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Geographical Distribution and Osteological Variation in Fossil and Recent Specimens of Two Species of *Kinosternon* (Testudines)

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ABSTRACT – New fossil records for *Kinosternon* are reported. *K. flavescens* and *K. subrubrum* are now known from the Upper Hemphillian Saw Rock Canyon local fauna, Seward County, Kansas. *K. flavescens* is also reported from the Aftonian Sand Draw local fauna, Brown County, Nebraska, and from the Cottrell locality of the Rexroad local fauna, Meade County, Kansas.

Variation in thickness of the hyo- and hypoplastron is shown to occur in the two *Kinosternon* species. *K. flavescens* from the Sand Draw local fauna has a distinctly thicker plastron than its Recent counterpart while the Cottrell locality specimens appear intermediate in thickness. *K. subrubrum* from the Saw Rock Canyon local fauna has distinctly thinner plastral elements than its Recent counterpart. *K. flavescens* from the Sand Draw local fauna and *K. subrubrum* from the Saw Rock Canyon local fauna are both substantially north of the present distribution of these species in the Plains region.

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INTRODUCTION

Parts of fifteen associated individuals of the turtle *Kinosternon flavescens* (Agassiz) from the Sand Draw local fauna, Brown County, Nebraska differ in the thickness of the hyo- and hypoplastron from Recent specimens of the same species. Because these differences in *Kinosternon* have not been reported in the literature, this study attempts to verify and quantify these differences. In addition, previously unreported *Kinosternon subrubrum* (Lacépède) and an unreported *K. flavescens* from the Saw Rock Canyon local fauna, Seward County, Kansas, plus *K. flavescens* from the Cottrell locality of the Rexroad local fauna, Meade County, Kansas are included in the study.

METHODS

The study was limited to the variation found in the hyo- and hypoplastral plates because these are well represented in the fossil material. They are readily identifiable when disarticulated, and are easily measured. Average thickness was calculated from 9 measurements at selected points on the hyo- and hypoplastron. In some cases, associated hyo- and hypoplastral plates were not available. In such cases, the average thickness of the individual plate was calculated from 6 measurements along the edges.

Among the Recent specimens, all individuals available were used, with the exception of those in which the pleural plates had not yet completely fused with the peripherals, these being considered immature. No such check was available for the fossil specimens but the almost general absence of overlap in the thickness of the hyo- and hypoplastral plates between the fossil and Recent specimens is enough to offset the error which may be present as a result of sample bias. Length measurements for hyo- and hypoplastral plates were made at the median line suture.

FOSSIL LOCALITIES

The fossil specimens used in the study are in the collections of the University of Michigan, Museum of Paleontology. Specimens of *Kinosternon flavescens* from the Sand Draw local fauna (McGrew, 1944; Taylor, 1960) were collected by Morris F. Skinner and Thomas M. Oelrich on the Oscar Booth farm in the NE ¼, N½, SW ¼ of Section 25, T. 31 N., R. 22 W., Brown County, Nebraska. The remains of approximately 26 individuals (15 complete enough for study) were found 20 feet above the base of the draw and 13 feet below the overlying widespread gravels (Bed 3 of McGrew, 1944, p. 43). All the specimens came from the same pocket, indicating that they probably represent the same population.

The specimens from the Saw Rock Canyon local fauna (Hibbard, 1964) came from near the center of the west section line of Section 36, T. 34 S., R. 31 W., XIT Ranch, Seward County, Kansas. They were collected by Claude W. Hibbard and parties. All of the *Kinosternon subrubrum* are represented by disarticulated pieces. None of these plates appear to go together and at least 27 individuals are represented (21 hyoplastron and 6 hypoplastron). One hyoplastral plate of *K. flavescens* was recovered from this locality.

Kinosternon flavescens from the Cottrell locality of the Rexroad local fauna were collected in the NW ¼, SE ¼, Section 16, T. 35 S., R. 29 W., Meade County, Kansas. These fossils were identified by Robert Preston and are represented by numerous plastral elements, mostly fragmented, with only one hypo- and three hyoplastral plates whole, or nearly so.

COMPARISONS OF SIZE AND THICKNESS

In order to determine if the observed differences in thickness of the hyo- and hypoplastral plates between the fossil and Recent specimens were the result of changes in the absolute size of these plates, several comparisons were made. Figure 1 shows the length of the combined hyo- and hypoplastral plates for all the Recent *Kinosternon flavescens* and the seventeen fossil *K. flavescens* for which both plates were available. No associated hyo- and hypoplastral plates of *K. subrubrum* were available in the fossil collections. Since most of the *K. subrubrum* specimens were hyoplastral plates, the length of these plates was compared between the fossil and Recent forms for any changes in length (Fig. 2). The same comparison of the length of the hyoplastral plates was also made for *K. flavescens* (Fig. 3). It is evident from these graphs that no significant length changes have occurred between the fossil and Recent forms of *K. flavescens* or *K. subrubrum.*

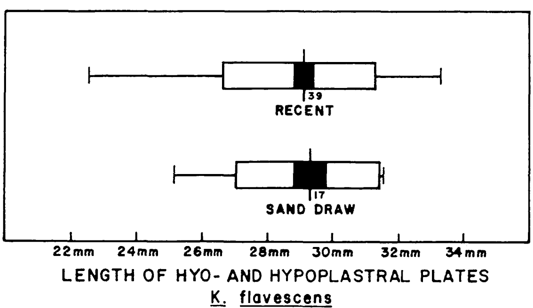

FIGURE 1. Comparison of the length of the combined hyo- and hypoplastral plates in fossil and Recent *Kinosternon flavescens.*

In addition to the above comparisons, the average thickness of the hyo- and hypoplastral plates between Recent specimens of *Kinosternon flavescens* and *K. subrubrum* were made (Fig. 4). There is considerable overlap in the average thickness of these plates between the two species.

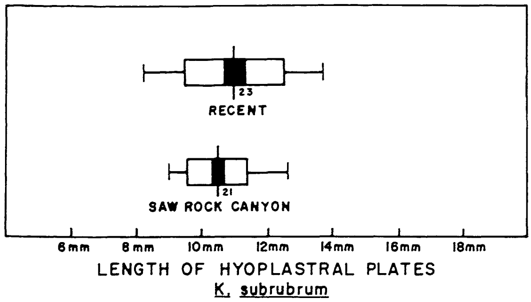

FIGURE 2. Comparison of the length of the hyoplastral plates in fossil and Recent *Kinosternon subrubrum.*

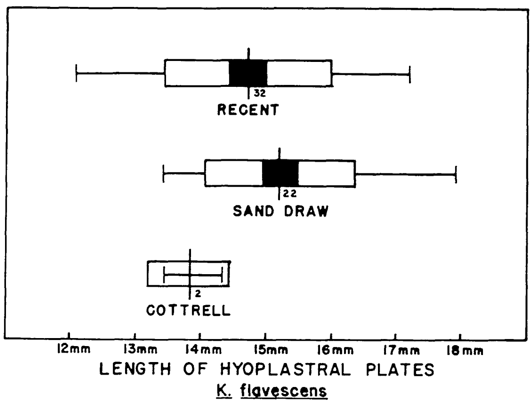

FIGURE 3. Comparison of the length of the hyoplastral plates in fossil and Recent *Kinosternon flavescens.*

This is significant in light of the differences in the average length of the hyo- and hypoplastron between Recent *K. flavescens,* 29.1 mm (22.5 mm - 33.2 mm), and Recent *K. subrubrum,* 19.2 mm (16.8 mm - 21.8 mm).

Figure 4 also compares the relative thickness of the hyo- and/or hypoplastral plates for the Saw Rock Canyon, Cottrell, Sand Draw and Recent specimens. Only specimens of *Kinosternon flavescens* are found in all four faunas. The single specimen from the Upper Hemphillian Saw Rock Canyon local fauna is thin, averaging 2.20 mm in thickness. The plates are considerably thicker, however, in the 4 Cottrell locality specimens and 15 Sand Draw specimens. (Although only four complete or nearly complete plates were available from the Cottrell locality, three other fragments had corresponding measurements which indicate they are probably within or near the plotted range of variation). Recent *K. flavescens,* although overlapping the Sand Draw, and to a greater extent the Cottrell locality specimens, in thickness, are substantially thinner. There are several ways in which to explain this variation in thickness. The variation could be geographical, or has fluctuated through time within the whole population, or it could be phylogenetic diversity.

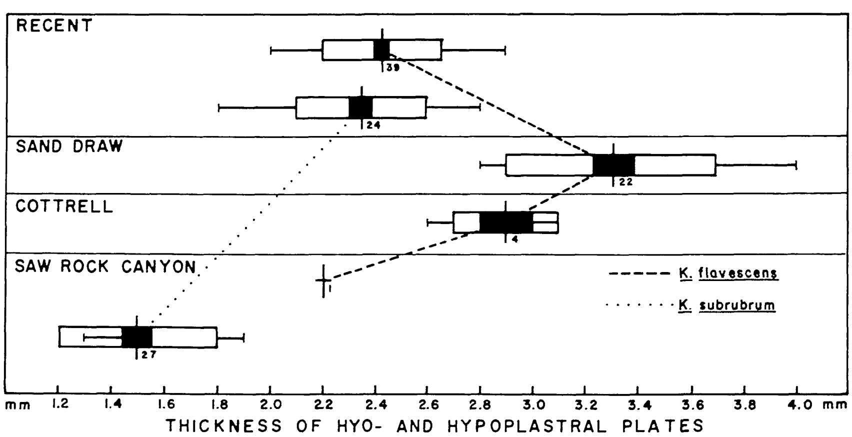

FIGURE 4. Comparison of the thickness of the hyo- and hypoplastral plates in fossil and Recent specimens of *Kinosternon flavescens* and *K. subrubrum.*

GEOGRAPHICAL VARIATION AND PLATE THICKNESS

The present distribution of *Kinosternon flavescens* (Fig. 5) is westward from a north-south line running through eastern Texas, Oklahoma, and Kansas to eastern New Mexico and southeastern

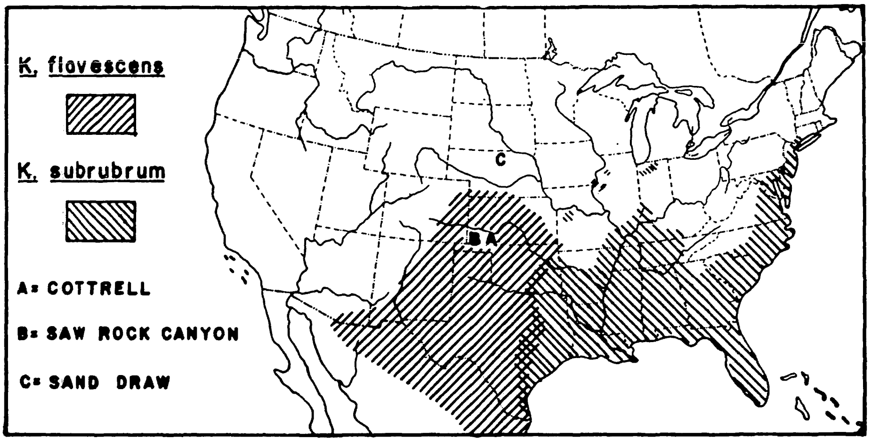

FIGURE 5. Map showing the location of the fossil local faunas discussed and the present distribution of *Kinosternon flavescens* and *K. subrubrum.*

Colorado (Conant, 1958). The northern extent of its range in south-central Nebraska, is about 150 miles south of the fossil population of *K. flavescens* from the Sand Draw local fauna, Brown County, Nebraska. The population from the Cottrell locality is well within the present range of the species.

The Recent distribution of *Kinosternon subrubrum* is eastward from a north-south line running through eastern Texas and Oklahoma throughout the southeastern United States. *K. subrubrum* extends up the Mississippi River valley into southern Indiana and Illinois and along the east coast as far north as New York. In addition, there is an isolated population in west-central Missouri and northwest Indiana (Conant, 1958). In the Plains region the northwestern extent of *K. subrubrum* is about 200 miles to the southeast of the fossil population in the Saw Rock Canyon local fauna.

Kinosternon flavescens and *K. subrubrum* are presently sympatric in only a narrow zone in east-central Texas and Oklahoma, despite the wide southern distributions of both. The known fossil record indicates that the two species were also, for the most part, not found together in the past. *K. flavescens* is described by Cahn (1929) as "preeminently a pond turtle," seldom found in streams. *K. subrubrum* can be found in almost any habitat except in large, very deep, or moving bodies of water. Carr (1952) states for *K. subrubrum,* "an optimum habitat is perhaps represented by a well established, though fluctuating, shallow-water ditch with considerable aquatic vegetation. Ponds are often mentioned as collecting sites. . ." These two species might thus be expected to be found together. Precisely what biological or other factors are presently separating them, or separated them in the past, is unknown.

To what degree the differences in distribution between the fossil and Recent populations for each species might affect the thickness of the hyo- and hypoplastral plates can, of course, not be determined because of the paucity of fossil specimens and localities. Be that as it may, among Recent specimens of the two species, from widely separated localities, no such variation is present. Furthermore, although the limited number of specimens make generalizations difficult, the Cottrell pasture *K. flavescens* average substantially thicker. If they are truly thicker, their presence well within the geographical range of the Recent specimens does not substantiate geographical variation as a cause. Thus, it seems doubtful that the plate thickness variation was due solely to geographical variation.

THICKNESS VARIATION THROUGH TIME

When considering the variation in plate thickness of *Kinosternon flavescens* through time it is evident from Figure 4 that there is a marked difference between the Aftonian interglacial Sand Draw specimens and the Recent specimens. The single specimen from the preglacial Saw Rock Canyon local fauna provides tantilizing temptations for speculation but not enough information for drawing sound conclusions. It is possible that this specimen represents an immature individual, although the length of this hyoplastral plate, 15.7 mm, is well within the range of Recent adult specimens. Assuming the specimen is adult, it tells nothing about the variation present in the population existing at that time. If, however, the Sand Draw and Recent populations are considered as norms for the amount of variation which exists in the population at any one time, then it is possible to safely assume that the Saw Rock Canyon local fauna specimens were smaller than the Sand Draw local fauna specimens.

The specimens from the Cottrell locality appear to be intermediate in plate thickness between the Saw Rock Canyon and Sand Draw specimens. Hibbard (personal communication) considers the Cottrell locality fauna as intermediate in age between the Fox Canyon and Rexroad faunas and thus preglacial. By the beginning of the Pleistocene, then, the plates of *Kinosternon flavescens* were thicker than those of the earlier Saw Rock Canyon local fauna. At the time of the Aftonian Sand Draw local fauna the hyo- and hypoplastral plates were at their greatest known thickness; these plates then became thinner from the time of the Sand Draw local fauna to the Recent populations.

Kinosternon subrubrum from the Saw Rock Canyon local fauna is distinctly thinner than its Recent counterpart. No other specimens of this species were available from the fossil populations of Pleistocene age and no clues to the pattern of variation are available between late Pliocene time and the Recent.

It is difficult to discern a causative agent for the variation in thickness through time. When discussing biological changes during the Pleistocene, climatic deterioration first comes to mind as a cause. The apparent thickening of *Kinosternon flavescens* from the Saw Rock Canyon specimens to the Cottrell specimens could possibly be interpreted as being caused by the onset of the Pleistocene, but the age of the Cottrell fauna makes this unlikely. Also, climatic causes do not explain why the Aftonian interglacial Sand Draw specimens are thicker than the Recent specimens which are also interglacial, or postglacial as the case may be. It would appear that climatic factors alone were not critical in the fluctuations in thickness of the hyo- and hypoplastron.

PHYLOGENETIC DIVERSITY AND PLATE THICKNESS

A third possibility responsible for the observed variation in plate thickness is that the faunas represent different branches of the *Kinosternon* line, one tending toward a thicker plastron, the other not. Auffenberg (1962, 1963) reported among fossil testudinine turtles of the genus *Geochelone* similar variations in shell thickness. Quoting from the 1962 paper, p. 632:

> The earlier Pleistocene members of this (*Geochelone turgida*) series were already divided into two populations. Both are found in deposits of the western United States. One is represented by *johnstoni*, which retains the sculpturing of the Pliocene members, but is larger, and the other by an undescribed species of similar size, but with a thinner, smoother shell. It occures in the Gilliland fauna.

Much of the change reported by Auffenberg, however, was related to changes in size through time while no significant size changes were detected in *Kinosternon.* Nonetheless, it is possible that the *Kinosternon flavescens* in the Cottrell and Sand Draw faunas represent one phylogenetic line with thicker shells and those from the Recent and Saw Rock Canyon another line with thinner shells. Similarly, the Saw Rock Canyon *K. subrubrum* and recent *K. subrubrum* could be closely related but different phylogenetic lines. Because of the paucity of *Kinosternon* specimens and localities it is not possible to draw definitive conclusions and in actuality a number of factors may be operating to cause the variation.

CONCLUSIONS

Both *Kinosternon flavescens* and *K. subrubrum* show marked variation in the thickness of their hyo- and hypoplastral plates from the Upper Pliocene to the Recent. The distribution of these species has also changed since the Upper Pliocene, both being found farther to the south in the Plains region than in the past. The possible causes for this variation are discussed but the present data do not show the recognition of any single cause. Nonetheless, the demonstrated variation present in the two *Kinosternon* species calls for the investigation of other fossil and Recent turtles to see if similar variation is present and if there is an overall pattern.

ACKNOWLEDGMENTS

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SPECIMENS EXAMINED

Kinosternon flavescens, Sand Draw local fauna, University of Michigan, Museum of Paleontology (UMMP): V56418, V56781, V56784-86, V56790-1, V65794-96, V56798-800, V57576-77.

Kinosternon flavescens, Cottrell locality of the Rexroad local fauna, UMMP: V57575 (Numerous plastral elements).

Kinosternon flavescens, Saw Rock Canyon local fauna, UMMP: V33792.

Kinosternon flavescens, Recent, University of Michigan, Museum of Zoology: 10712-14, 10716-10724, 10726-10734, S2942-S2947, Meade County, Kansas.

Kinosternon flavescens, Recent, U. S. National Museum: 19058, Mexico; 95383-85, Brewster Co., Texas; 95396-97, Val Verde County, Texas; 100561-63, Hill County, Texas; 100553, 100555-56, Hill County, Texas.

Kinosternon subrubrum, Saw Rock Canyon local fauna, UMMP: V33792, (numerous hyo- and hypoplastral elements).

Kinosternon subrubrum, Recent, University of Michigan, Museum of Zoology: S-791, Georgia; S-304, New York; S-823-25, Georgia, Florida, Alabama; S-901, Georgia.

Kinosternon subrubrum, Recent, Carnegie Museum: 34501, 34410, 35997, 37275, 37295, 38661, West Virginia.

STATISTICAL PARAMETERS

	OR	$\bar{X}$	σ	$S_{\bar{X}}$	N
Kinosternon flavescens					
RECENT					
Hyo-	12.1 - 17.2	14.77	1.35	.23	32
Hyo- & Hypo-	22.5 - 33.2	29.06	2.30	.37	39
Thickness	2.0 - 2.9	2.42	.24	.04	39
Sand Draw					
Hyo-	13.4 - 17.9	15.18	1.18	.25	22
Hyo- & Hypo-	25.1 - 31.5	29.25	2.18	.53	17
Thickness	2.8 - 4.0	3.31	.40	.08	22
Cottrell					
Hyo-	13.4 - 14.3	13.85	.64	.45	2
Hyo- & Hypo-	—	—	—	—	—
Thickness	2.6 - 3.1	2.90	.22	.11	4
Saw Rock Canyon					
Hyo-	—	15.70	—	—	1
Hyo- & Hypo-	—	—	—	—	—
Thickness	—	2.20	—	—	1
Kinosternon subrubrum					
RECENT					
Hyo-	8.2 - 13.7	11.00	1.55	.32	23
Hyo- & Hypo-	16.8 - 21.8	19.19	1.55	.32	23
Thickness	1.8 - 2.8	2.34	.29	.05	24
Saw Rock Canyon					
Hyo-	9.0 - 12.6	10.43	.96	.21	21
Hyo- & Hypo-	—	—	—	—	—
Thickness	1.3 - 2.0	1.56	.19	.04	27

OR = observed range; $\bar{X}$ = mean; σ = standard deviation; $S_{\bar{X}}$ = standard error of mean; N = number of specimens

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