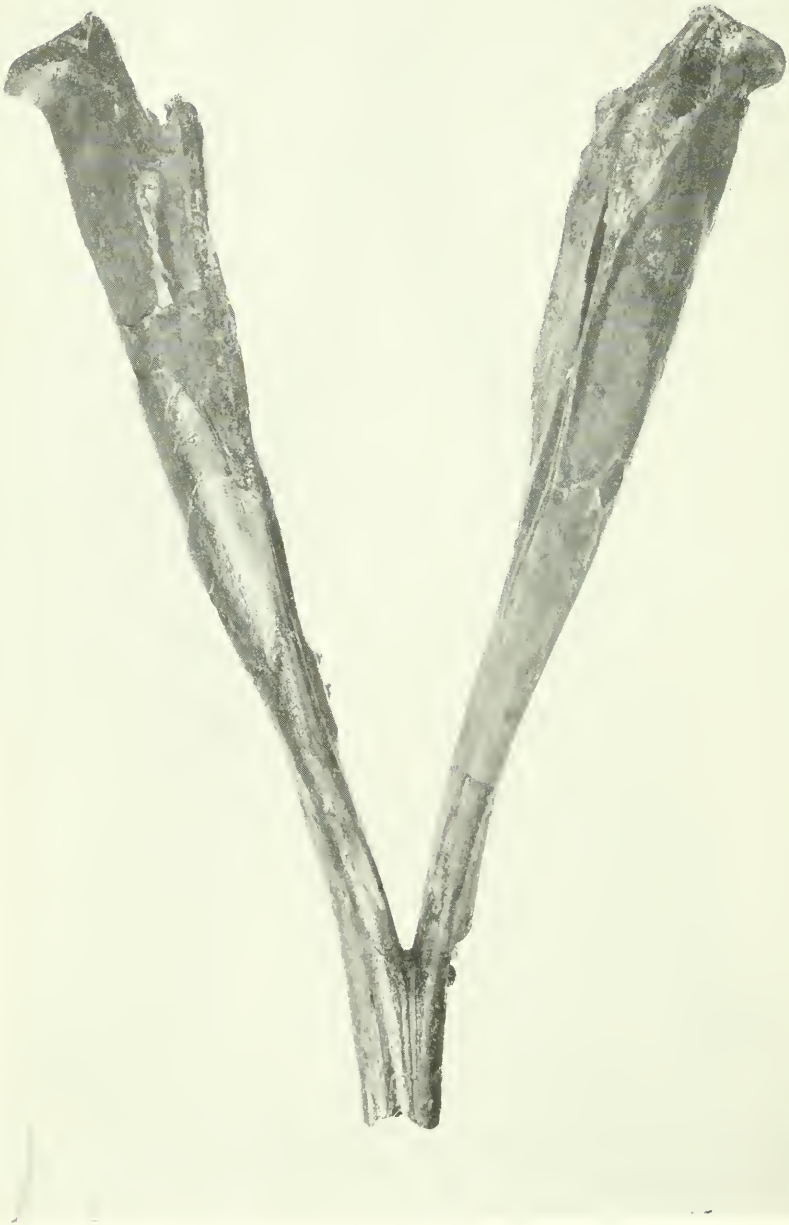
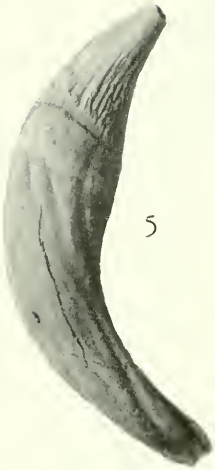


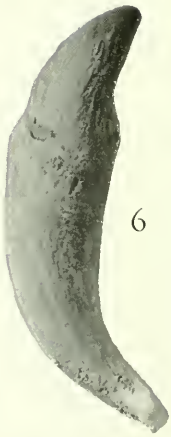
Phocageneus venustus Leidy (referred specimen, USNM 21039), dorsal view of mandibles.



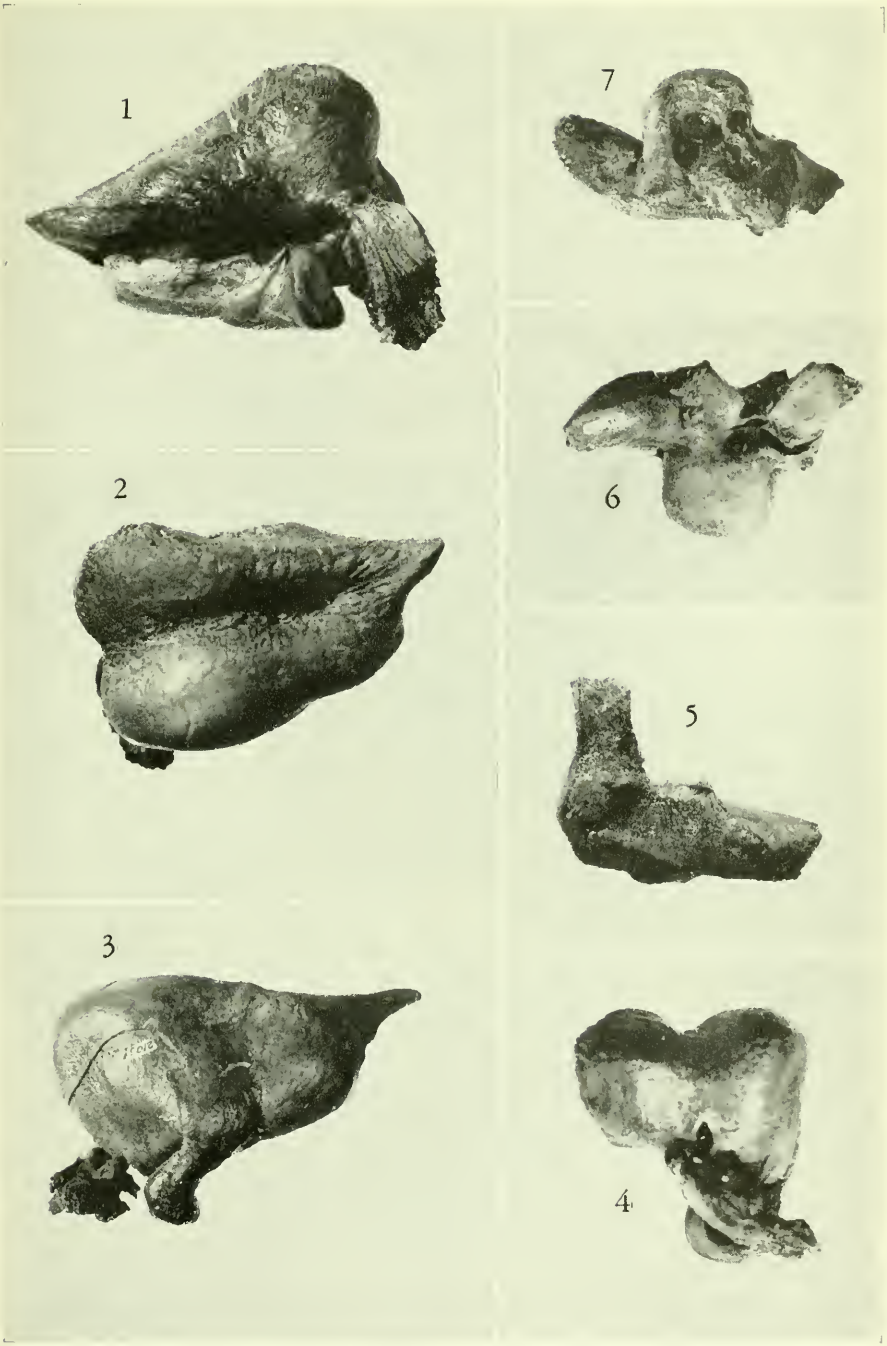
Phocageneus venustus Leidy (referred specimen, USNM 21039), ventral view of mandibles.

Phocageneus venustus Leidy, type tooth (ANSP 11227): 1, external view; 2, posterior view; 3, internal view. Referred teeth (USNM 20139): 4, external view, eleventh tooth, right; 5, internal view, sixth, left; 6 internal view, fourth, right. All X 2.



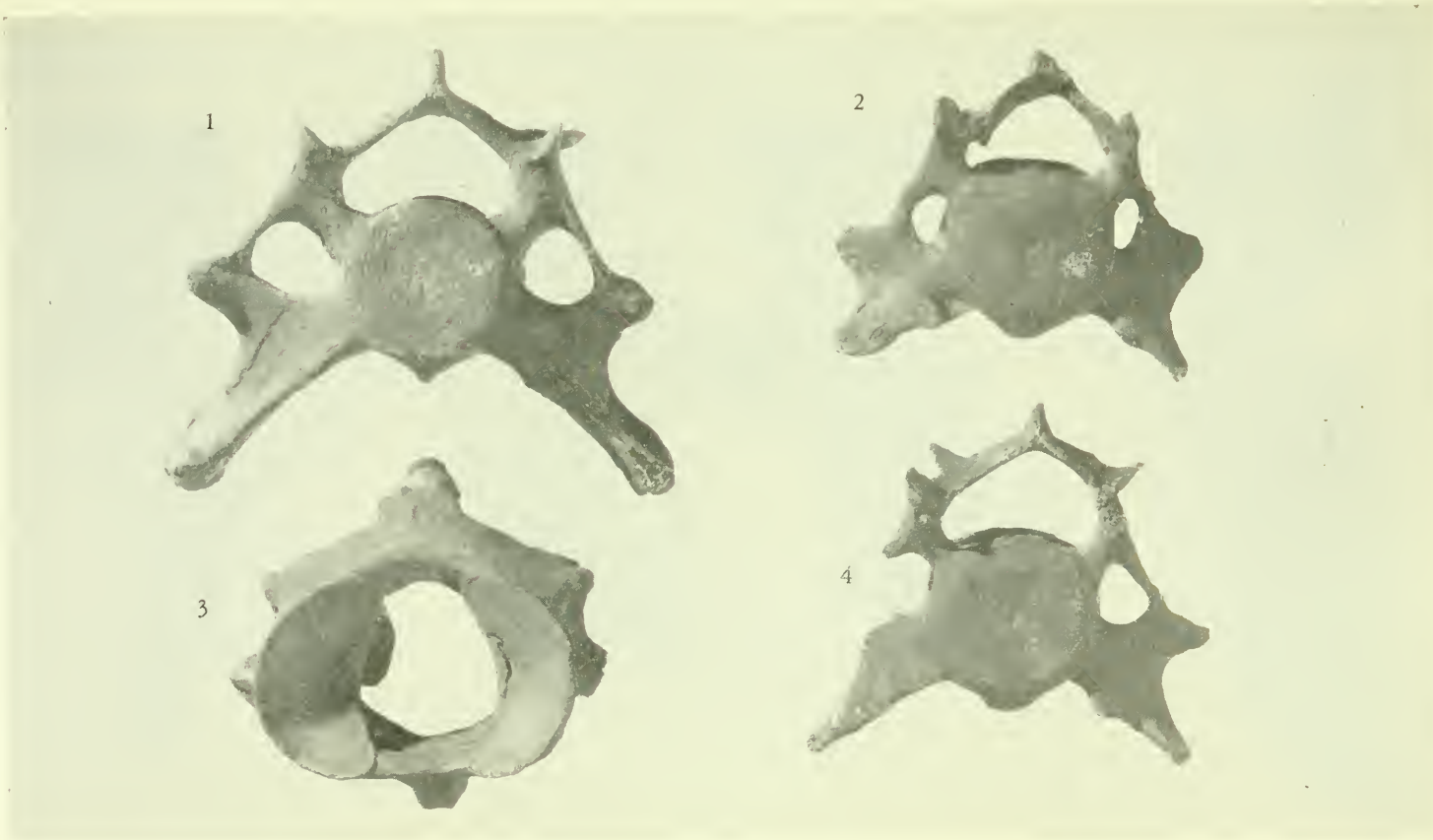


Phocageneus venustus Leidy, teeth (referred specimen, USNM 20139): 1, internal view, tenth tooth, left; 2, internal view, second, right; 3, internal view, hindmost, ? right; 4, internal view, hindmost, ? right; 5, internal view, twelfth or thirteenth, right; 6, external view, eleventh, left. Figure 4, X 4; all others X 2.



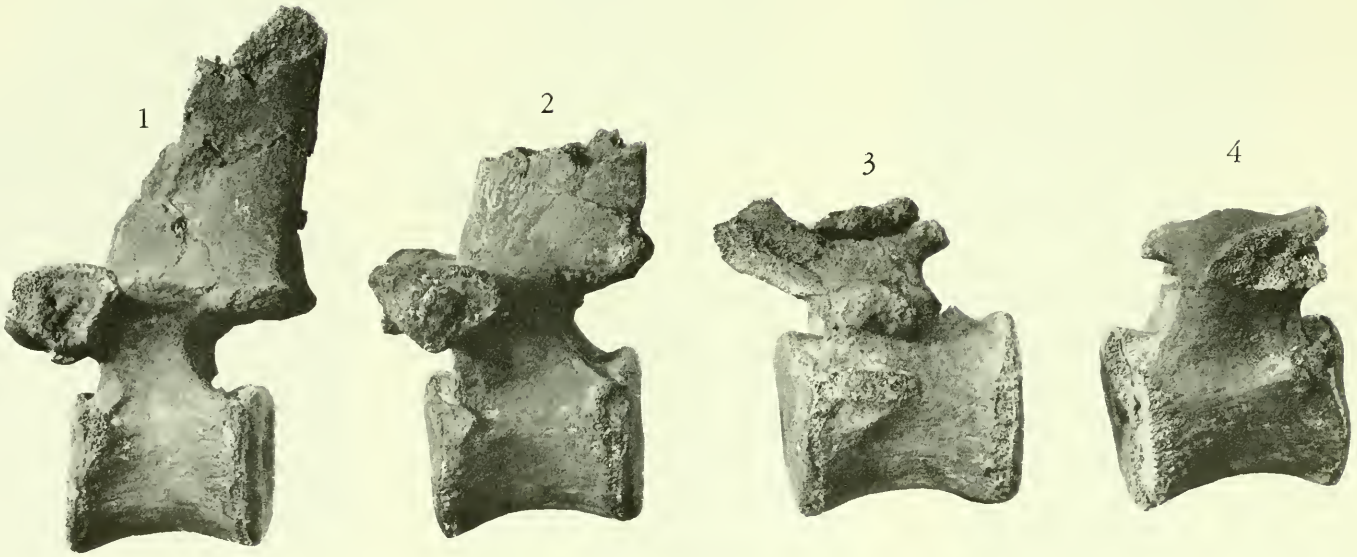
Phocageneus venustus Leidy, left tympanic bulla and left periotic (referred specimen, USNM 21039): 1, dorsal view, tympanic bulla; 2, ventral view, tympanic bulla; 3, external view, tympanic bulla; 4, posterior view, tympanic bulla; 5, external view, periotic; 6, tympanic or ventral view, periotic; 7, cerebral or internal view, periotic.

Phocageneus venustus Leidy, right tympanic bulla and right periotic (referred specimen, USNM 21039): 1, external view of tympanic bulla and periotic; 2, cerebral or internal view of tympanic bulla and periotic; 3, posterior view of tympanic bulla and periotic.

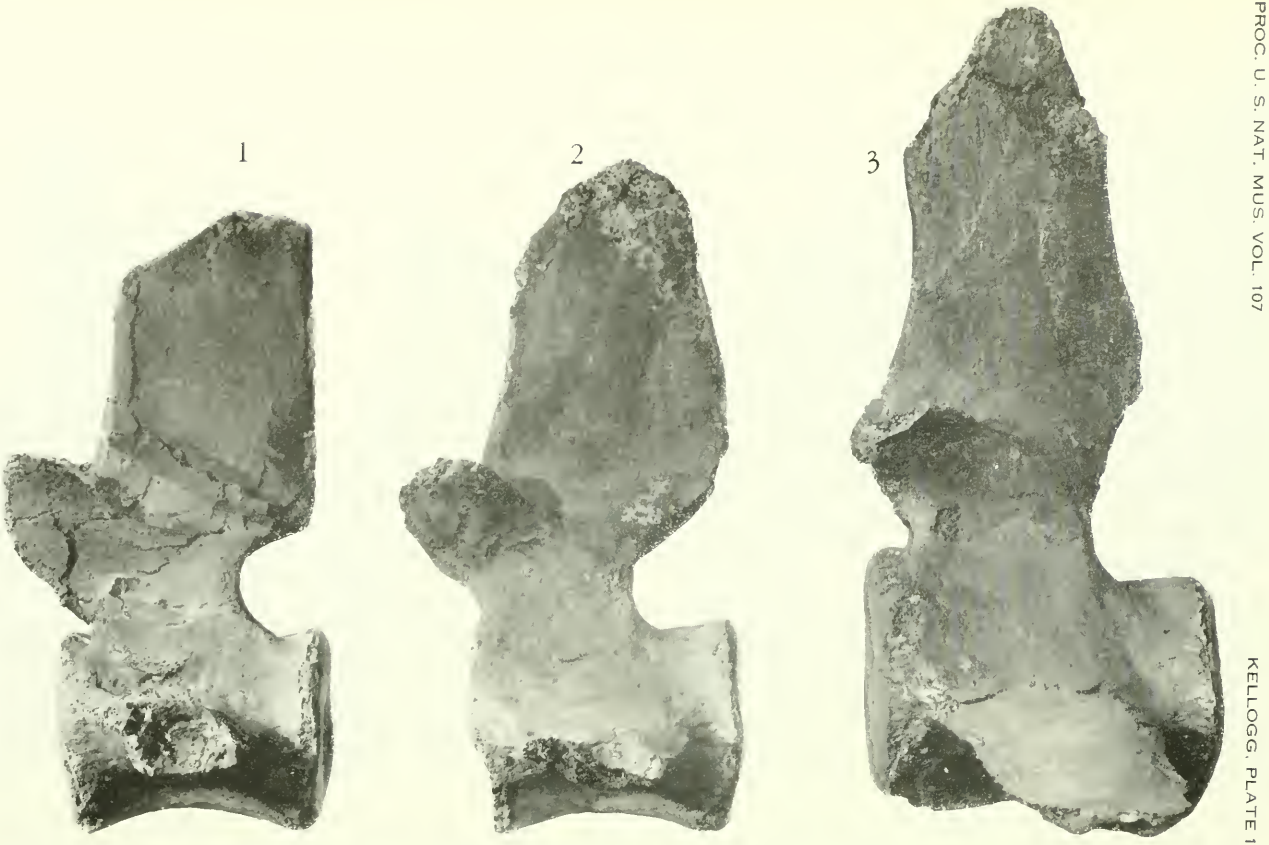


Phocageneus venustus Leidy (referred specimen, USNM 21039): 1, anterior view, sixth cervical; 2, anterior view, third cervical; 3, anterior view, atlas; 4, anterior view, fifth cervical.

Phocageneus venustus Leidy (referred specimen, USNM 21039): 1–4, lateral views of first, second, third, and fourth dorsals, respectively.

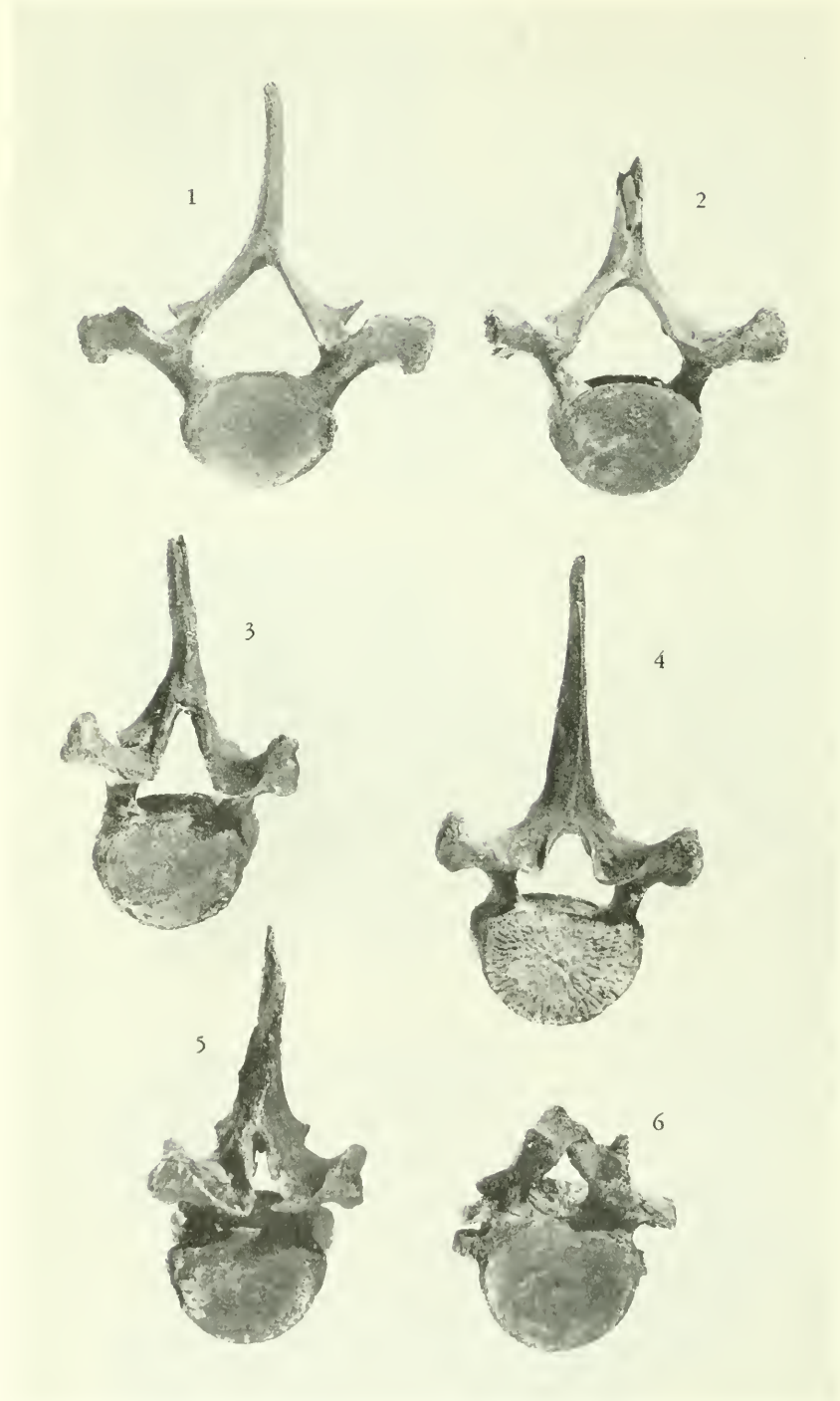


Phocageneus venustus Leidy (referred specimen, USNM 21039): 1–4, lateral views of fifth, sixth, seventh and eighth (reversed) dorsals, respectively.

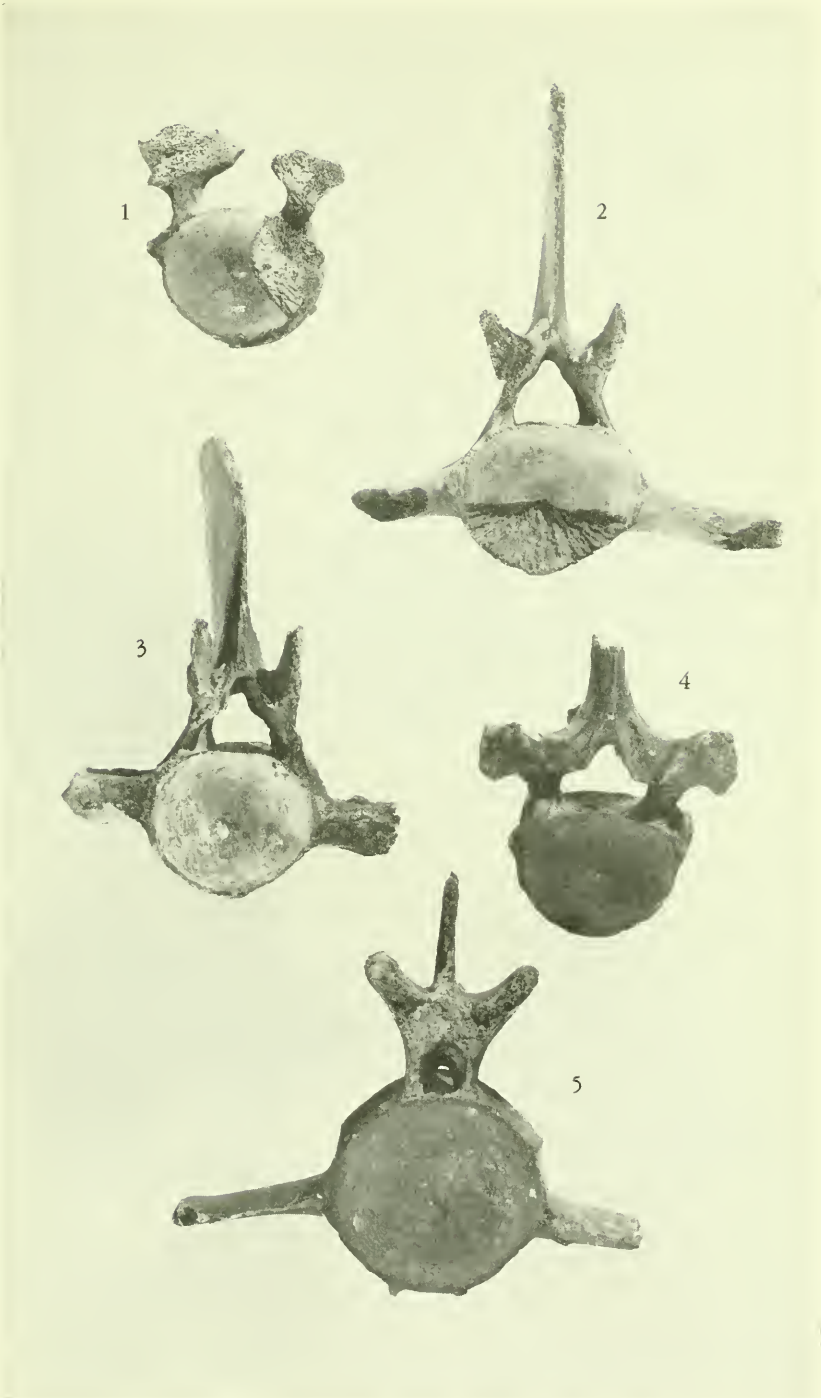


Phocageneus venustus Leidy (referred specimen, USNM 21039): 1 and 2, lateral views of ninth and tenth dorsals; 3, lateral view of anterior lumbar.

Phocageneus venustus Leidy (referred specimen, USNM 21039): 1–3, lateral views of caudals.



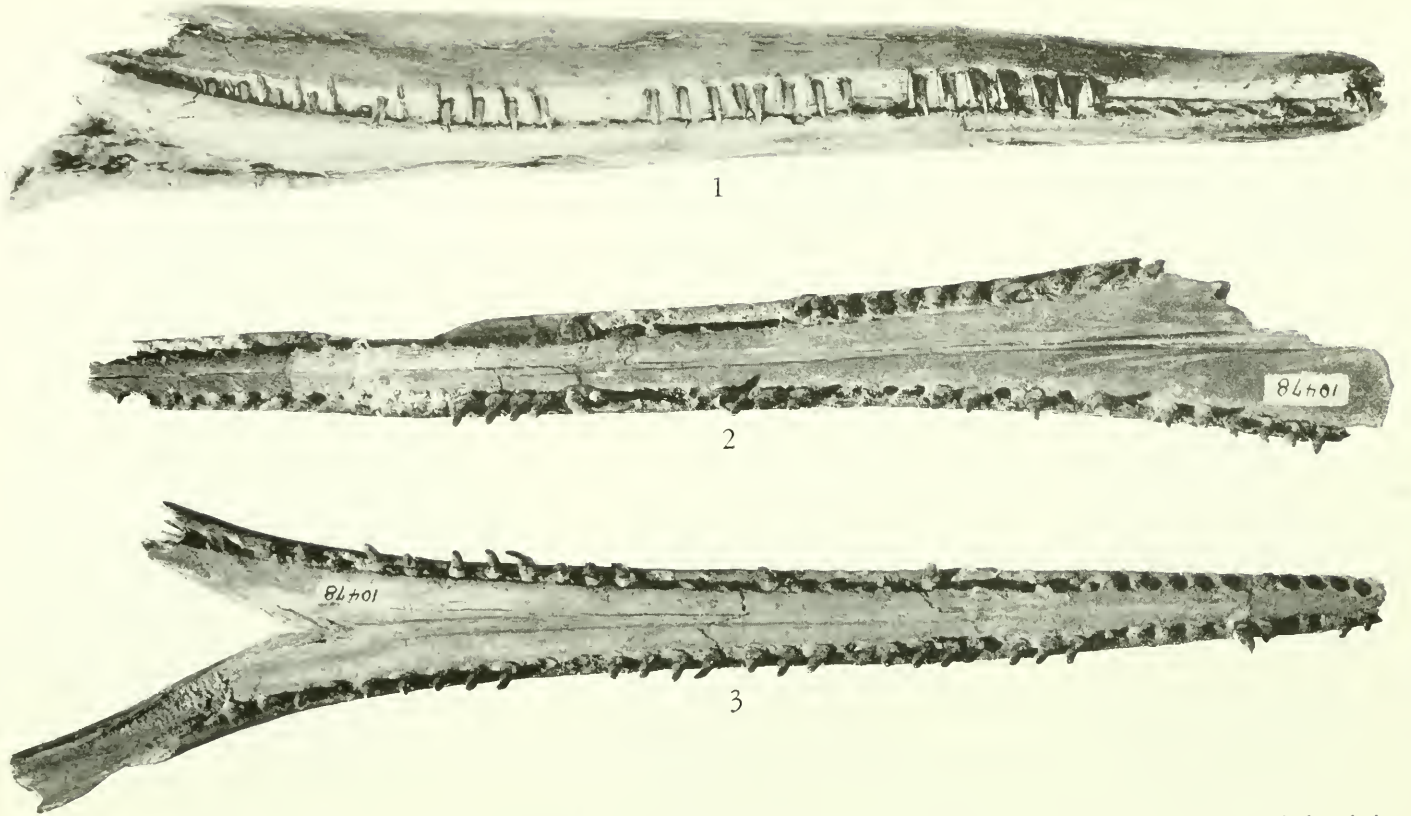
Phocageneus venustus Leidy (referred specimen, USNM 21039): 1–6, anterior views of first, second, third, fourth, fifth, and seventh dorsals, respectively.



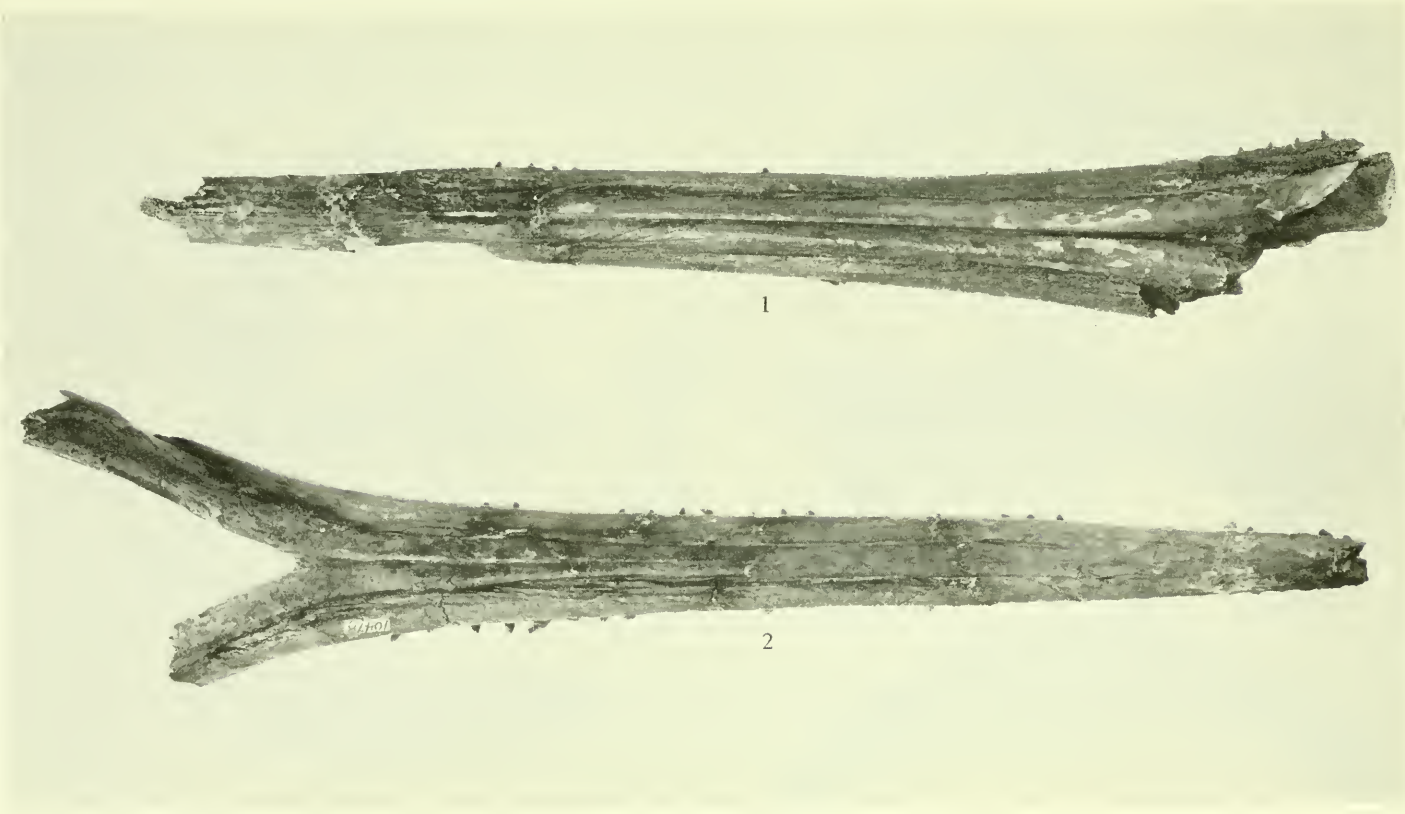
Phocageneus venustus Leidy (referred specimen, USNM 21039): 1–4, anterior views of eighth, tenth, ninth, and sixth dorsals, respectively; 5, anterior view of caudal.

Phocageneus venustus Leidy (referred specimen, USNM 21039): 1, anterior view of lumbar; 2 and 3, anterior views of caudals.

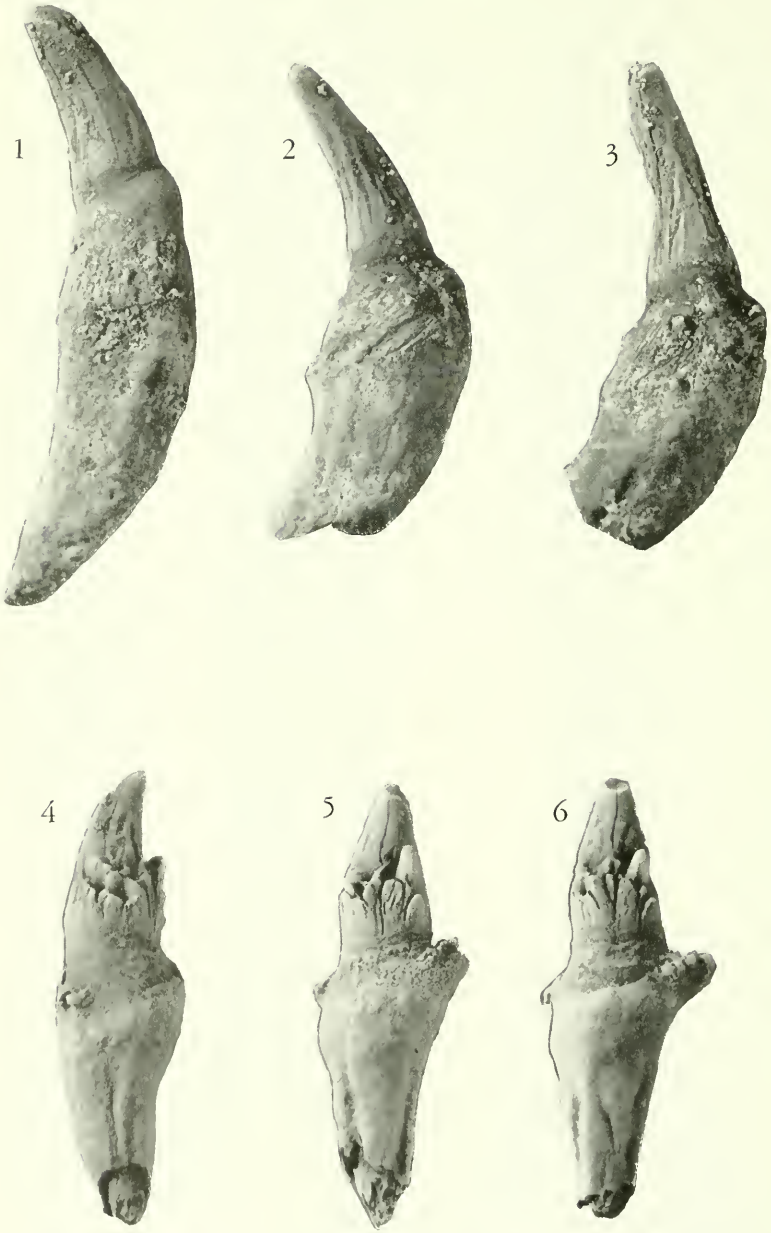
Phocageneus venustus Leidy (referred specimen, USNM 21039): 1, dorsal view of terminal caudal; 2 and 3, lateral views of chevrons; 4 and 5, segments of sternum.



Araeodelphis natator, new genus, new species (type, USNM 10478): 1, lateral view of rostrum and mandibles; 2, ventral view of rostrum; 3, dorsal view

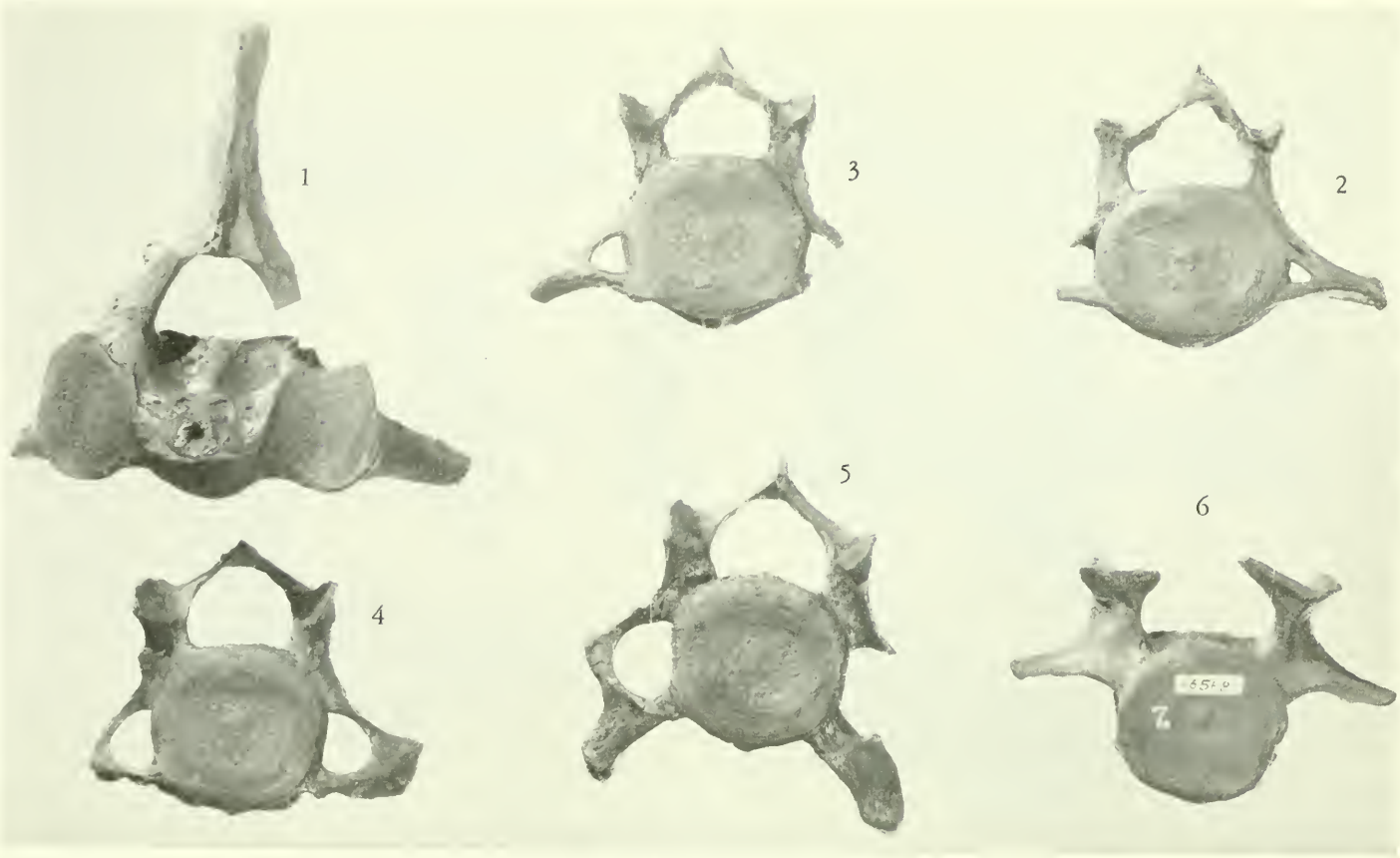


Araeodelphis natator, new genus, new species (type, USNM 10478): 1, dorsal view of rostrum; 2, ventral view of mandibles.

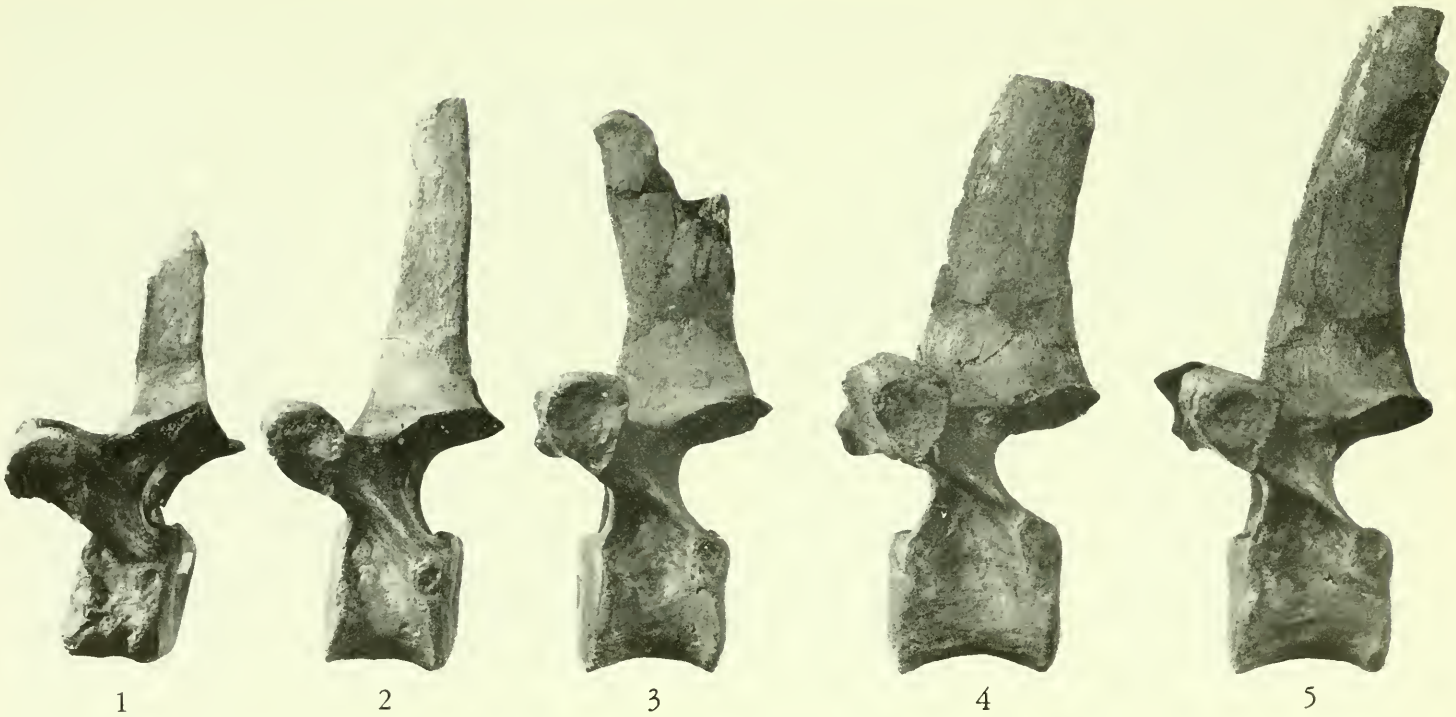


Araeodelphis natator, new genus, new species (type, USNM 10478): 1–3, internal views of anterior teeth; 4–6, internal views of posterior teeth.

Araeodelphis natator, new genus, new species (referred specimen, USNM 16569): 1–6, lateral views of axis and third, fourth, fifth, sixth, and seventh cervicals, respectively.



Araeodelphis natator, new genus, new species (referred specimen, USNM 16569): 1–6, anterior views of axis and third, fourth, fifth, sixth, and seventh cervicals, respectively.

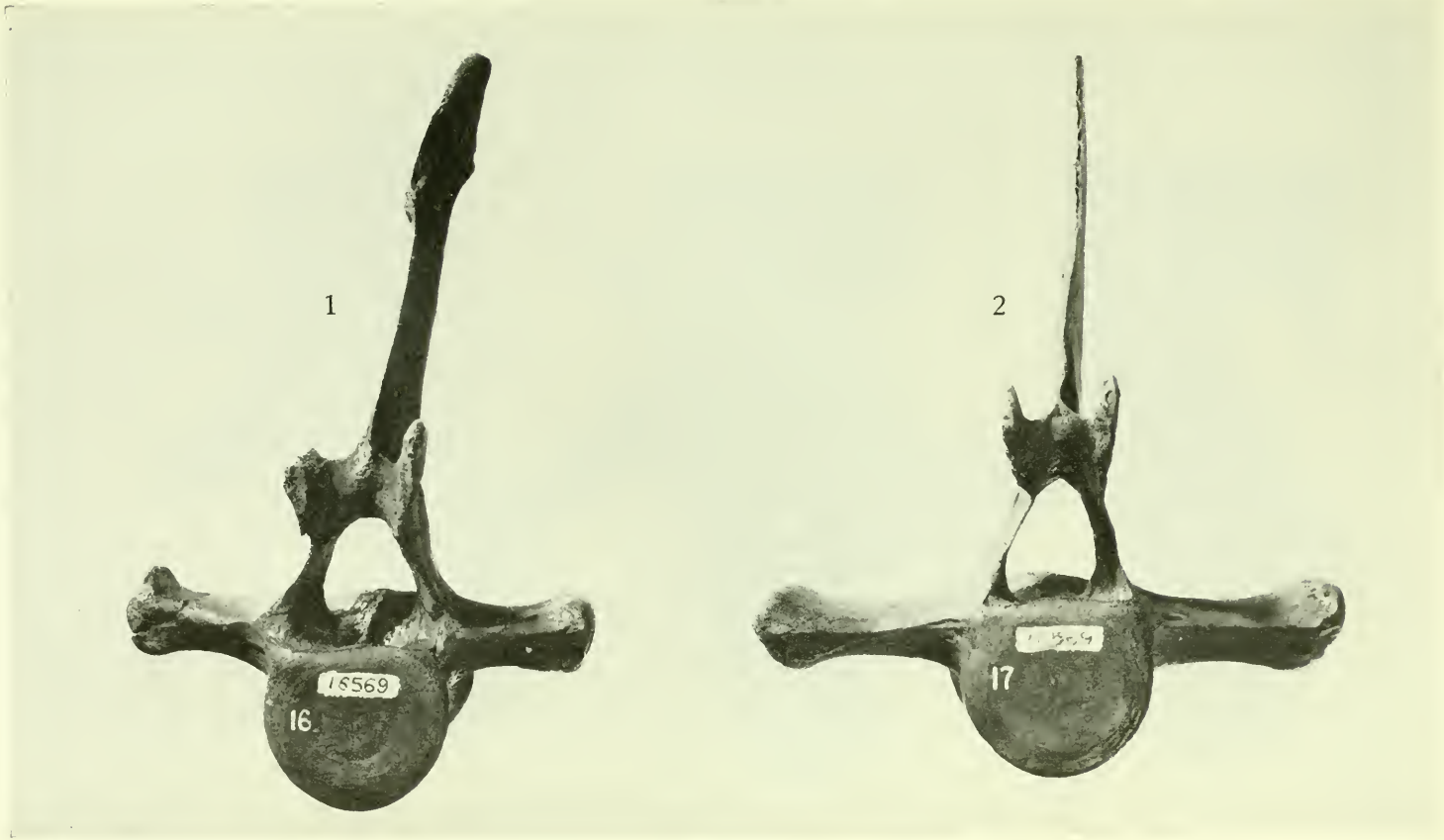


Araeodelphis natator, new genus, new species (referred specimen, USNM 16569): 1–5, lateral views of first, second, third, fourth, and fifth dorsals, respectively.

Araeodelphis natator, new genus, new species (referred specimen, USNM 16569): 1–4, anterior views of first, second, third, and fourth dorsals, respectively.

Araeodelphis natator, new genus, new species (referred specimen, USNM 16569): 1–4, lateral views of sixth, seventh, eighth, and ninth dorsals, respectively.

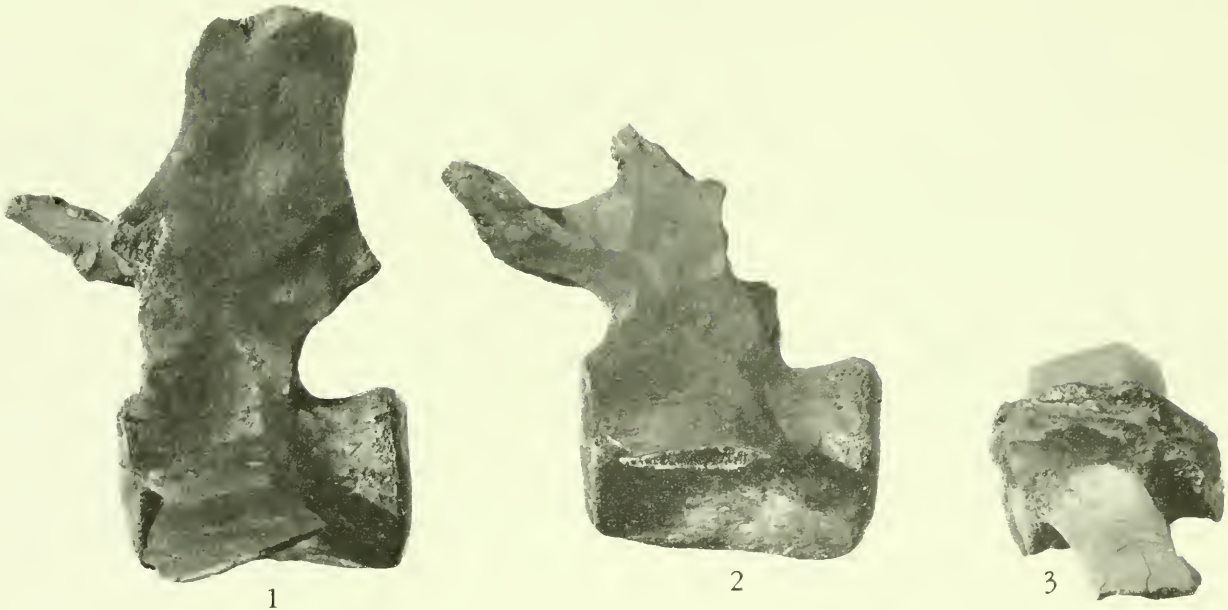
Araeodelphis natator, new genus, new species (referred specimen, USNM 16569): 1–4, anterior views of fifth, sixth, seventh, and eighth dorsals, respectively.



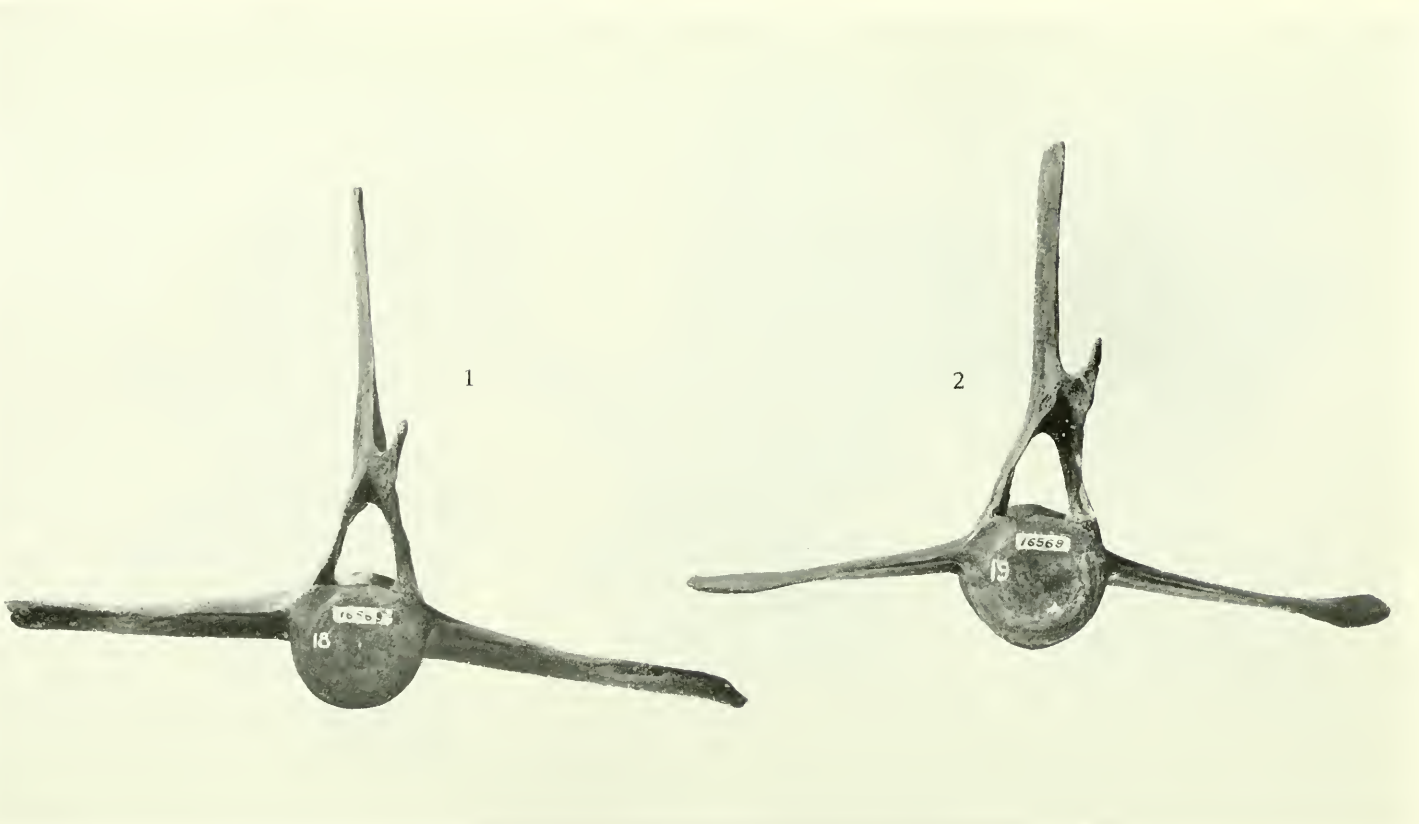
Araeodelphis natator, new genus, new species (referred specimen, USNM 16569): 1 and 2, anterior views of ninth and tenth dorsals, respectively.

1 2 3

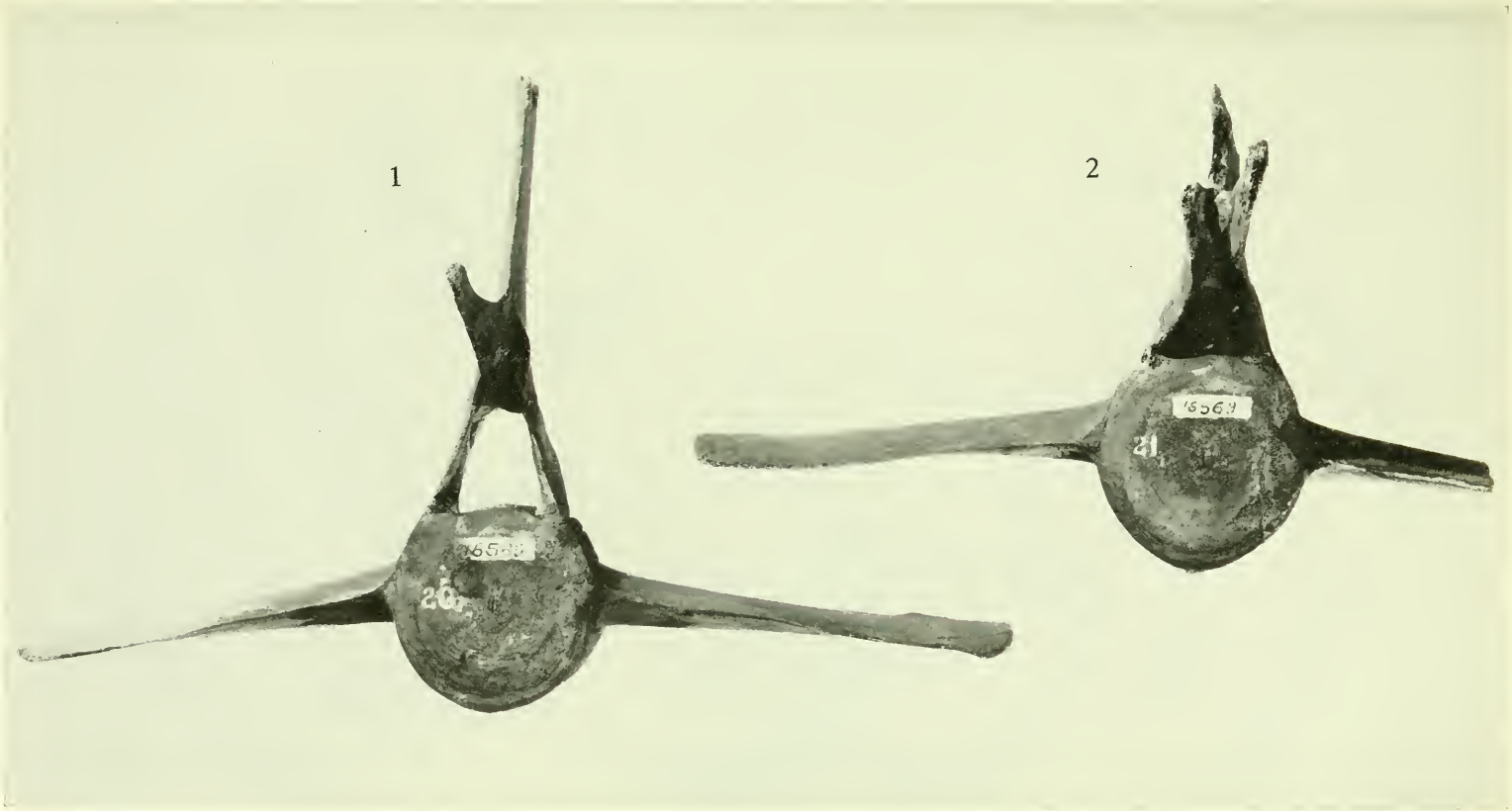
Araeodelphis natator, new genus, new species (referred specimen, USNM 16569): 1–3, lateral views of tenth dorsal and first and second lumbars, respectively.



Araeodelphis natator, new genus, new species (referred specimen, USNM 16569): 1–3, lateral views of third, fourth, and indeterminate lumbar, respectively.



Araeodelphis natator, new genus, new species (referred specimen, USNM 16569): 1 and 2, anterior views of first and second lumbars, respectively.



Araeodelphis natator, new genus, new species (referred specimen, USNM 16569): 1 and 2, anterior views of third and fourth lumbars, respectively.

Araeodelphis natator, new genus, new species (referred specimen, USNM 16569): 1, first rib, left; 2, second rib, left; 3, fourth rib, left; 4, sixth rib, left; 5, second rib, right; 6, third rib, right; 7, fourth rib, right; 8, sixth rib, right; 9, seventh rib, right.