IX. A NEW TURTLE FROM THE DUCHESNE OLIGOCENE OF THE UINTA BASIN, NORTHEASTERN UTAH.

By John Clark.*

During the summer of 1931, the Carnegie Museum field-party under Mr. J. LeRoy Kay discovered and collected a fossil turtle from the basal Oligocene of the Uinta Basin, Utah. The specimen was recovered from two large blocks, which had broken from massive light gray sandstone weathering brown at the surface. Although the two portions into which the shell had been broken nowhere made contact with each other, the matrix of the blocks made such broad and excellent contacts that the shell could be restored exactly as it had been before the breakage occurred. All through the sandstone were masses of poorly preserved vegetable matter, including several parts of leaves, which resembled maple- or oak-leaves; and one small fragment, which Dr. O. E. Jennings, Curator of the Section of Botany, Carnegie Museum, has identified as either the cone of a sequoia, or the base of an alder-stem.

Study of the specimen was conducted under the direction of Mr. O. A. Peterson, Curator of Fossil Mammals, Section of Vertebrate Paleontology, Carnegie Museum. The author is indebted to Mr. Peterson and Mr. Kay for assistance and encouragement in the preparation of this paper; to Messrs. L. S. Coggeshall and S. Agostini, preparators, for advice and assistance in freeing the specimen from the matrix; to Mr. Sydney Prentice for his patience and skill in making the drawings; and to Dr. W. J. Holland for assistance in coining the generic name and for finally revising and editing the paper. Measurements of early Tertiary species of the genera *Hadrianus*, *Stylemys*, and *Testudo*, used throughout the text, are those published by Hay[1] and Gilmore.[2] Mr. Barnum Brown of the American Museum of

*Submitted by John Clark, B.S., 1931, University of Illinois, to the Graduate School of the University of Pittsburgh in partial fulfilment of the requirements for the degree of Master of Science.

[1]Hay, O. P. *Fossil Turtles of North America.* Carnegie Institution of Washington. 1908.

[2]Gilmore, C. W. *The Fossil Turtles of the Uinta Formation.* Memoirs of the Carnegie Museum, Vol. VII, No. 2, Nov. 1915.

Natural History has very kindly made available for comparison the pelvic girdles of *Hadrianus* and *Testudo*, A. M. N. H., No. 1068 and No. 1160.

Family TESTUDINIDÆ Gray.

Genus CYMATHOLCUS[3] gen. nov.

Cymatholcus longus Clark, sp. nov.

Type: Carapace; plastron; pelvis; pectoral girdle; both sides complete series of caudals; two complete and one partially complete cervical vertebrae (C. M. Cat. Vert. Foss., No. 11,891).

Locality: "Hoot Owl Canyon," fifteen miles southwest of Vernal, Uinta County, Utah.

Horizon: Duchesne beds, basal Oligocene.

Generic characters: Sulcus between marginal scutes and plastral scutes strongly looped. Sulcus between costal scutes and marginal scutes ventral to costo-peripheral suture. Costo-peripheral suture minutely and openly, but definitely, digitated. Differentiation of costal bones about midway between that of *Hadrianus* on the one hand and of *Stylemys* and *Testudo* on the other. Shell longer and higher in proportion to width than in other genera of the family. Anterior lobe of plastron with lip conforming to the general contour of the lobe. Bridge short. Posterior lobe very long. Antero-posterior dimension of pelvis about equal to width of pelvis across dorsal rims of acetabula. Pubes long, lateral borders making a very low angle with the midline. External tail very short or absent.

Specific characters: Lateral border of first vertebral scute flared anteriorly. Lateral border of third vertebral bracket-shaped. Anterior border of plastral lip thick, semi-circular in cross-section. Sulci of plastron deeply incised. Pectoral scutes very narrow, with anterior and posterior borders parallel. Deep posterior notch in plastron. Epipubes long antero-posteriorly, narrow transversely. Ischio-pubic foramina long antero-posteriorly and narrow transversely.

CARAPACE

As seen from the front, the carapace is marked by its gently rounded, almost vertical sides and its broad, flat top. The flatness is somewhat

[3]From κῦμα = *wave*; ὁλκός = *furrow*.

accentuated by crushing over the inguinal buttresses, but anteriorly it is actual. The anterior opening is broad, and higher dorso-ventrally than in *Stylemys*; the lip of the plastron gives the effect of the sides of the opening being depressed, although the rim of the carapace is al-

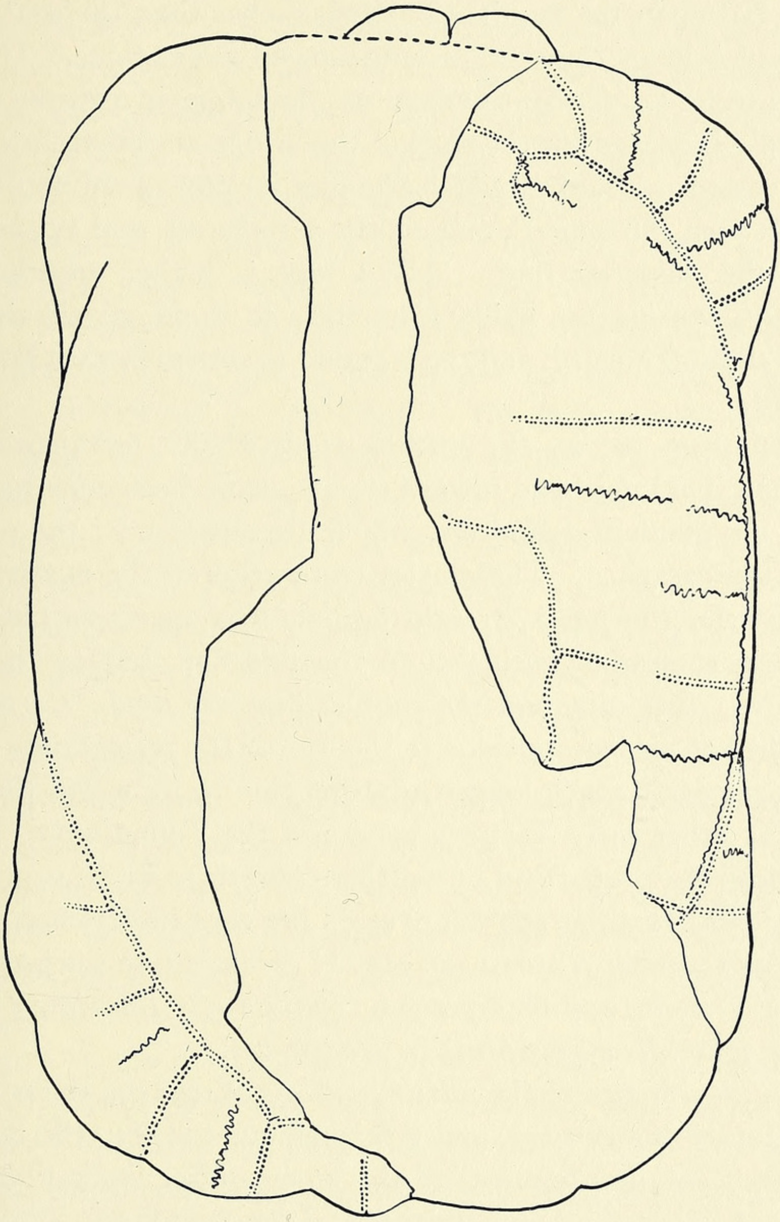

FIG. 1. Dorsal View of Shell of *Cymatholcus longus, Gen. et sp. nov.* (C. M. Cat. Vert. Foss., No. 11.891). 1/6 nat. size.

most straight. The lateral flare produces a marked prominence at the angle of the free border. The sides of the carapace are so curved that the upper ends of the peripherals swell out slightly further laterally than does the marginal keel.

From a lateral view the arch of the carapace, highest over the inguinal buttresses, is most apparent. Anteriorly the slope is moderate; posteriorly it falls away with steepness, which is slightly increased by distortion of the caudal region. The center of gravity of the mass seems to fall upon the inguinal buttress rather than the center of the bridge, which gives the shell an unbalanced appearance. The down-sloping anterior border continues across the bridge in a strong marginal keel, deeply indented for the sulci of the bridge marginals, and merges with the posterior border, which changes its downward course at the suture between the seventh and eighth peripherals, and slopes upward to form the posterior flare. The bridge is higher anteriorly than posteriorly, causing the axillary buttress to slope steeply downward and only slightly inward, and the inguinal to extend inward rather than downward.

As seen from below, the outline is decidedly rectangular. The lateral marginal lines bend inward slightly from both ends to the sulci between marginals five and six, which are situated at the narrowest point of the carapace. The plaster restoration of the median section of the anterior rim has a straight border; it is very possible that the border was somewhat recurved to the mid-line, but as there is no evidence in either direction the simpler line was used. Certainly the border did not project anterior to the line of the restoration.

The carapace is much longer in proportion to its width than in the case of the other early Tertiary genera of the *Testudinidæ*. Measurements show the proportion of width to length to be 62.6 per cent in this specimen; 72.3 per cent to over 85 per cent in *Stylemys*; 83.3 per cent (*Testudo uintensis*) to 91 per cent (*T. brontops*) in the pre-Miocene species of *Testudo*; and 68.5 per cent (estimated, *Hadrianus tumidus*) to 83 per cent (*H. majusculus*) in *Hadrianus*.

Due to the absence of the nuchal and pygal regions, the widespread obliteration of the sutures, and a ferruginous coating, the removal of which often entailed removal of the bone-surface, very little can be determined about the bony structure of the carapace. Costals three and four and peripherals from one to eight are distinguishable; about half of the bridge-suture and most of the costo-peripheral suture can be traced definitely.

The costo-peripheral suture is situated about half-way between the plastron and the top of the carapace, and is thrown into open digitations approximately 1 mm. long. It differs thereby from *Stylemys* and *Hadrianus*, in which[4] "the rounded border of each peripheral joins the similar border of a neighboring costal." In *Hadrianus*, *Stylemys*, and the Oligocene species of *Testudo*, the costo-peripheral suture follows closely the costo-marginal sulcus. In the specimen at hand the suture is from 8 to 13 mm. higher than the sulcus along the sides of the carapace; at the sutural angle between the nuchal, first peripheral, and first costal, it is 33 mm. higher; and at a point 29 mm. lateral to the angle it is 52 mm. higher. The first peripheral of *S. capax* and of *H. corsoni* rises considerably above the dorsal sulcus of the first marginal of those species, so that the height of the first peripheral is at most a specific and not a generic character.

Costals three and four reveal a degree of differentiation, which is intermediate between that of *Hadrianus* on the one hand and of *Stylemys* and *Testudo* on the other. The third costal is decidedly wedge-shaped, but the fourth costal is almost rectangular. In *H. majusculus* there is no appreciable differentiation in the third and fourth costals. Costal three of *H. corsoni* loses distally about 25 per cent of its proximal width, and costal four loses about 8 per cent. Costal three of *Cymatholcus longus* narrows distally 43 per cent, and costal four expands 16 per cent. Hay gives no measurements for *S. nebrascensis*, but says[5] "the degree of this differentiation differs somewhat in individuals, and in general is not so well developed as in *S. conspecta* and *S. capax*." Costal three of *S. conspecta* loses 58 per cent of its proximal width and costal four gains 100 per cent; costal three of *S. capax* narrows by 45 per cent of its width; and costal four expands 48 per cent. In *T. brontops*, costal three narrows 27 per cent; costal four expands 60 per cent; in *T. laticunea* costal three widens .05 per cent; costal four widens 113 per cent.

In regard to the peripherals there is very little that need be said. The free borders are acute, with a noticeable flare at the antero-lateral angle and a strong flare over the hind legs. The suture between the peripherals and the plastron is irregular, but its general trend is in a straight line. About half of the bridge is plastral and half peripheral. The bridge is so deeply furrowed for the sulci of the marginals that the intervening spaces look inflated, resembling in this respect *T. brontops*.[6] The angle between the nuchal, first peripheral,

[4]Hay, O. P. Fossil Turtles of North America. p. 370.

[5]Hay, *op. cit.*, p. 387.

[6]Hay, *op. cit.*, p. 398.

and first costal is outside the lateral sulcus of the first vertebral scute; a characteristic which is regarded as being of specific significance.

The scutes are represented by half of vertebral three, costals one, two, and three; and marginals two to nine on the right side, and marginals nine through twelve on the left side.

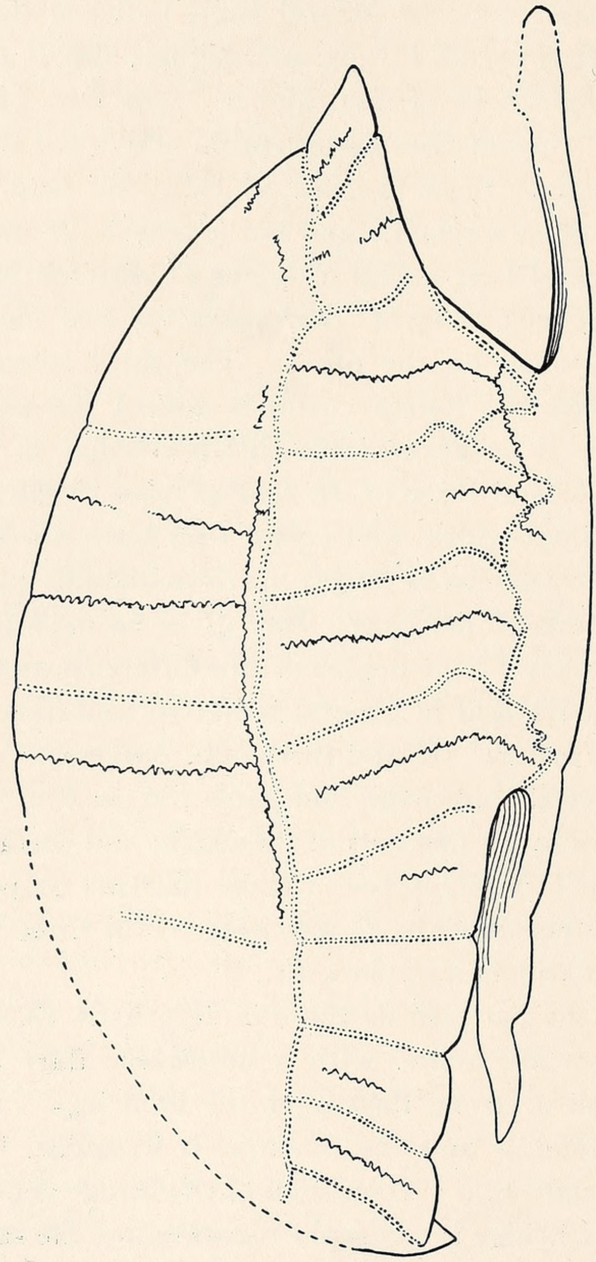

FIG. 2. Lateral View of Shell of *Cymatholcus longus Gen. et sp. nov.* (C. M. Cat. Vert. Foss., No. 11,891). 1/6 nat. size.

A small but very interesting bit of the border of vertebral one is also preserved. Starting from a broken edge at a point 61 mm. from the midline and 60 mm. from the vertebro-marginal sulcus, it extends downward and slightly inward 36 mm. to a point 57 mm. from the midline and 23 mm. from the vertebral-marginal sulcus. Making at this point an angular turn outward, it extends 30 mm. to its junction with the vertebral-marginal sulcus 75 mm. from the midline and 23 mm. mesial to the sulcus between marginals one and two. This angulated expansion is unparalleled among the other early Tertiary *Testudinidæ*, and is apparently characteristic of this species.

Vertebral three is approximately as long as it is wide. The anterior sulcus extends postero-laterally from the midline in a curve which is convex anteriorly and reverses its convexity near its junction with the vertebral-costal sulcus. The vertebral-costal sulcus is shaped like a printer's bracket, ( ). It possesses no differences from corresponding scutes in specimens of *Stylemys* and *Testudo*, other than slight features subject to individual variation.

The costals are simple, separated from each other and from the marginals by sulci, which are almost straight and possess no distinctive characteristics.

The marginals are highly specialized, and form one of the chief bases for erection of the genus. As the inter-marginal sulci pass over the marginal keel of the carapace they are curved forward, and recurve below the keel. The sulcus separating the axillary scute from marginal four parallels and lies immediately posterior to the externo-anterior border of the axillary buttress for its entire length. Just above the axillary notch, a short sulcus demarcates the boundary between the axillary and the plastron. From the junction of these two, the plastro-marginal sulcus swings antero-dorsally in a sharp curve, and gradually works postero-dorsally until it reaches its highest point, the junction with the sulcus between marginals four and five, when it is running directly posteriorly. The inter-marginal sulcus continues its postero-ventral course (becoming, of course, plastro-marginal), and makes an open curve slightly more ventrally located than the first curve. It passes postero-dorsally to a high point considerably less dorsal than the first, and about 20 mm. anterior to its junction with the sulcus between marginals five and six, and thence in an undulating line, lowest where crossed by the suture between peripherals five and six, to its junction with the sulcus between marginals six and seven. The inter-marginal sulcus, continuing plastro-marginally, is convoluted into two reversed S curves just before it reaches the border of the inguinal buttress, which it does about 30 mm. above the inguinal notch.

The general effect is as if the rectanguloid marginals were set *en echelon*, the antero-distal corner of each projecting over the plastral portion of the bridge.

PLASTRON

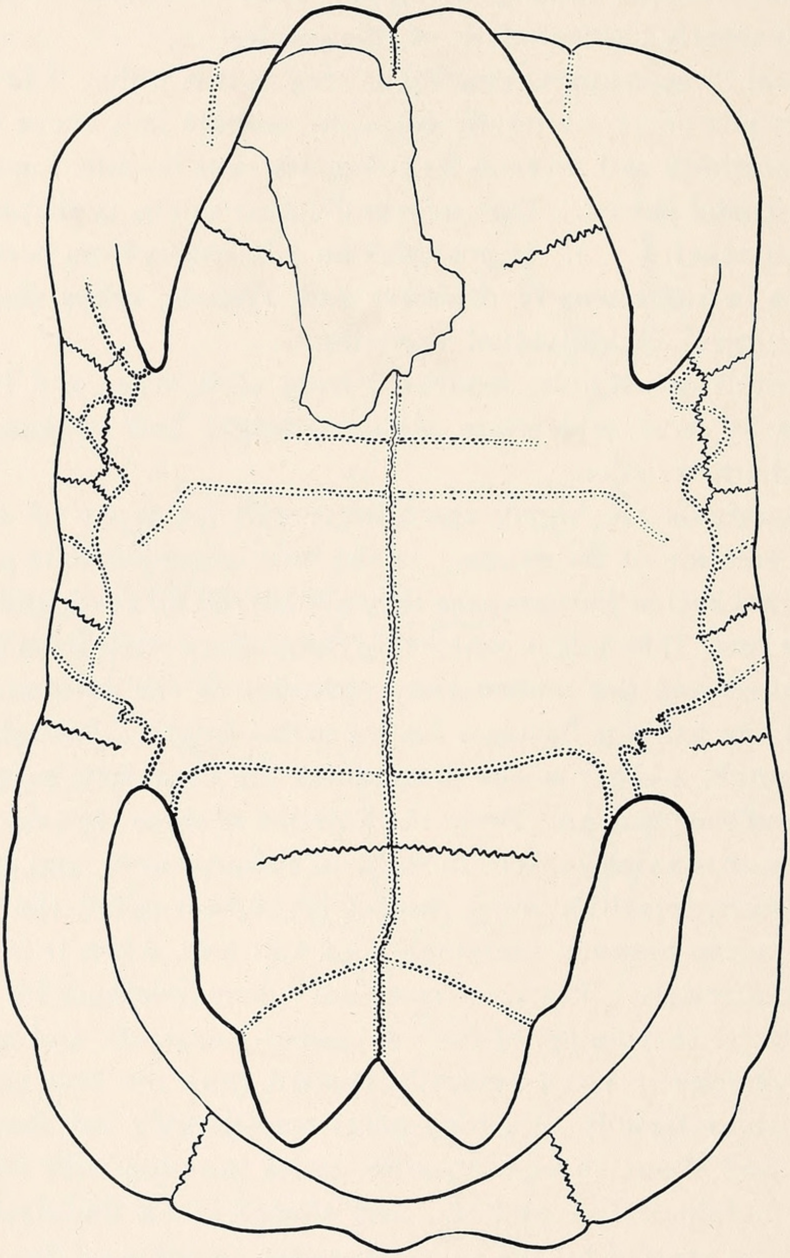

FIG. 3. Ventral View of Shell of *Cymatholcus longus, Gen. et sp. nov.* (C. M. Cat. Vert. Foss., No. 11,891). 1/6 nat. size.

The plastron has unfortunately undergone such extensive fracturing of the anterior lobe that many important characters are lost. The sutures are coalesced so completely that parts of the epi-hyoplastral and hypo-xiphyplastral are all that remain. The right bridge has been faulted, forcing that side of the plastron about 65 mm. dorsally; the left is uncrushed.

The plastron is long, relatively narrow, and massively built. Posterior to the pectorabdominal sulcus it is decidedly concave, so the individual was probably a male.

In its general features the anterior lobe strongly resembles that of *Stylemys*. It is sharply upcurved anteriorly, and the lip is confluent with the general contour of the lobe, as in *Stylemys*. Transversely the lobe is flat, or very slightly convex downward. As nearly as can be determined, the lip is short, rather wide, and thicker and more rounded at its anterior border than is the case in *Stylemys*. The lateral borders of the lobe are bevelled from the dorsal side to an acute edge, while the rim of the lip is 14 mm. thick and semi-circular in cross-section. Back of the lip, the epiplastra are 25 mm. thick, and at the humero-pectoral sulcus the hyoplastra have a thickness of 15 mm. The length of the anterior lobe is 73.4 per cent of its width, which corresponds closely to the proportions in various other species of the *Testudinidæ*.

The bridge in *Cymatholcus* is remarkably short—only 228 mm. from the axillary notch to the inguinal notch. Gilmore[7] has computed the proportion of length of bridge to length of plastron in all the specimens available to him and has arrived at the following percentages: *Hadrianus*, 38 per cent; *Stylemys*, 49 per cent; *Testudo*, 44 per cent. *Cymatholcus* has the bridge 37 per cent of the total length of the plastron, 656 mm. If, as Hay[8] states, the *Testudinidæ* have tended to elongate the bridge at the expense of the posterior opening of the shell, then in this character *Cymatholcus* is very primitive. This is to be expected from its stratigraphic relations to *Stylemys* and *Testudo*, but forms a marked contrast to the specialization evident in the carapace.

The concavity of the plastron between the bridges produces a strong ventral swelling extending from the axillary to the inguinal notches.

As might be expected from the shortness of the bridges, the posterior lobe is very long. Using the measurements of Hay and Gilmore as a basis for comparison, the proportion of length to width is

[7]Gilmore, *op. cit.*, p. 155.

[8]Hay, *op. cit.*, p. 370.

60.8 per cent to 65.6 per cent in *Hadrianus*; about 56 per cent in *Stylemys*; and 45.9 per cent to 60 per cent in the Oligocene species of *Testudo*. In *Cymatholcus longus* the proportion is 75 per cent.

The lobe is massively yet beautifully constructed. The borders taper gently backward toward their intersection with the femoral anal sulcus, narrow sharply to the intersection, then continue parallel to their former course to the tips of the xiphyplastra. The terminal notch is deep, and the free borders of the xiphyplastra curve slightly to the subacute terminations of the bones. The lateral borders of the lobe are at the inguinal notches planes 45 mm. high and almost vertical. Posteriorly they warp to the dorsal surface of the plastron, and bevel the xiphyplastra to acute lateral edges. Meeting on each tip a plane which bevels the border of the notch, they form on the dorsal surface of each tip a low median ridge, concave antero-dorsally. The ventral portion of the lobe covered by the anal scutes is convex antero-dorsally, while that covered by the femorals is noticeably concave antero-dorsally and strongly so transversely. A ridge extends around the dorsal rim of the lobe from the inguinal buttresses to the midline, where it dies out. Cupped in the posterior curve of this ridge is an ovoid swelling, measuring 70 mm. antero-dorsally and 102 mm. transversely.

As has been mentioned, the sutures of the plastron have been almost entirely obliterated. The epihyoplastral suture meets the border of the plastron 137 mm. from the free edge of the lip, and extends postero-mesially for 52 mm. to a fracture, making an angle about thirty degrees posterior to a straight transverse line. As there is at the point where it is broken no sign of the epientoplastral suture, the entoplastron cannot have been more than 144 mm. (twice the distance from the fracture to the midline) wide, and was probably somewhat less.

The sutures between the hypoplastra and the xiphyplastra show near the midline. They are somewhat less curved than is the case in the other genera of the family, forming an almost straight transverse line.

In contrast to the weak expression of the sutures, the sulci are deeply grooved and, except around the axillary notch, are strikingly evident.

On inspecting the plastron, the character most immediately apparent is the tabular shape of the pectoral scutes. Their anterior and posterior sulci are parallel transverse lines, continuing 29 mm. apart as if plotted with instruments, to the points where the pectorals flare over the anterior portions of the bridges. The figures of Hay show this character developed in *Testudo farri*, *T. osborniana*, *T. impensa* *T. orthopygia*, and to a lesser extent in *Hadrianus tumidus*, H. *schuch1erti*, *Stylemys conspecta*, and *S. capax*, so it must be considered a character of specific and not of generic importance.

The abdominal scutes are rather long. The femoral-abdominal sulcus is convex posteriorly, with its intersection with the midline as its most posterior point. The femoral scutes are trapezoidal, with the midline and the almost parallel lateral borders as bases, and the posteriorly convex abdominal-femoral sulci and the anteriorly convex femoral-anal sulci as sides. The anals are irregularly quadrilateral and have curved edges; they are of medium size. A small axillary scute is present, covering the anterior border of the axillary buttress and not reaching the ventral or lateral surfaces of the bridge. Whether or not there was an inguinal scute cannot be determined.

VERTEBRAL COLUMN

The portions of the vertebral column which have been preserved are: one partial and two complete cervical vertebræ; part of the first thoracic vertebra with the heads of the first, second, and third ribs; and the complete series of caudals, lacking only the anterior portion of the first caudal and the left side of the first six.

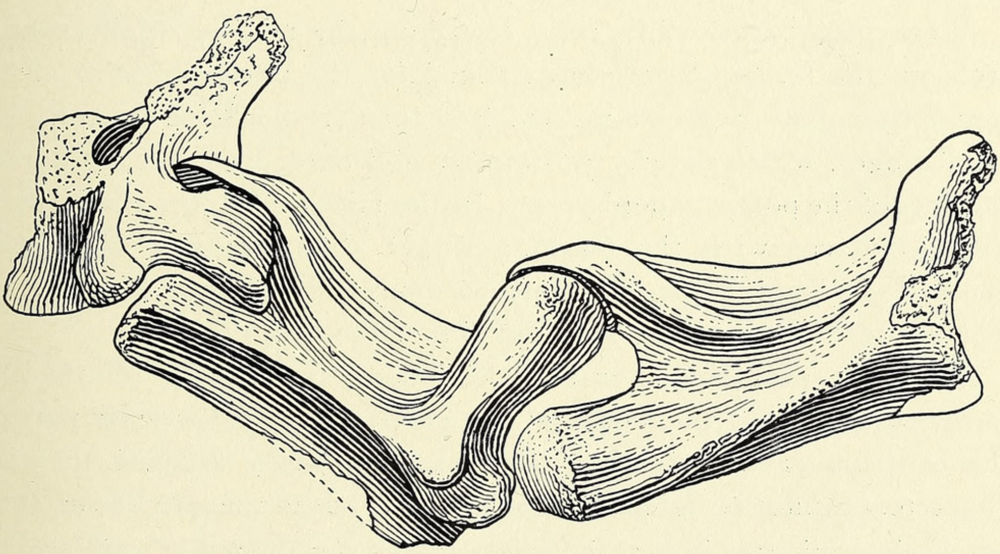

FIG. 4. Cervical Vertebræ of *Cymatholcus longus*. (C. M. Cat. Vert. Foss., No. 11,891). About 4/5 nat. size. (Shown from the right)

Judging from the nature of their zygapophysial articulations, the cervical vertebræ represent numbers four, five, and six, or numbers five, six, and seven. The centrum of the foremost vertebra is concave anteriorly and convex posteriorly; the middle vertebra has its centrum concave anteriorly. The anterior portion of the last vertebra is so closely appressed to the posterior portion of the second that it was thought better not to separate them, so the characters of those portions of their centra cannot be determined.

Each of the three vertebræ has heavy transverse processes arising from the anterior terminal portion of the centrum. These are closely associated with the pedicles forming the bases for the almost vertical prezygapophyses, which are supported along their anterior edges by a flare of bone from the anterior end of the neural arch. This arrangement forms a deep concavity, open dorsally and posteriorly, for reception of the postzygapophyses of the preceding vertebra during flexion of the neck. A strong ridge extends from the transverse process posteriorly to the antero-ventral rim of the intervertebral foramen.

The postzygapophyses extend backward almost parallel to the centrum and their articular facets are set facing laterally and only a little ventrally. A ridge extends from the lateral side of the postzygapophysis antero-ventrally over the lateral wall of the neural arch; in the anterior-most vertebra it joins the dorsal portion of the transverse process; while in the middle vertebra it fades out immediately after leaving the postzygapophysis.

A very slight, threadlike ridge lies along the midline of the neural arch, on the foremost vertebra flanked for the posterior third of its course by narrow depressions, which in turn are bordered laterally by small ridges, which diverge posteriorly and extend out on the dorsal surfaces of the postzygapophyses. In the middle vertebra the median ridge coalesces with the flanking ridges about midway along the neural arch, leaving a shallow median depression, triangular in shape, which has for its base the posterior rim of the neural arch.

A narrow, prominent ventral keel follows the midline for the anterior two-thirds of the length of the centrum. The posterior part of the centrum of the anterior vertebra is so badly crushed that its characters cannot be determined accurately, but in the middle vertebra the keel terminates in a rather deep triangular depression, which has its apex directed anteriorly.

The right prezygapophysis and a fragment of the centrum of the first thoracic vertebra have been preserved. Dimensions are given in Table IX.

The three ribs present show an advanced stage of the reduction described by Hay[9] as one of the features of the evolution of the *Testudinidæ*. The first and second ribs are strong, and fused for most of their free length, forming an admirable, arched support for the centrum of the first thoracic vertebra. The third rib, which is almost certainly typical of all the ribs save the first two and the tenth, is so reduced that the shaft is but 5 mm. wide and 2.5 mm. thick. Hay[10] mentions a specimen of *Testudo radiata* with a shell 305 mm. long, in which the rib-heads are "very slender blades 5 mm. thick horizontally and 2 mm. high." Since the specimen at hand has a carapace more than twice as large as that of Hay's *T. radiata*, reduction of the rib-heads to the same actual size would mean a proportionate reduction twice as great. Although in his monograph Hay gives no measurements for *Hadrianus* and *Stylemys*, it is safe to assume from his statements regarding these genera[11] that the reduction in *Cymatholcus* is carried much further than in *Hadrianus*, and is at least equal to that in *Stylemys*.

The sacrum is represented by a few fragments, too battered to merit description, which adhere to the left ilium.

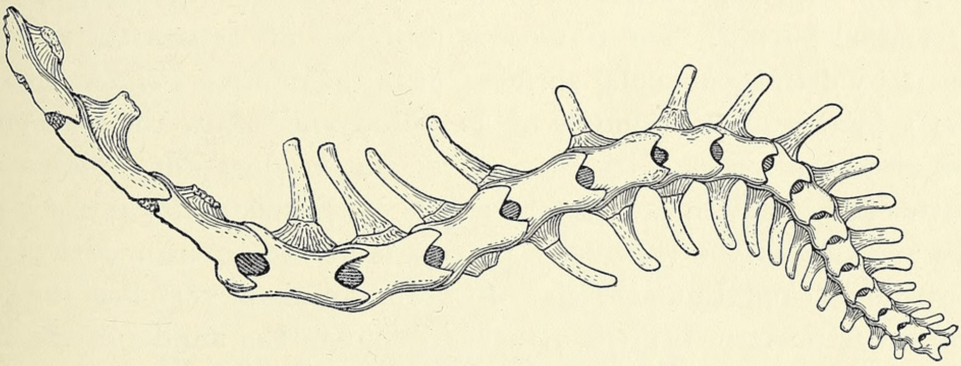

FIG. 5. Caudal vertebræ of *Cymatholcus longus*. (C. M. No. 11,891). One-half natural size.

The tail is composed of nineteen vertebræ. It was enmatrixed in death pose, with the first caudal abutting against the sacrum.

The shortness of the tail is worthy of note. The vertical height of the pelvis is 175 mm.; the length of the tail is 210 mm. From the nature of the articulations of the anterior caudals it is apparent that

[9] *Op. cit.*, p. 369.
[10] *Ibid.*, p. 369.
[11] *Ibid.*, p. 369.

the maximum downward curvature possible during life would not suffice to bring the tip of the tail ventral to the dorso-posterior border of the plastron. Moreover, as the anal portion of the posterior lobe of the plastron is contained within the flare of the carapace, rather than being ventral to it, the skin of the anal region must have stretched horizontally, so that the external tail was at most a tiny protuberance and very possibly was not present at all.

Hay's figures of the distal end of the tails of *Testudo osborniana*[12] and *T. orthopygia*[13] show the caudals expanded to support the dermal armor; the tapered caudal termination of *Cymatholcus* obviously is not constructed to furnish support. As one dermal bone was found with the shell there is no doubt that *Cymatholcus* possessed this. This is added evidence for the absence of an external tail.

Caudals numbers one, two, and three resemble one another; number two is best preserved. It has the transverse process short and heavy, ending in a tuberosity. The neural arch is high, and flat on the dorsal surface, and the inter-vertebral foramina are large.

From caudal number four to number nineteen, the vertebræ are similar, differing from the first three in having lower neural arches and long, tapering transverse processes. Number nineteen is merely a terminal button. The transverse processes are separated from the centra by definite articular surfaces, as in the modern *Testudo radiata*. Hay's figures of the caudals of *T. orthopygia*[14] show the transverse processes continuous with the centra, and he does not mention the matter in his description, so the status of this character is not clear. The position of the transverse process is at the anterior part of the centrum in caudal number six. In the more distal vertebræ the process shifts posteriorly; it is attached about in the middle of the centrum of caudal number nine. It is attached at the rear of the centrum of caudal number ten, and distal to number ten each process articulates partly with the succeeding vertebra.

PECTORAL GIRDLE

The shoulder-girdles are powerfully, but gracefully proportioned, and exhibit the two characters described by Hay[15] as typical of the

[12] *Op. cit.*, p. 427.
[13] *Ibid.*, p. 445.
[14] *Op. cit.*, pp. 445-446.
[15] *Op. cit.*, p. 370.

Testudinidæ, i.e., an expanded coracoid and a procoraco-scapular angle of more than ninety degrees. Hay has figured the shoulder-girdle for those species where it is known, but in his monograph he has made no attempt to describe it for any members of the family. From comparison with his illustrations and with the shoulder-girdle of *Hadrianus corsoni* (A. M. N. H., No. 1068), it apparently seems that the shoulder-girdle of *Cymatholcus longus* possesses no generic characters exclusively its own.

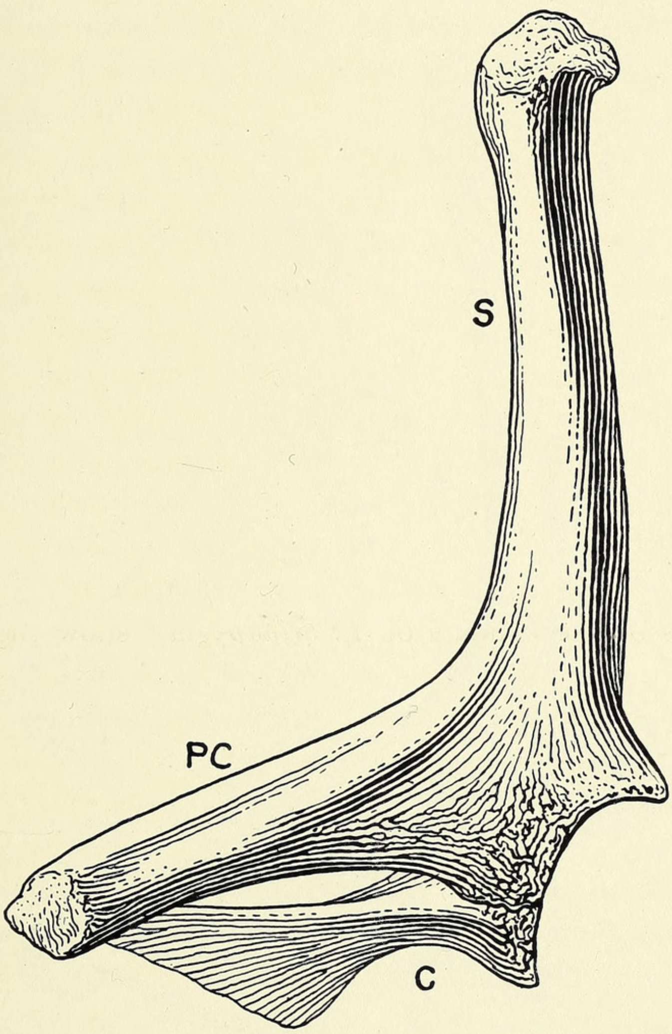

FIG. 6. Anterior view of left side of pectoral girdle of *Cymatholcus longus*. (C. M. No. 11,891). One-half natural size. S, scapula; PC, precoracoid; C, coracoid.

The lateral side of the scapula is enlarged into a supporting pillar, which flattens as it extends dorsad and is expanded at its tip into the dorsal termination of the bone. The termination is elongated ovoid in cross-section, with the long axis running anteromesially to postero-laterally. A rounded eminence arises from the anterior moiety of the termination, embraced posteriorly by a comma-shaped depression with the tail of the comma pointing mesially. There is a slight, but distinct, recurve in the lower part of the pillar, before it flares out as the dorsal rim of the glenoid cavity. For the ventral half of its course the pillar is flanked mesially by a gradually widening flange of bone, flat posteriorly and broadly concave anteriorly, which merges in a sweeping curve with the precoracoid.

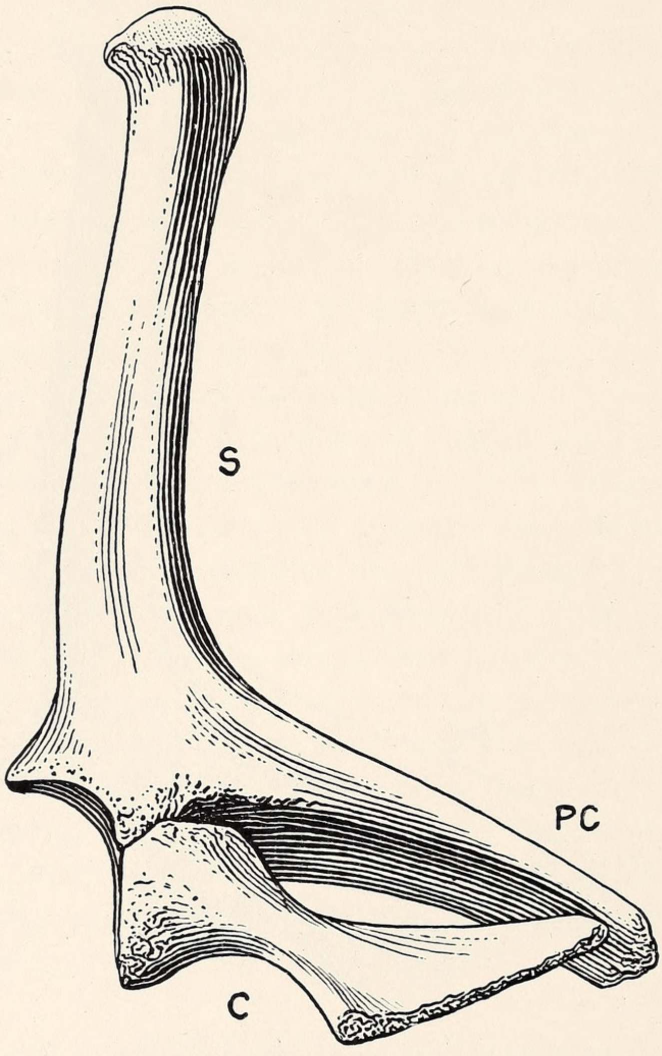

FIG. 7. Posterior view of left side of pectoral girdle of *Cymatholcus longus*. (C. M. No. 11,891). One-half natural size. S, scapula; PC, precoracoid; C, coracoid.

The precoracoid is very elongated, with a cross-section ovoid in outline for its entire free length. The bone is twisted so that the long axis of the cross-section is vertical near the glenoid cavity and almost horizontal at the median termination, the ventral edge curving out and becoming anterior and the dorsal edge swinging posteriorly as they approach the median tip. On the anterior face of the precoracoid a triangular concavity with its base meets the similar concavity descending the scapula; the two together form a broad, depressed area with apical tongues extending along the shafts of the bones. On the posterior surface of the precoracoid just mesial to the glenoid cavity, the ventro-laterally directed apex of a sharp triangular prominence forms the dorsal border of the facet for articulation with the coracoid. The precoracoid terminates medially in a simple rounded end, with a slightly expanded rim.

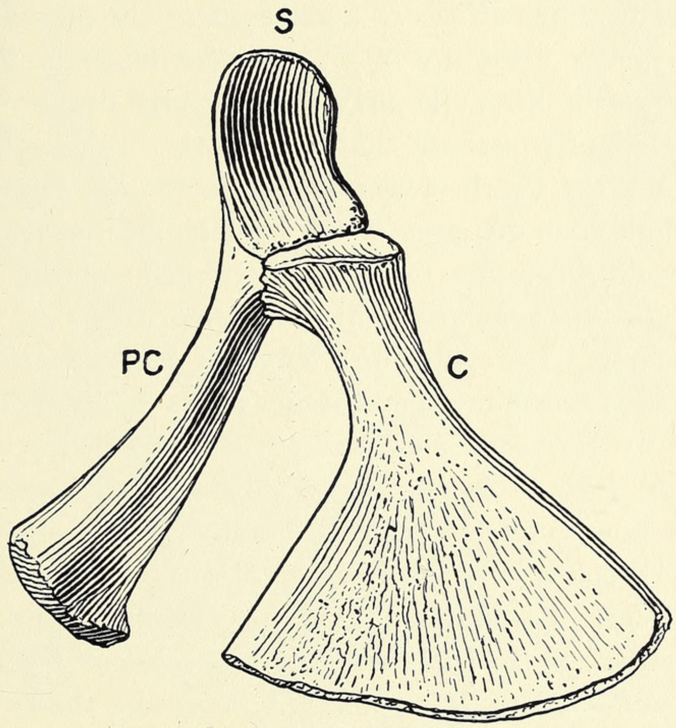

FIG. 8. Inferior view of left side of pectoral girdle of *Cymatholcus longus*. (C. M. No. 11,891). One-half natural size. S, scapula; PC, precoracoid; C, coracoid.

From a massive head forming the ventral part of the glenoid cavity, the coracoid narrows to a short neck and then flares to a wide, almost flat blade. The head is thickened dorsally by a heavy protuberance bearing a dorsolaterally directed facet for articulation with the facet of the precoracoid. The neck of the coracoid is directed away from the precoracoid at an angle of about sixty degrees, but the expansion of the coracoid blade is so great that its anterior border approaches the medial end of the precoracoid at a low angle. The blade of the coracoid is not a true plane; its anterior third is warped very slightly dorsally, and its postero-mesial angle is a little depressed.

The glenoid cavity is in outline a narrow rectangle with semicircles replacing the short sides. The scapular-precoracoid portion is almost twice as long as wide and is gently concave longitudinally and transversely. The coracoid portion is almost circular, with a broad, convex rim and a small central concavity, and is set at an angle of about one hundred twenty degrees to the scapular-precoracoid portion.

PELVIC GIRDLE

A casual inspection suffices to make evident the marked differences between the pelvic structure of *Cymatholcus longus* and that of the other *Testudinidæ*. First, the pelvis is very high dorso-ventrally, and its length is slightly greater than its width. In all the specimens figured by Hay the width, measured across the ilia at the dorsal rim of the acetabula, is much greater than the length, measured from the anterior tips of the pubes to the posterior rim of the ischia. The pelvis of *Hadrianus corsoni* (A. M. N. H. No. 1068) is 113 mm. wide and 87 mm. long. The width of a pelvis of *Testudo laticunea* (A. M. N. H. No. 1160) is 108 mm., and its length is 95 mm. The measurements given by Hay for *Testudo vago*[16] are: width, 120 mm.; length, 58 mm. For *Testudo impensa*[17] his measurements are: width, 276 mm.; length (measured by me from his illustration, *op. cit.*, p. 435), 192 mm. The pelvis of a specimen of *Stylemys* in the Carnegie Museum (Cat. Vert. Foss., No. 1515) has the following dimensions: width 131 mm.; length, 105 mm. In *Cymatholcus longus* the width is 145 mm., and the length is 150 mm. Secondly, the pubes, anterior to the ischiopubic foramina, are very broad, and their lateral borders make angles of about fifteen degrees with the midline, while in all of Hay's illustrations the angle is forty-five degrees, or greater. Finally, the pelvic elements are so thoroughly ankylosed, that it is difficult to perceive the symphyses, whereas the specimen of *Stylemys* at hand and many specimens figured by Hay have the symphyses loose and the bones somewhat separated. While the extensive ankylosis in the present specimen is unquestionably due in part to the advanced age of the individual, it is probable that the union of the pelvic elements was

[16]*Op. cit.*, p. 416.

[17]*Ibid.*, p. 435.

always closer than was the case in the other early Tertiary *Testudinidæ*.

The ilium resembles that of *Stylemys nebrascensis*. It is heavy, and has an anterior pillar, which is continuous with the ascending

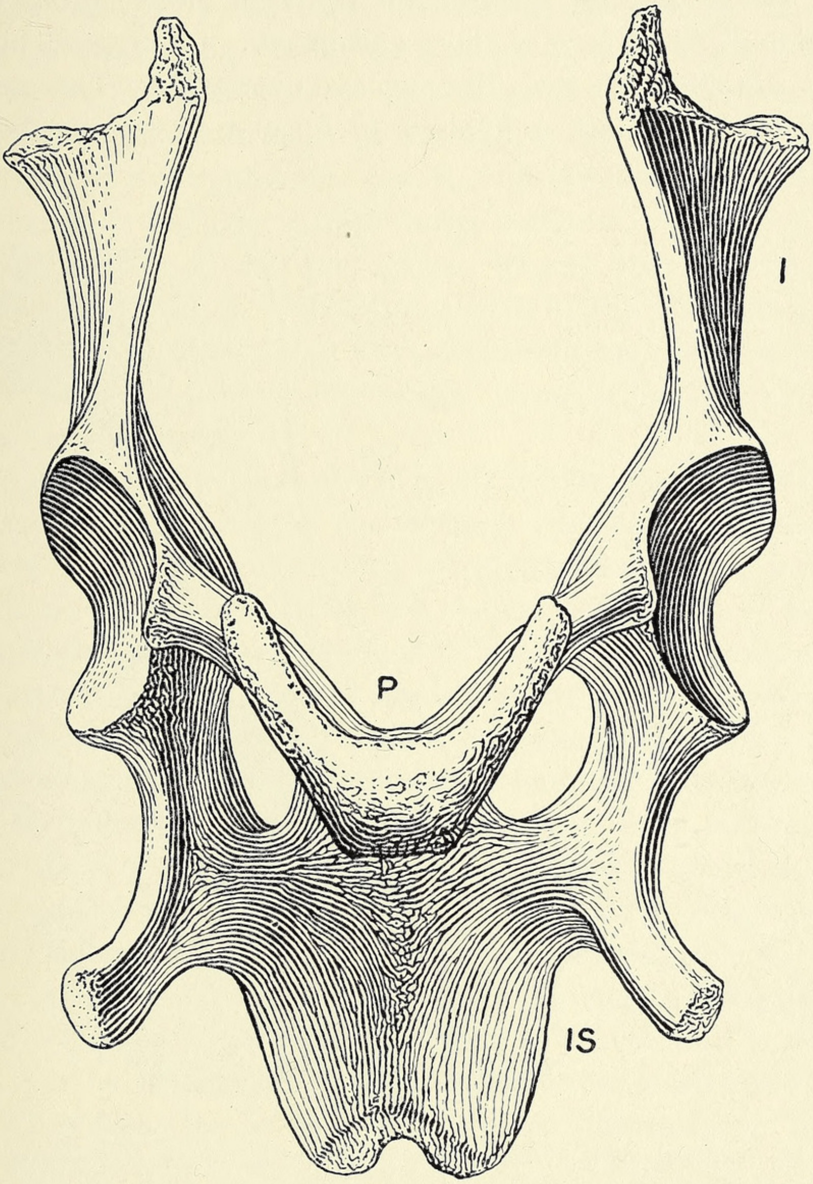

FIG. 9. Ventral view of pelvic girdle of *Cymatholcus longus*. (C. M. No. 11,891). One-half natural size. I, ilium; P, pubis; IS, ischium.

buttress of the pubis. The dorsal border has a wide posterior flare; the flare curves inward, as in *Stylemys*. The length of the ilium is less than the antero-posterior length of the pelvis, while in *Stylemys* the two are almost the same, and in *Testudo vaga* the ilium is the longer; however, this difference is due rather to the lengthening of the pelvis of *Cymatholcus* than to any iliac peculiarity.

The ischium is very massive. A short, flat bar with an acute anterior edge and a rounded posterior edge extends from the posteroventral portion of the acetabulum to the main ischiac mass. The anterior ischiac process, meeting the posterior pubic process to form the ischiopubic bar, is very short and heavy. Its cross-section is an isosceles triangle with the sides concave outwardly. The main portions of the ischia are ankylosed to form a posteromedian mass,

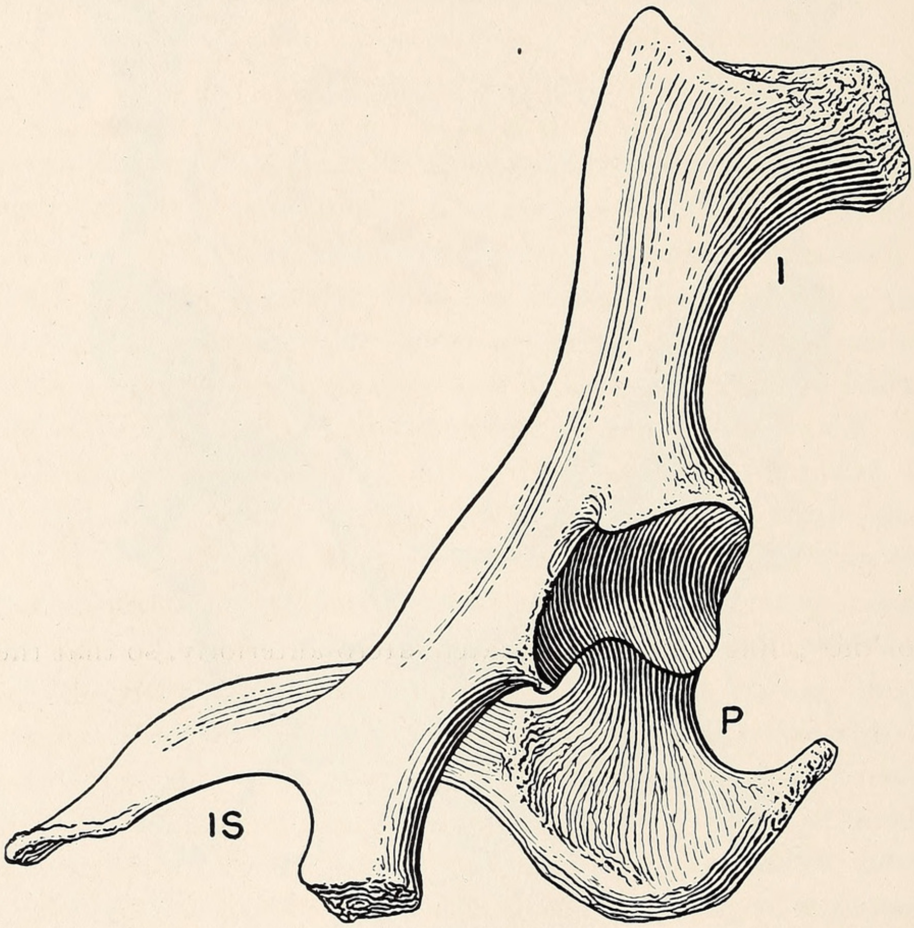

FIG. 10. Lateral view of right side of pelvic girdle of *Cymatholcus longus*. (C. M. No. 11,891). One-half natural size. I, ilium; P, pubis; IS, ischium.

deeply excavated posterodorsally, and possessing a strong, acute ventral keel along the midline. The posterior border is deeply arched downward, and lies in a plane almost parallel to the plane of the ascending pubic buttresses. The free tips of the ischia are small, conical, and acute. The ischiac symphysis is set at an angle of about one hundred and ten degrees to the line of the pubic symphysis.

Each pubis consists of four parts: a laterodorsal ascending buttress;

a lateroventral epipubis; a medio-anterior expanded blade; and a medioposterior pubo-ischiac process.

Posteriorly the ascending buttress expands into the pubic portion of the glenoid cavity; anteriorly it rises to blend with the anterior pillar of the ilium. For the ventral half of its course, the anteromedial border of the buttress is acute, extending as a ridge, which rapidly merges with the dorsal surface of the blade of the pubis. The antero-internal rim of the ischiopubic foramen curves behind this ridge and flattens against the inner surface of the buttress.

The epipubis is of medium length, having a cross-section more nearly flat than that of *Hadrianus corsoni*, and is rather long antero-dorsally. It is inclined about thirty degrees from the vertical, and is directed slightly forward. Its distal termination is very slightly expanded anteroposteriorly.

The pubo-ischiac process of the pubis is longer and slenderer than the corresponding process of the ischium. Starting near its anterior portion is a median ventral keel, increasing posteriorly, which continues on the ischiac process as the ventral ischiac keel. The ischio-pubic foramina, which are encircled by the ischia and the parts of the pubes just described, are ovoid in outline and of medium size.

The blade of the pubis is long anteroposteriorly and very thin. The median symphysis is elevated in a prominent dorsal carina. The tips of the pubic blades are situated latero-anteriorly, so that there is between them a wide and deep notch. Anteriorly there is a poorly ossified, poorly preserved extension of the blades, which seems to represent an ossified cartilage. This has been omitted from all measurements of the bones of the pelvis and its measurements have been placed in Table VIII, so that anyone, considering it a portion of the pelvis proper, may by adding its measurements to those given arrive at what he would conceive to be the correct pelvic dimensions. It seems highly unlikely that in an individual so old, in which all of the other parts are thoroughly ossified and some are ankylosed, the anterior portion of the pubes would remain partly cartilaginous. On the other hand, it is extremely probable that in such an individual several of the cartilages would be partly calcified and in the present case this offers apparently the more logical interpretation.

The acetabula are trilobate; the pubic portion of the acetabulum is demarcated by marginal notches deeper than that which separates the iliac from the ischiac. The sutures are completely obliterated.

Although the difficulties of determining evolutionary affinities of a genus from the study of one individual are evident, it appears that *Cymatholcus* possesses such decisive characteristics, that I feel justified in stating what seems to be its most probable relationship to the other genera of the *Testudinidæ*. It is to be hoped that future collections may establish beyond doubt the phylogeny of this interesting group.

RELATIONS

Hay[18] and Gilmore[19] regard *Hadrianus* and *Testudo* as being closely related, using the shape of the anterior plastral lobe as a character separating these genera from *Stylemys*. The anterior lobe of the plastron of *Cymatholcus* closely resembles that of *Stylemys* in the configuration of the lip to the general outline of the lobe. It is logical, therefore, to assume that *Hadrianus* and *Testudo* belong to one phylum[20] of the *Testudinidæ*; *Stylemys*, and *Cymatholcus* to another. Hay's genus *Achilemys* differs from both these groups in having no epiplastral lip.

It is clear, however, that *Cymatholcus* is to be regarded not as ancestral to *Stylemys*, but rather as related to the latter genus through a common ancestral stock. This idea is supported by the development of certain specializations not found in *Stylemys*. The long, narrow outline of the carapace, the digitate costoperipheral suture, the elaborately looped marginoplastral sulcus, the high degree of reduction evident in the third rib, and the long, narrow pelvis are specializations along lines, in all of which *Stylemys* is less developed.

As has been quoted previously, Hay believes that one of the tendencies of Testudinate evolution has been the lengthening of the bridge posteriorly. The axillary buttress of *Cymatholcus* rises slightly upon the first costal; the inguinal buttress does not cross the costoperipheral suture, and due to obliteration of the sutures, it cannot be determined whether the buttress rises toward costal five or costal six. However, the proportionately short bridge and very long posterior plastral lobe are made apparent by inspection and measurement.

It is possible that in this case retention of a primitive character

[18] *Op. cit.*, pp. 374-386.

[19] Gilmore, C. W., *Fossil Turtles of the Uinta Formation*, Mem. Carn. Mus., Vol. VII, No. 2, Nov. 1915, p. 154.

[20] Using the word "*phylum*" as it is employed by Prof. H. F. Osborn in his monograph on the Titanotheres. (U. S. G. S. Monograph 55).

was distinctly to the advantage of the race. The long posterior free space gives the animal room for a powerful stride, and the lung space provided in the high, arched shell suggests that *Cymatholcus* was able to move swiftly and easily. The sturdy, beautiful construction of the skeletal elements, particularly the pelvis, is in agreement with this idea. As the posterior lobe of the plastron is within the flare of the carapace, the posterior limbs must have been situated almost under the body rather than lateral to it, which also represents an adaptation for more efficient movement on land.

The Eocene and basal Oligocene ancestors of *Stylemys* are yet to be found. Forms transitional between the ancestral Stylemids and the rather highly specialized *Cymatholcus* should occur not later than the lower Eocene.

TABLE I

CARAPACE.

GENERAL PROPORTIONS.

Length	690
Width of bridge	432
Length, anterior to axillary notches	195
Width across axillary notches	290
Greatest width anterior to bridge	420
Width across inguinal notches	305
Greatest width posterior to bridge	440
Length posterior to inguinal notches	280
Height, marginal keel to top of shell (Plus about 50 mm. short due to crushing)	275
Approximate height of anterior opening	90
Width, narrowest point along marginal keel (Sulcus between marginals five and six)	404*
Length of bridge	250

TABLES

(NOTE):

1. All measurements are in millimeters.

2. Measurements with a possible error of more than five and less than ten millimeters are starred.

Measurements with a possible error of more than ten millimeters are given as approximations.

3. In the carapace, the length of an element is its proximodistal extent, and its width is circumferential. Length is measured along the anterior border.

4. In the plastron, length of all elements is measured anterodorsally; width is measured transversely.

TABLE II

CARAPACE. PLATES.

Costals.

No.	Length	Width, proximal	Width, distal
3	235*	72*	41
4	235*	84*	98

Peripherals

No.	Length	Width, proximal	Width, distal
1	95	66	
2	101	40	113
3	98	70	93 along margin, 116 extreme
4	90	88	68
5	112	82	93
6	134	91	64
7	131	55	85
8	138*		
10	110	54	93
11	105		

TABLE III

CARAPACE. SCUTES.

Vertebral Number 3

Length, antero-posteriorly lateral border	midline
142	155*
Width, transversely posterior border	medially
116*	152

Costals

No.	Length	Width, proximal	Width, distal
1	(Same as width proximal)	205	229
2	204	150	150
3	215	133	152

MARGINALS

No.	Length	Width, proximal	Width, distal
1			
2	53	66	95
3	73	64	98
4	65	88	88 along marginal keel
5	117	87	73 along marginal keel
6	154	92	70 along marginal keel
7	199	75	82 along marginal keel
8	125	37	79
9	108	54	88
10	99	50	95
11	98	56	71
12	88	74	78*
	Posterior		
12	100		

TABLE IV

PLASTRON. GENERAL PROPORTIONS.

Extreme length	656*
Length along midline	612*
Length of anterior lobe	210*
Width at base of anterior lobe	286
Length of bridge	228
Width midway along bridges	426
Length of posterior lobe	209
Width at base of posterior lobe	278
Length of lip (approximate)	80
Width of lip, posteriorly (approximate)	130
Thickness of lip, posteriorly (approximate)	50
Length of posterior notch	45
Width of posterior notch	109

TABLE V

PLASTRON. PLASTRAL BONES.

XIPHYPLASTRON

Length along midline	124
Length along lateral edge	165*
Approximate width at anterior end	120

TABLE VI

PLASTRON SCUTES.

PECTORAL

Length at midline		29
Width	to axillary notch	146
	to border of marginals	186

ABDOMINAL

Length	at midline	174
	along ventral swelling at bridge	163
Width, anterior		199

FEMORAL

Length	at midline	109
	along lateral border	158
Width, anterior		132

ANAL

Length at midline	58
Anterior border	94
Posterior border	73
Lateral border	76

TABLE VII

SHOULDER GIRDLE.

SCAPULA

Length, to rim of glenoid cavity		155
Distal expansion	antero-posterior	21
	transverse	33
Length to angle of precoracoid		125
Scapular-precoracoid angle		115*

PRECORACOID

Length to rim of glenoid cavity		76
Length to angle of scapula		90
Free termination	antero-posterior	30
	dorso-ventral	16

CORACOID

Length of external border		95
Length of anterior border		82
Length of internal border		89
Length of blade	anterior	50
	posterior	61
Length, glenoid cavity to blade		37
Thickness of neck, dorsoventrally		12
Thickness of neck, anteroposteriorly		17

GLENOID CAVITY

Length (straight line)	51
Length, scapular-precoracoid	38
Length, coracoid	24
Width, scapular	25
Width, coracoid	28

TABLE VIII

PELVIS.

GENERAL

Tip of prepubis to dorsal border of ilium (measured vertically)	175
Width across iliac rims of acetabula	145
Width between tips of epipubes	124
Width between antero-dorsal tips of ilia	134*
Extreme length of pelvis	150

ILIUM

Length to pubo-iliac symphysis	100
Length to ischio-iliac symphysis	96*
Length of dorsal border	68*
Antero-posterior thickness of neck	29
Mesio-lateral thickness of neck	11

ISCHIUM

Length along midline	Dorsal	59
	Ventral	46
Length from ischio-iliac symphysis to posteromedial termination of ischium		74
Distance between posterior tips of ischia		64
Distance from midline to posterior tips	Antero ventral	65*
	Postero dorsal	42
Free length of posterior tips		17
Transverse measurement of ischiopubic symphysis		27

PUBIS

Width just anterior to epipubes		75
Width across anterior tips of pubes		44
Length of symphysis (dorsal)		75
Distance from anterior pubo-ipipubic angle to anterior tip of pubis		51
Distance between bases of ascending pillars		39
Proximo-distal length of epipubes	Anterior	30
	Posterior	37
Antero-posterior length of epipubis at neck		22
Antero-posterior length of epipubis at distal termination		26
Mesio-lateral thickness of epipubis		11
Length of pubis along midline from ascending pillars to pubo-ischiac symphysis		28

Acetabular Cavity

Tip of iliac rim to pubo iliac symphysis	38
Tip of iliac rim to ischio iliac symphysis	24
Tip of ischiac rim to ischio iliac symphysis	14
Tip of ischiac rim to ischio pubic symphysis	19
Tip of pubic rim to pubo iliac symphysis	26
Tip of pubic rim to pubo ischiac symphysis	23
Iliac tip to pubic tip	50
Iliac tip to ischiac tip	37
Pubic tip to ischiac tip	36

Ischiopubic Foramina

Antero posterior dimensions	Right	39
	Left	41
Transverse dimensions	Right	31
	Left	27
Distance between foremost points on rims		56
Distance between hindmost points on rims		43
Distance between lateral borders		73

Ossified Cartilage

Length at midline	22
Length at pubic tips	15

TABLE IX

VERTEBRAL COLUMN.

Anterior Cervical Vertebra

Length of centrum	51
Length of neural arch along midline	34
Distance from anterior tip of prezygapophysis to posterior tip of postzygapophysis	60
Width of anterior face of centrum	17
Width of posterior face of centrum (approximate)	15
Height of posterior intervertebral foramen	7
Length (antero-posterior) of posterior intervertebral foramen	11
Width across prexygapophyses	26
Width across postzygapophyses	25

Middle Cervical Vertebra

Length of centrum	46
Length of neural arch along midline	31
Distance from anterior tip of prezygapophysis to posterior tip of postzygapophysis	49
Width of anterior face of centrum	13
Width across prezygapophyses	28
Width across postzygapophyses	24

POSTERIOR CERVICAL VERTEBRA

No significant dimensions preserved.

FIRST THORACIC VERTEBRA

Length of centrum	20*
Transverse distance between tip of prezygapophysis and anterior rim of centrum	18
Length of prezygapophysis anterior to the anterior epiphysis of the centrum	12

FIRST RIB

Free length	25
Anterior-posterior length of head	15
Dorso-ventral thickness of head (approximate)	4

SECOND RIB

Free length	34
Antero-posterior thickness of head	23
Dorso-ventral thickness of head (approximate)	6
Antero-posterior thickness of shaft 10 mm. from point of fusion with costal plate	14
Dorso-ventral thickness of shaft 10 mm. from point of fusion with costal plate	7

THIRD RIB

Free length	36
Antero-posterior thickness 10 mm. from centrum	5
Dorso-ventral thickness 10 mm. from centrum	2.5
Antero-posterior thickness 5 mm. from point of fusion with costal plate	12.5
Dorso-ventral thickness 5 mm. from point of fusion with costal plate	2.0

CAUDAL SERIES

Length	210

SECOND CAUDAL VERTEBRA

Length of centrum	17
Length of neural arch	25
Width of neural arch (approximate)	13
Height of neural arch	15
Height of centrum (posterior)	11
Length of transverse process (approximate)	11
Height of intervertebral foramen (between vertebræ 1 and 2)	10
Length of intervertebral foramen (between vertebræ 1 and 2)	10.2

SEVENTH CAUDAL VERTEBRA

Length of centrum	14
Length of neural arch	16
Width of neural arch	9
Height of neural arch (posterior)	6

Length of transverse process	17
Height of intervertebral foramen (between vertebræ 6 and 7)	2.5
Length of intervertebral foramen (between vertebræ 6 and 7)	5.0

TERMINAL CAUDAL VERTEBRA

Length	4
Width anteriorly	3.4
Width posteriorly	2.2

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