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Article VII.—INDIVIDUAL AND AGE VARIATIONS IN THE SKULLS OF RECENT CROCODILIA[1]

By Charles C. Mook

Plates X to XII

In studying a collection of Pleistocene crocodiles from Cuba, considerable difficulty in the determination of species was encountered, through the wide range in some characters of the skulls, coupled with close similarities in other characters. It was first thought that many of the differences were of specific value, but closer study has suggested that they are due rather to individual variation or age variation or, more probably, both. In order to determine the value of variations of this sort the writer has studied a large series of Recent crocodilian skulls. The material available included an extensive collection in The American Museum of Natural History; another large collection, particularly rich in the less common species, in the Museum of Comparative Zoology, made available for study by Dr. Thomas Barbour; and several skulls of South American crocodiles belonging to the collections of the Museum of the University of Michigan, loaned by Dr. A. G. Ruthven. The material consisted of the following skulls: *Crocodilus americanus*, a large series, ranging from 6.3 cm. to 73.5 cm. in length; a series of skulls of *Alligator mississippiensis* ranging from 3.7 cm. to 49.0 cm. in length; and a series of skulls of *Caiman sclerops* ranging from 12.7 cm. to 23.5 cm.; also several individuals each of *Tomistoma schlegelii* and *Crocodilus porosus*.

In this study an attempt was made to separate age variations from those which are entirely individual; this was difficult, owing to the intergradation of the two types of characters. The results may be only approximate, but they do indicate the trend of variation among different individuals of the same age and of variations depending upon the age of the individuals.

Age Characters

The age characters have been determined by comparison of series of individuals of various sizes in a number of species. Many of them are the same in all of the species studied; others are peculiar to certain species; the application of the latter sort is of course much more limited than the former.

[1]Contributions to the Osteology, Affinities, and Distribution of the Crocodilia. No. 4.

1. PROPORTIONAL RELATIONS OF LENGTH TO BREADTH.—The relative proportions of length to breadth vary considerably with age, also to a certain extent among individuals of the same age.

In a large series of individuals the measurements and ratios of breadth over length are as follows:

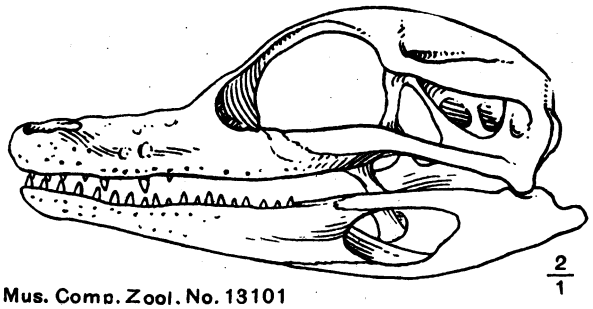


Fig. 1. Skull of a very young alligator (*Alligator mississippiensis*). Mus. Comp. Zool. No. 13101. Twice natural size. Lateral view, left side.

	Length, Supraoccipital to Snout	Breadth, Across Quadratojugals	Ratio
Crocodilus americanus			
Mus. Comp. Zool. No. 5002	6.3cm.	2.7cm.	.428
Mus. Comp. Zool. No. 5008	8.8	3.9	.443
Mus. Comp. Zool. No. 5007	11.6	5.0	.431
Amer. Mus. No. 15182	19.3	8.4	.430
Mus. Comp. Zool. No. 5032	22.0	10.2	.463
Amer. Mus. No. 15175	30.8	14.9	.483
Amer. Mus. No. 7120	37.9	19.35	.510
Amer. Mus. No. 7132	39.5	18.3	.462
Amer. Mus. No. 7121	40.3	20.0	.496
Mus. Comp. Zool. No. 5391	45.5	22.9	.503
Mus. Comp. Zool. No. 10921	49.1	29.2	.594
Mus. Comp. Zool. No. 13104	57.0	33.4	.585
Amer. Mus. No. 7139	73.5	36.8	.500
Caiman sclerops			
Mus. Comp. Zool. No. 5082	12.55	7.4	.589
Amer. Mus. No. 5239	13.35	8.2	.614
Mus. Univ. Mich. No. 53113	14.9	8.5	.570
Mus. Univ. Mich. No. 53112	17.8	10.0	.561
Mus. Comp. Zool. No. 5031	18.75	10.95	.584
Amer. Mus. No. 15184	19.6	12.4	.632
Amer. Mus. No. 15183	24.8	16.2	.653

Alligator mississippiensis

	Length, Supraoccipital to Snout	Breadth, Across Quadrato jugals	Ratio
Mus. Comp. Zool. No. 13101	3.53cm.	1.98cm.	.560
Mus. Comp. Zool. No. 13102	3.95	2.13	.539
Amer. Mus. No. 2321	5.3	2.75	.518
Amer. Mus. No. 2320	5.7	3.02	.529
Mus. Comp. Zool. No. 13103	9.65	4.80(est.)	.496
Amer. Mus. No. 12752	19.35	9.80	.506
Amer. Mus. No. 7130	32.9	18.1	.550
Amer. Mus. No. 15178	33.9	18.6(est.)	.548
Amer. Mus. No. 15181	48.8	25.0	.512

This indicates that in *Crocodilus americanus* and *Caiman sclerops* there is a marked, though irregular, broadening of the skull with age. In *Alligator mississippiensis* there is only slight change from young to old, a slight narrowing being noticeable in the older specimens.

These comments are based upon the relations of the length to the breadth across the quadrato-jugals. If the breadth were taken across the snout, at the expansion near the fourth or fifth maxillary teeth, the results would be essentially the same, though differences might be noted in particular cases.

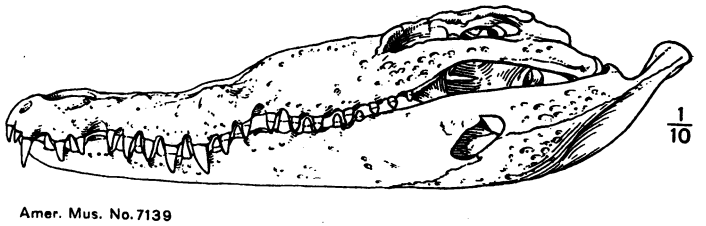


Fig. 2. Skull of an old crocodile (*Crocodilus americanus*). Amer. Mus. No. 7139. One-tenth natural size. Lateral view, left side.

2. Proportional Relations of Preorbital and Orbital-postorbital Regions.—In all young crocodilians the preorbital, or facial, regions are short compared with the postorbital, or cranial, regions; in some cases the facial regions are actually shorter than the cranial. In each of the existing species of crocodiles the preorbital region, measured from the anterior end of the orbits to the tip of the snout, in the adult, is longer than the orbital-postorbital region, measured from the anterior ends of the orbits to the median point of the posterior border of the cranial table. In the gavial and other long-snouted forms

this relation is very marked; in the alligators and short-snouted caimans and crocodiles it is much less notable. The value of any given facio-cranial ratio as an age character depends, more or less, upon the form of the adult. In any case, the adult forms have the facial region longer than the cranial.

Crocodilus americanus

	Postorbital Region	Preorbital Region	Po. R. / Pr. R.
Mus. Comp. Zool. No. 5002	3.0cm.	3.3cm.	.909
Mus. Comp. Zool. No. 5008	3.7	5.2	.711
Mus. Comp. Zool. No. 5007	4.5	7.0	.642
Amer. Mus. No. 15182	6.5	12.6	.515
Mus. Comp. Zool. No. 5032	7.2	14.8	.486
Amer. Mus. No. 15175	9.7	20.8	.466
Amer. Mus. No. 7120	11.8	26.0	.453
Amer. Mus. No. 7132	12.0	27.8	.431
Amer. Mus. No. 7121	12.2	28.1	.433
Mus. Comp. Zool. No. 5391	12.5(est.)	33.0	.378
Mus. Comp. Zool. No. 10921	16.5	33.0	.500
Mus. Comp. Zool. No. 13904	15.5	41.5(est.)	.373
Amer. Mus. No. 7139	17.0	53.0	.320

These figures (with the exception of Mus. Comp. Zool. No. 10921, which receives comment below) indicate a very marked increase in the preorbital region, compared with the orbital-postorbital region, during the growth of the American crocodile. The exception, noted above, occurs in a large specimen originally referred by Gundlach to *C. rhombifer*. Its departure from the normal condition may represent an extreme of individual variation, or perhaps a geographic variation. The range from very young to very old, in this character, is very marked, the cranial region being over nine-tenths of the length of the snout in the youngest specimen, and less than one-third in the oldest.

Caiman sclerops

	Postorbital Region	Preorbital Region	Po. R. / Pr. R.
Mus. Comp. Zool. No. 5082	5.40cm.	6.80cm.	.794
Amer. Mus. No. 5239	5.90	7.50	.786
Mus. Univ. Mich. No. 53113	6.20	8.50	.729
Mus. Univ. Mich. No. 53112	7.00	10.50	.666
Mus. Comp. Zool. No. 5031	7.60	11.15	.681
Amer. Mus. No. 15184	7.90	11.40	.692
Amer. Mus. No. 15183	9.45	15.35	.622

In this species the relative elongation of the preorbital region with age is notable, but is not extreme as in *Crocodilus americanus*. This may be partly accounted for by the larger size and greater age of the smallest and youngest specimen compared with the smallest and youngest specimen of *C. americanus*. This qualification is not of great importance, however, as the progressive elongation of the snout from medium-sized to large individuals is much less than in the American crocodile. The largest skull in this series, while much smaller than several of the *C. americanus* skulls, is not far from the maximum size of the species.

Alligator mississippiensis

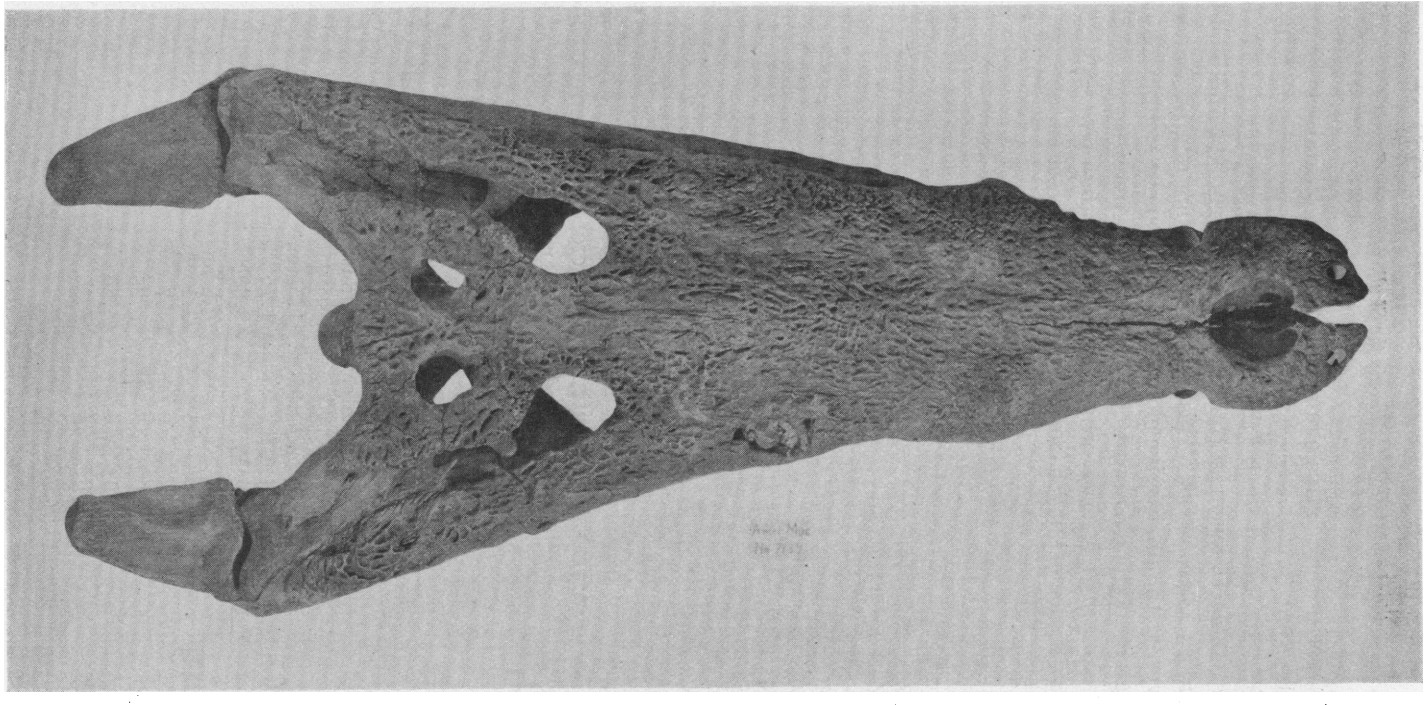
	Postorbital Region	Preorbital Region	Po. R. / Pr. R.
Mus. Comp. Zool. No. 13101	2.2cm.	1.4cm.	1.507
Mus. Comp. Zool. No. 13102	2.3	1.45	1.586
Amer. Mus. No. 2321	2.8	2.4	1.166
Amer. Mus. No. 2320	3.05	2.7	1.129
Mus. Comp. Zool. No. 13103	4.7	5.0	.940
Amer. Mus. No. 12752	8.2	11.45	.716
Amer. Mus. No. 7130	11.4	21.5	.530
Amer. Mus. No. 15178	12.0	21.7	.552
Amer. Mus. No. 15181	15.1	34.0	.444

In this species, also, there is a progressive increase in the length of the facial region, as compared with the cranial region, during growth.

3. Size of Orbits.—The orbits in young crocodiles are relatively much larger than in full-grown ones. This character is quite marked and is independent of variations in size of orbits in different species.

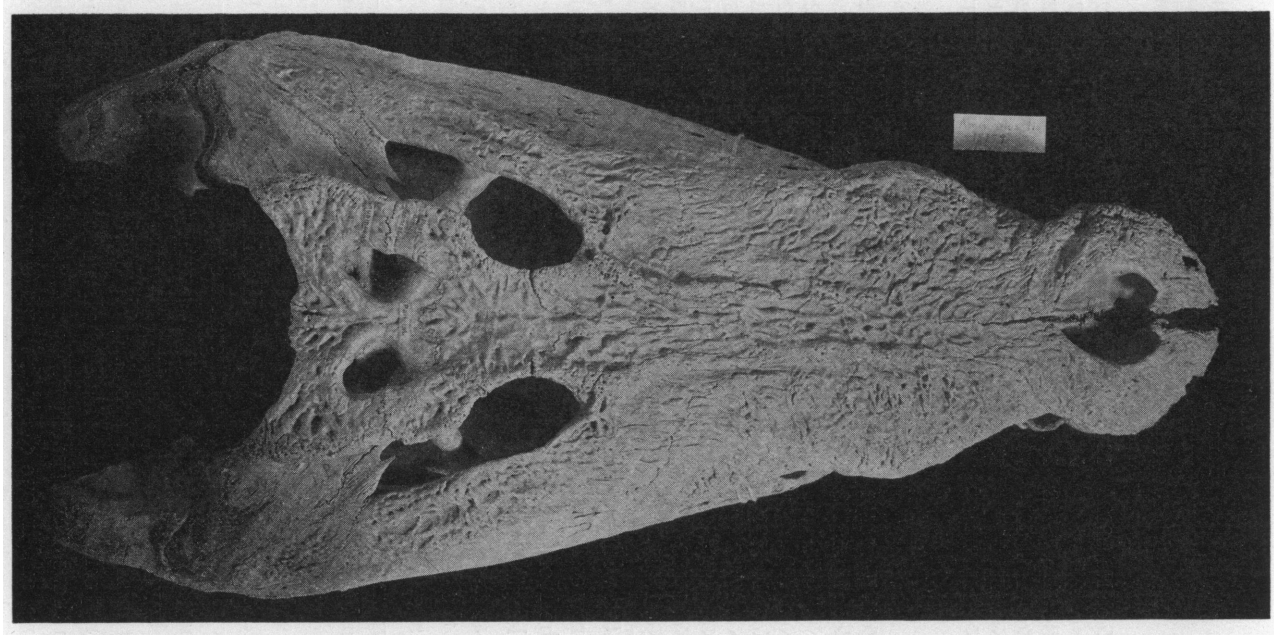
Crocodilus americanus

	Length, Supraoccipital to Snout	Breadth, Interorbital space	Length, Right Orbit	Breadth, Right Orbit	Ratio, Length Orbit / Length Skull
Mus. Comp. Zool. No. 5002	6.3cm.	.38cm.	1.55cm.	1.25cm.	.246
Mus. Comp. Zool. No. 5008	8.8	.50	1.75	1.40	.198
Mus. Comp. Zool. No. 5007	11.6	.70	2.00	1.70	.172
Amer. Mus. No. 15182	19.3	1.50	2.80	2.22	.145
Mus. Comp. Zool. No. 5032	22.0	1.90	3.10	2.50	.140
Amer. Mus. No. 15175	30.8	3.00	4.7	3.5	.152
Amer. Mus. No. 7120	37.9	3.60	5.35	4.05	.141
Amer. Mus. No. 7132	39.5	4.05	4.80	3.50	.121
Amer. Mus. No. 7121	40.3	4.10	5.10	3.85	.126
Amer. Mus. No. 7139	73.5	6.85	6.50	5.10	.088



Amer. Mus. No. 7139.

Fig. 3. Skull of an old crocodile (*Crocodilus americanus*). About one-sixth natural size. Superior view.



Amer. Mus. No. 15179. ⅛.

Fig. 4. Skull of an old crocodile (*Crocodilus porosus*). Superior view.

	Length, Supraoccipital to Snout	Breadth, Interorbital Space	Length, Right Orbit	Breadth, Right Orbit	Ratio, Length Orbit / Length of Skull
	Caiman sclerops				
Mus. Comp. Zool. No. 5082	12.55cm.	.85cm.	3.05cm.	2.35cm.	.243
Amer. Mus. No. 5239	13.35	.995	3.20	2.60	.232
Mus. Univ. Mich. No. 53113	14.90	1.00	3.30	2.70	.221
Mus. Comp. Zool. No. 5031	18.75	1.50	3.80	3.20	.202
Amer. Mus. No. 15184	19.60	1.95	3.80	3.20	.193
Amer. Mus. No. 15188	24.80	2.20	4.40	4.00	.177
	Alligator mississippiensis				
Mus. Comp. Zool. No. 13101	3.53	.25	1.05	1.00	.297
Mus. Comp. Zool. No. 13102	3.95	.30	1.20	1.10	.303
Amer. Mus. No. 2321	5.30	.35	1.55	1.30	.292
Amer. Mus. No. 2320	5.70	.40	1.70	1.35	.299
Mus. Comp. Zool. No. 13103	9.65	.70	2.50	1.80	.259
Amer. Mus. No. 12752	19.35	1.60	4.35	2.85	.224
Amer. Mus. No. 7130	32.9	2.70	6.20	4.20	.191
Amer. Mus. No. 15178	33.9	2.50	7.10	4.15	.209
Amer. Mus. No. 15181	48.8	4.55	7.80	4.70	.159

Correlated with the progressive reduction in the relative size of the orbits is a progressive increase in the relative breadth of the interorbital plate. In the North American crocodile the orbits do not change their relations of length to breadth to any considerable extent during growth. In *Caiman sclerops* the breadth of the orbits increases with age relatively faster than the length. In the alligator the orbit becomes relatively longer with age.

4. Size and Shape of the Supratemporal Fenestræ.—The supratemporal fenestræ are small and slit-like in the very young stages; in later stages they become rounder; in old ones they usually become small and nearly circular. The size of the fenestræ varies greatly among the different genera and species of crocodiles in the adult stages. In the common gavial (*Garialis indicus*) these fenestræ are very large; in most crocodiles they are small. In *Caiman trigonatus* they are absent, even in a comparatively young individual. In *Caiman sclerops* the size and shape of the fenestræ are definitely age characters and are important as such. The younger specimens have relatively large fenestræ (though they are smaller than those of the species of *Crocodilus*), the older ones have very small fenestræ, and in one old individual (Amer. Mus. No. 15183) the fenestræ are closed at the surface. The covering of the right fenestra

in this specimen is completely ossified; the left cover is ossified except for a minute area which is membranous. This indicates that decrease in size, and eventually complete obliteration, of the supratemporal fenestræ are characters associated with old age. In *Caiman trigonatus* and *C. palpebrosus* the process of closing the fenestræ appears to have been accelerated to such a degree that the condition produced has attained at least specific, perhaps even generic, value.

5. Spacing and Position of the Supratemporal Fenestræ and Relative Size of Cranial Table.—In baby alligators and crocodiles the centers of the supratemporal fenestræ are immediately posterior to the centers of the orbits; the fenestræ themselves are widely spaced apart. In older, half-grown, individuals the centers of the fenestræ are posterior to the inner portions of the orbits; in all the crocodiles except the caimans the space between the fenestræ at this stage is relatively less than in very young individuals; in all of the old individuals studied, except the caimans, the fenestræ are close together, their centers being posterior to the inner borders of the orbits. The fenestræ thus appear to migrate inward during growth. Of course, the actual method of attaining this result is failure of growth between the fenestræ while growth was being accomplished rapidly in other regions.

Correlated with this apparent inward migration of the supratemporal fenestræ is the fact that the cranial table is relatively broader in young individuals than in old ones.

Crocodilus americanus

	Breadth, Across Quadrato-jugals	Breadth of Cranial Table	Ratios, Breadth of C. T. over Breadth of Quadrato-jugals
Mus. Comp. Zool. No. 5002	2.7cm.	2.12cm.	.785
Mus. Comp. Zool. No. 5008	3.9	2.70	.692
Mus. Comp. Zool. No. 5007	5.0	3.30	.660
Amer. Mus. No. 15182	8.4	5.00	.595
Mus. Comp. Zool. No. 5032	10.2	5.80	.568
Amer. Mus. No. 15175	14.9	8.40	.563
Amer. Mus. No. 7120	19.35	11.50	.594
Amer. Mus. No. 7132	18.30	12.30	.672
Amer. Mus. No. 7121	20.0	11.55	.577
Amer. Mus. No. 7139	36.8	18.15	.493

Caiman sclerops

	Breadth, Across Quadrato-jugals	Breadth, of Cranial	Ratios Breadth of C. T. over Breadth of Quadrato-jugals
Mus. Comp. Zool. No. 5082	7.4cm.	4.35cm.	.587
Amer. Mus. No. 5239	8.2	4.61	.562
Mus. Univ. Mich. No. 53113	8.5	5.20	.611
Mus. Univ. Mich. No. 53112	10.0	5.80	.580
Amer. Mus. No. 15185	10.1	5.85	.578
Mus. Comp. Zool. No. 5031	10.95	6.05	.552
Amer. Mus. No. 15184	12.4	7.28	.587
Amer. Mus. No. 15183	16.2	8.95	.552
Alligator mississippiensis			
Mus. Comp. Zool. No. 13101	1.98	1.55	.782
Mus. Comp. Zool. No. 13102	2.13	1.65	.774
Amer. Mus. No. 2321	2.75	2.10	.763
Amer. Mus. No. 2320	3.02	2.25	.745
Mus. Comp. Zool. No. 13103	4.80(est.)	3.20	.666
Amer. Mus. No. 12752	9.80	5.62	.573
Amer. Mus. No. 7130	18.10	9.75	.538
Amer. Mus. No. 15178	18.60(est.)	9.70(est.)	.521
Amer. Mus. No. 15181	25.0	13.00	.520

In addition to the relative narrowing of the cranial table growth, a change in the shape of the table may be noted. In all of the very young specimens studied the posterior part of the cranial table is narrower than the central or anterior parts; in the older individuals the posterior portion of the cranial table is the broadest.

6. CHANGE OF SURFACE OF CRANIAL TABLE.—In all of the young specimens of *Crocodilus americanus* and *Alligator mississippiensis* studied the superior surface of the cranium is convex, and in figures of *Caiman sclerops* (none of the specimens available are young enough to show this character) the same appears to be true. In older individuals of all three species the cranial table is flat, and in one old individual of *C. americanus* (Amer. Mus. No. 7139) it is slightly concave. In two half-grown individuals of *C. porosus* (Amer. Mus. Nos. 7115 and 7131) the cranial table is slightly concave and in a very old individual (Amer. Mus. No. 15179) the table is very distinctly concave. In several species of crocodiles, both living and fossil, this condition appears to have been accelerated, comparatively young and small individuals having the cranial table concave.

7. SHAPE OF SNOUT.—In all the very young crocodilian skulls studied and in all figures of such skulls examined, the snouts are sharp-pointed and are triangular in outline. Their increase in length with age has been noted above. In all old individuals examined the snout has lost its early acute condition and become more or less rounded. The degree of this rounding depends upon the character of the snout in the various species. In some species the snout increases considerably in both length and breadth; in others the increase in length is much more rapid than the increase in breadth. In all young crocodilian skulls the superior surface of the snout is concave in antero-posterior profile. In many species the profile of the snout in the adult is convex, the change from the concave to convex condition being gradual; in other species the attaining of a convex profile appears to have been accelerated, so that a half-grown individual exhibits a marked degree of convexity; in still other species the profile remains concave throughout life.

8. NUMBER OF TEETH BENEATH THE ORBIT.—In their description of the skull of *Gavialosuchus eggenburgense* Toula and Kail quote Burmeister as follows: "Je mehr Oberkieferzähne unter der Orbita stehen, desto jünger ist ein Krokodil." This statement is justified by the conditions noted in the series of specimens studied. The conditions in regard to the number of teeth under the orbit at various stages may be summarized in the following tables.

Crocodilus americanus

	Length of Skull	Number of Teeth Beneath Orbit	
		Right	Left
Mus. Comp. Zool. No. 5002	6.3cm.	5	5
Mus. Comp. Zool. No. 5008	8.8	5	5
Mus. Comp. Zool. No. 5007	11.6	4½	4
Amer. Mus. No. 15182	19.3	4	4
Mus. Comp. Zool. No. 5032	22.0	3½	3½
Amer. Mus. No. 15175	30.8	3	3
Amer. Mus. No. 7120	37.9	2	2½
Amer. Mus. No. 7132	39.5	1	1
Amer. Mus. No. 7121	40.3	1½	2
Amer. Mus. No. 7139	73.5	1	1

	Length of Skull	Number of Teeth Beneath Orbit Right	Left
Caiman sclerops			
Mus. Comp. Zool. No. 5082	12.55cm.	4	4
Amer. Mus. No. 5239	13.35	3½	3½
Mus. Univ. Mich. No. 53113	14.9	4	4
Mus. Univ. Mich. No. 53112	17.8	inc.	4
Mus. Comp. Zool. No. 5031	18.75	4	4
Amer. Mus. No. 15184	19.6	4½	4½
Amer. Mus. No. 15183	24.8	3½	3½
Alligator mississippiensis			
Mus. Comp. Zool. No. 13102	3.95	7	7
Amer. Mus. No. 2321	5.30	5	5
Amer. Mus. No. 2320	5.70	5	5
Mus. Comp. Zool. No. 13103	9.65	4½	4½
Amer. Mus. No. 12752	19.35	3	3
Amer. Mus. No. 7130	32.9	0	0
Amer. Mus. No. 15178	33.9	½	0
Amer. Mus. No. 15181	48.8	0	0
Caiman niger			
Mus. Comp. Zool. No. 4043	34.7	4	4
Amer. Mus. No. 15171	46.0	2	3
Tomistoma schlegelii			
Mus. Comp. Zool. No. 12459	53.8	1	1
Amer. Mus. No. 15177	76.3	0	0
Crocodilus porosus			
Amer. Mus. No. 7715	30.5	2	2
Amer. Mus. No. 7131	35.8	2½	1½
Amer. Mus. No. 15179	64.2	½	½

The general rule appears to hold among all of the species studied, except perhaps *Caiman sclerops*. In that species it is noticeable only to a very slight degree. This may be due partly to the fact that the species is a very short-snouted form, but mostly to the fact that the series studied contains no very young specimens, consequently the full range of variation is not ascertainable.

9. Degree of Lateral Contraction of the Snout and Vertical Festooning of the Skull and Jaws.—In all young crocodiles the lateral borders of the snout are rather smooth, either as straight lines or as gentle curves. In older individuals the snout is usually contracted at one or more points. The degree of contraction varies greatly among the

various genera and species; for example, in the American alligator the amount of contraction is very slight, even in a very old specimen, while in old individuals of *Crocodilus porosus* the constrictions are very marked. In any particular species, however, the degree of contraction varies with age. In most crocodilian skulls there are two definite points at which these contractions may be found. One of those is immediately behind the last premaxillary teeth, where the premaxillo-maxillary sutures descend over the sides of the snout and where the fourth tooth of the lower jaw bites against the upper jaw. This constriction is very prominent in some species even at an early age, and Cuvier separated genera on the basis of this tooth biting into a notch, or constriction, outside the snout or in a pit on the under surface of the snout.

The correct evaluation of the condition of this constriction as an age character is rather difficult. In the alligators, in the caimans, and in the gavial it is never very prominent; in the true crocodiles it is very prominent in all the species at some stages but varies greatly among the species as to its condition at a particular stage. In all of the young specimens of *C. americanus* studied the notch is distinctly present, though the general outline of the snout is smooth; in older individuals of the same species the notch is equally prominent, if not more so; the same is true of the limited series of *C. porosus* skulls. In old individuals of some of the short-snouted species of *Crocodilus*, for example *C. palustris*, the notch is less prominent, the fourth mandibular teeth sometimes biting into pits as in the alligators instead of into notches. In the very young specimen which was used by Cope as the type of *Perosuchus fuscus* (Mus. Acad. Nat. Sci. Phila. No. 9720) it was noted by Fowler, who referred it to *Caiman sclerops*, as well as by Cope, that the fourth mandibular tooth on one side bit into a pit and on the other side into a notch. In the series of Pleistocene skulls from Cuba mentioned above, the younger individuals all have the notches deep with the fourth mandibular teeth biting into them, while the larger, older specimens have the constrictions less prominent and their fourth mandibular teeth bit into pits. Specimens of intermediate size show intermediate conditions, such as the fourth mandibular teeth biting partly into shallow pits and partly into notches, or on one side biting into a notch and on the other into a pit.

The difficulty of using the condition of this so-called "canine" notch as an age character is apparent. The present interpretation of this character is that in certain species which are known to be broad-snouted in old age one may expect the fourth mandibular tooth to grade from the normal crocodilian position in a notch to a position inter-

nal to the margin of the snout, biting into a pit. The presence of the pit may not mean a reduction of the constriction itself, but rather a general broadening of the snout. In some of the Pleistocene skulls from Cuba the fourth mandibular teeth bite into pits, but the constrictions are marked In general it may be said that this constriction increases with age, but care must be taken in applying this rule to fossil forms whose specific habit is not known.

A second point at which the snout is usually somewhat constricted is in the region of the sixth or seventh maxillary teeth; the exact position varies somewhat among the different species of *Crocodilus* and considerably among the different genera, depending upon the member of the maxillary dental series which is largest in size. This constriction is usually very slight or absent altogether in the youngest stages, but with age it becomes more and more marked until in very old individuals it is usually very deep; this varies somewhat among the genera and species of crocodiles, but is true as a general statement of all of them except a few long-snouted forms such as *Garialis gangeticus* and *Tomistoma schlegelii*. In the last-mentioned species the snouts are characterized by special depressions between the teeth, differing somewhat from normal crocodilians.

The vertical looping, or festooning, which is notably characteristic of the crocodilian skull in general, varies directly, in its prominence, with the age of the individual. In very young individuals it is scarcely, if at all, noticeable; in old individuals, except those of the excessively long-snouted species it is very prominent. The festooning agrees with the lateral constricting in position. The vertical concavities of the borders of the premaxillaries and maxillaries coincide with the lateral constrictions, and the vertical convexities agree with the lateral expansions.

10. Cranial Overhang.—In all of the young skulls the cranial region is large in proportion to the anterior portion of the skull on the palatal aspect of the skull as well as on the superior aspect. In these skulls the basioccipital and basisphenoid bones occupy a considerable portion of the ventral surface, the posterior borders of the pterygoids being almost under the orbits, while in older skulls the occipital region is pushed farther back, the posterior borders of the pterygoids being far back of the level of the orbits.

11. Other Characters.—The pitting and the rugose condition of the surface of many of the bones of the crocodilian skull is greatly emphasized in old individuals. In all of the young skulls examined the surface is relatively smooth; in the individuals of medium size the

pitting is deeper and the surfaces rougher; in very old individuals, particularly those of *Crocodilus porosus*, the surface of the bone is exceedingly rough. The thickness of the bone also varies considerably with age. Specific characters, such as the oblique ridges in front of the orbits of *C. porosus*, the median elevation of the snout of *C. americanus*, and the facial ridges of some of the caimans, are usually emphasized in old individuals.

Characters of Geographic Variation

A number of skulls examined possess characters which appear to be explainable best as geographic variation. A large series of skulls of the American alligator were seen to have certain areas variable in regard to the degree of pitting. Certain surfaces which in one group of skulls are smooth, in another group are distinctly pitted. There is no apparent transition from the strongly pitted to the smooth types, and the size was found to range considerably in both smooth and rough groups, so age has little to do with it. The large skull of *Crocodilus americanus* (Mus. Comp. Zool. No. 10921), which varied from others of the species in proportions as indicated in the foregoing tables, is known to have come from Cuba, while most of the skulls studied came from Florida. Another skull of the same species (Amer. Mus. No. 7121) varies somewhat in proportions from the remainder of the series. Several of the American crocodile skulls have the teeth directed sharply forward, while others have them extending vertically downward from the jaws. In the specimens of *Caiman sclerops* two individuals have the teeth of the mandible grouped in an abnormal manner, and the skulls themselves have somewhat unusual proportions. In none of these cases is there any appreciable degree of intergradation. It appears reasonable to suppose, considering that the latter species, at least, has a wide geographic range, that the variations noted may belong to different geographic varieties. In the absence of definite data as to the exact localities of a considerable number of the specimens, it is not practicable to treat this subject fully at the present time. It is mentioned to suggest a possible explanation of some of the items noted above.

Individual Characters

Among the skulls of several of the species variations were noted which certainly are not concerned with the age of the individuals and which do not appear to be definite enough to come under the head of geographic variations. Many of the irregularities of the tables of in-

crease or decrease of certain porportions with age, noted above, may be due merely to individual variation. Among these characters may be noted the following: variations in the size and direction of the teeth; unequal numbers of teeth on opposites of the same skull; variations in the contour of the snout; variations in the contour of the cranial table; variations in the form of certain sutures, particularly the premaxillo-maxillary suture on the palatal surface of the skull; the separation of the nasal bones from the narial aperture on the surface of the skull or the entrance of the nasals into this cavity at the surface; extent of piercing of the skull by mandibular teeth; the degree of excavation of the premaxillary and maxillary by the mandibular teeth and of the mandible by the teeth of the upper jaw; differences in the size of the prominences over the larger teeth; convergence or parallelism in direction of various borders, and many other characters of relatively small value and lack of uniformity or stability.

PLATE X

PLATE X

Skulls of *Crocodilus americanus*

One-sixth natural size

Superior views

From left to right

Amer. Mus. No. 7120

Amer. Mus. No. 15175

Mus. Comp. Zool. No. 5032

Amer. Mus. No. 15182

Mus. Comp. Zool. No. 5007

Mus. Comp. Zool. No. 5008

Mus. Comp. Zool. No. 5002

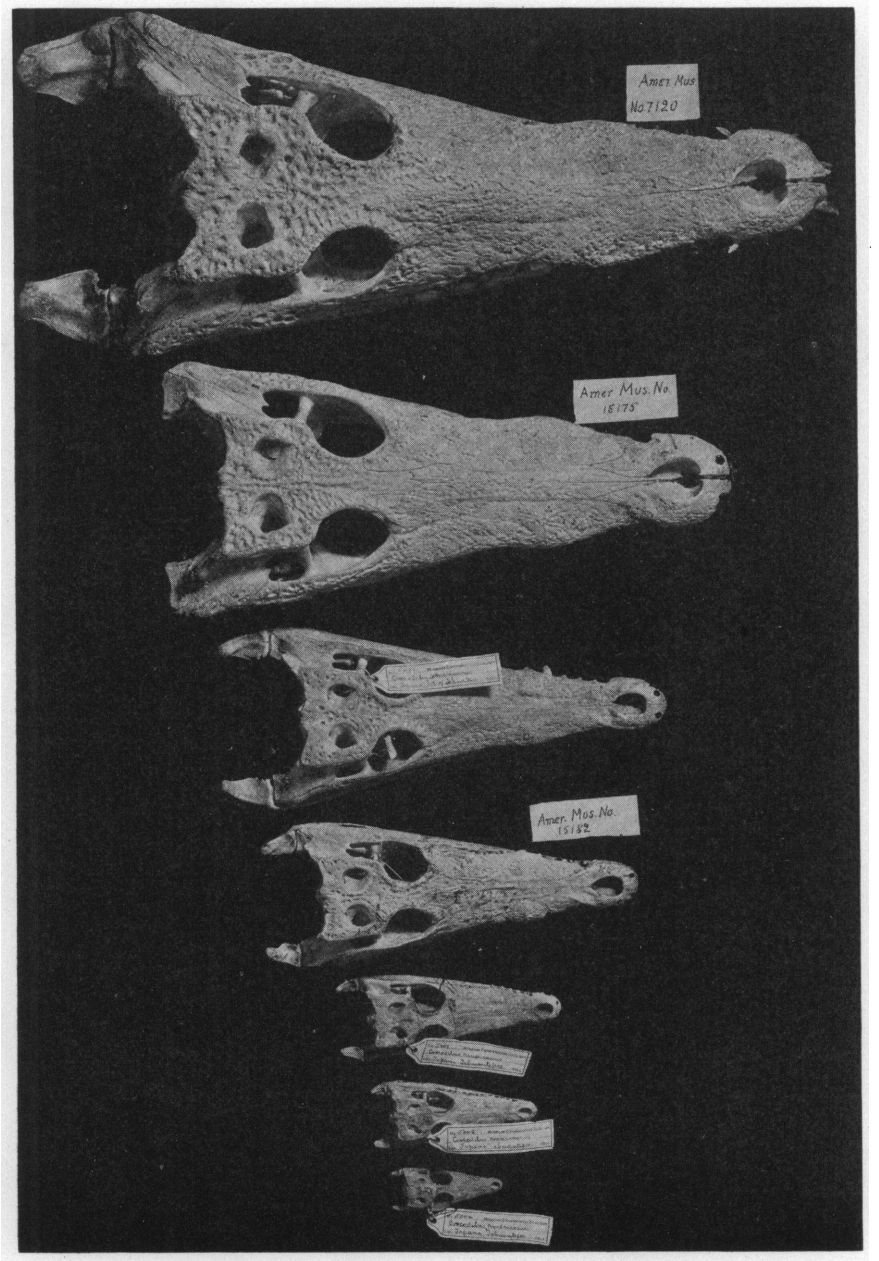

Amer. Mus
No 7120
Amer. Mus. No.
15175
Amer. Mus. No.
15152

PLATE XI

Skulls of *Caiman sclerops*
One-fifth natural size
Superior views
From left to right
Amer. Mus. No. 15183
Amer. Mus. No. 15184
Mus. Comp. Zool. No. 5031
Mus. Univ. Mich. No. 63112
Mus. Univ. Mich. No. 53113
Amer. Mus. No. 5239
Mus. Comp. Zool. No. 5082

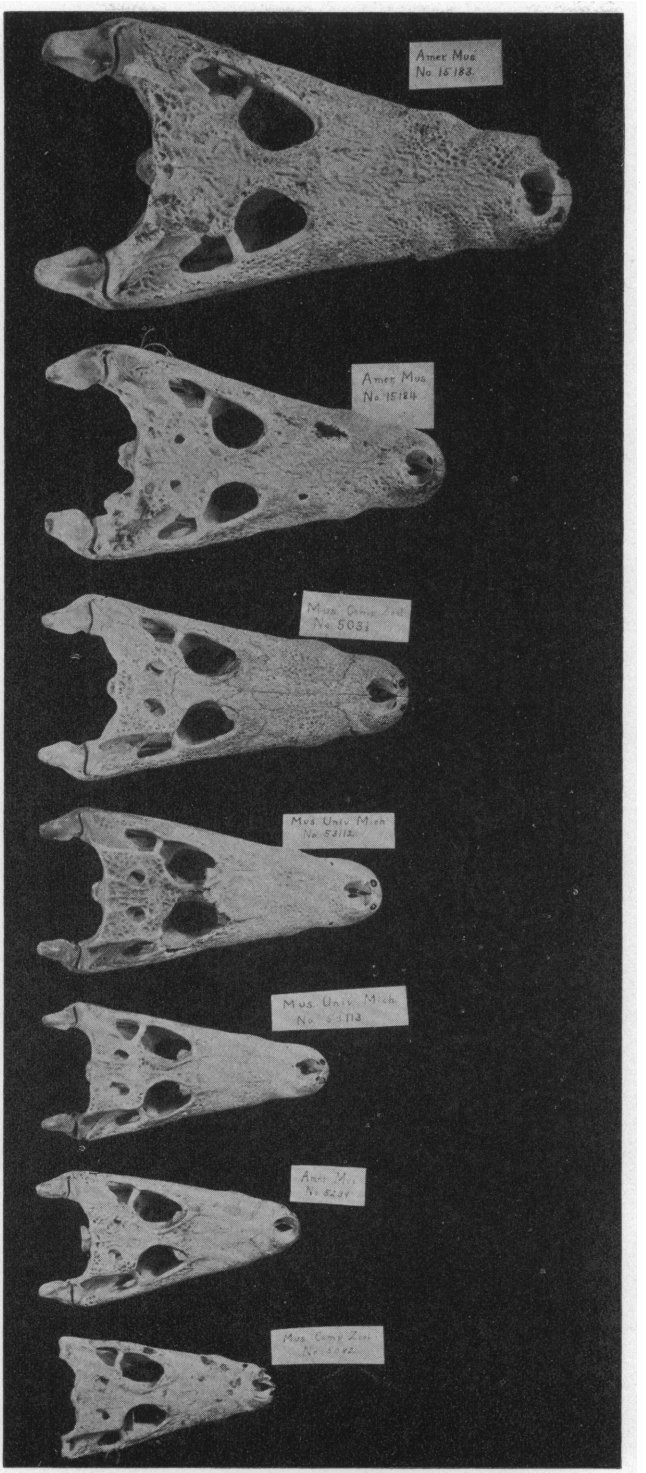

Amer. Mus.
No. 15183.
Amer. Mus.
No. 15184
Mus. Comp. Zool.
No. 5031
Mus. Univ. Mich.
No. 53112
Mus. Univ. Mich.
No. 53113
Amer. Mus.
No. 82431
Mus. Comp. Zool.
No. 5042

PLATE XII

Skulls of *Alligator mississippiensis*

One-fifth natural size

Superior views

From left to right

Amer. Mus. No. 15181

Amer. Mus. No. 15178

Amer. Mus. No. 12572

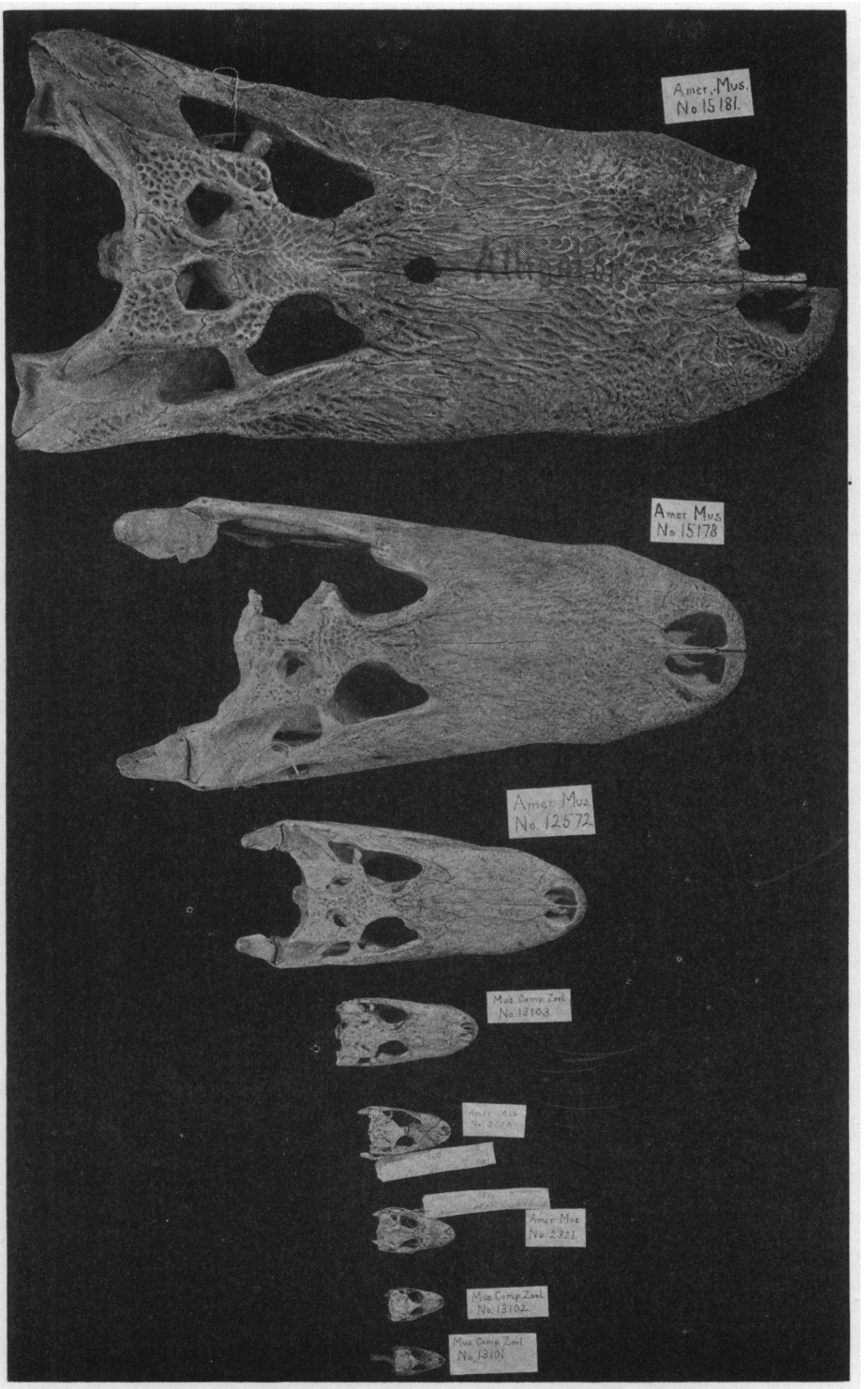
Mus. Comp. Zool. No. 13103

Amer. Mus. No. 2320

Amer. Mus. No. 2321

Mus. Comp. Zool. No. 13102

Mus. Comp. Zool. No. 13101


Amer. Mus.
No. 15181.
Amer. Mus.
No. 15178
Amer. Mus.
No. 12572
Mus. Comp. Zool.
No. 13103
Amer. Mus.
No. 2321
Mus. Comp. Zool.
No. 13102
Mus. Comp. Zool.
No. 13101