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FOSSIL HERPETOFAUNA OF THE LISCO C QUARRIES (PLIOCENE: EARLY BLANCAN) OF NEBRASKA*

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*Earlier workers in Nebraska regarded these deposits as situated in the Lisco Member, Broadwater Formation (Aftonian-Kansas, Early Pleistocene) in NW-SE valleys—Editors.

The Pliocene (Early Blancan, 3.8 Ma) herpetofauna of the Lisco C Quarry of Garden County, Nebraska, consists of at least two anurans, two testudines, four saurians, and ten snakes. Only one of these, *Sceloporus* cf. *S. robustus* Twente, is extinct. An eastern extralimital form, *Elaphe vulpina* (Baird and Girard) and possibly another, *Storeria* sp., occur in the Lisco C fauna. It is suggested that the Lisco C herpetofauna may indicate a cooler, moister paleoclimate than the later Blancan Sand Draw (3.5 Ma), Big Springs (2.5 Ma), and Hornets' Nest (2.0 Ma) herpetofaunas of Nebraska. The Lisco C herpetofauna could have lived in a habitat consisting of a small oxbow-pond surrounded by a marshy area giving way to a terrestrial situation.

† † †

INTRODUCTION

Fossil amphibians and reptiles are excellent indicators of paleoecological conditions (Rogers, 1984) and thus greatly supplement studies based mainly on analyses of mammalian assemblages. Vertebrate fossils have been collected from the Early Blancan Lisco C Quarries since 1939, but the herpetofauna from this important locality has never been published. The present paper details the Lisco C herpetofauna and provides comments about the paleoenvironment of the area.

Location and Geology

The fossils of this paper were collected from two adjacent sites, Quarry 2 and Diatomite Cliff, which together with several other fossiliferous sites are called "Lisco C" by the University of Nebraska State Museum (UNSM). These sites are located in western Garden County, Nebraska, in Section 21, T 18 N, R 45 W, where erosion has exposed the Broadwater Formation on the Conrad and Lila Wallace Farm (Fig. 1). The Broadwater deposits, composed largely of sands and gravels, are considered fluvial in origin. Some workers interpret these deposits as evidence for a major northeast-trending paleodrainage across Nebraska (Fig. 2) during the Pliocene. Locally, the Broadwater Formation contains isolated lenses of fine-grained sediments. The Lisco localities are developed within one of these fine-grained lenses, which is thought to represent oxbow-lake deposition. The horizontally-laminated Quarry 2 sediments are diatomaceous with a strong component of sand and silt and are considered shoreline deposits. The Diatomite Cliff Site is composed of pure diatomite, suggesting a more distant clastic source than Quarry 2, and probably represents deposits of a more central position in a relatively quiet, shallow lake.

Previous and Current Work

The Lisco C Site was discovered in 1938, and large scale excavations followed from 1939 to 1941 by field parties from the University of Nebraska State Museum. Remains of large mammals, especially the large camelid *Gigantocamelus*, were the most common fossils collected during this work. Except for fragmentary turtle remains, no herpetological fossils were recorded during early work at the Lisco

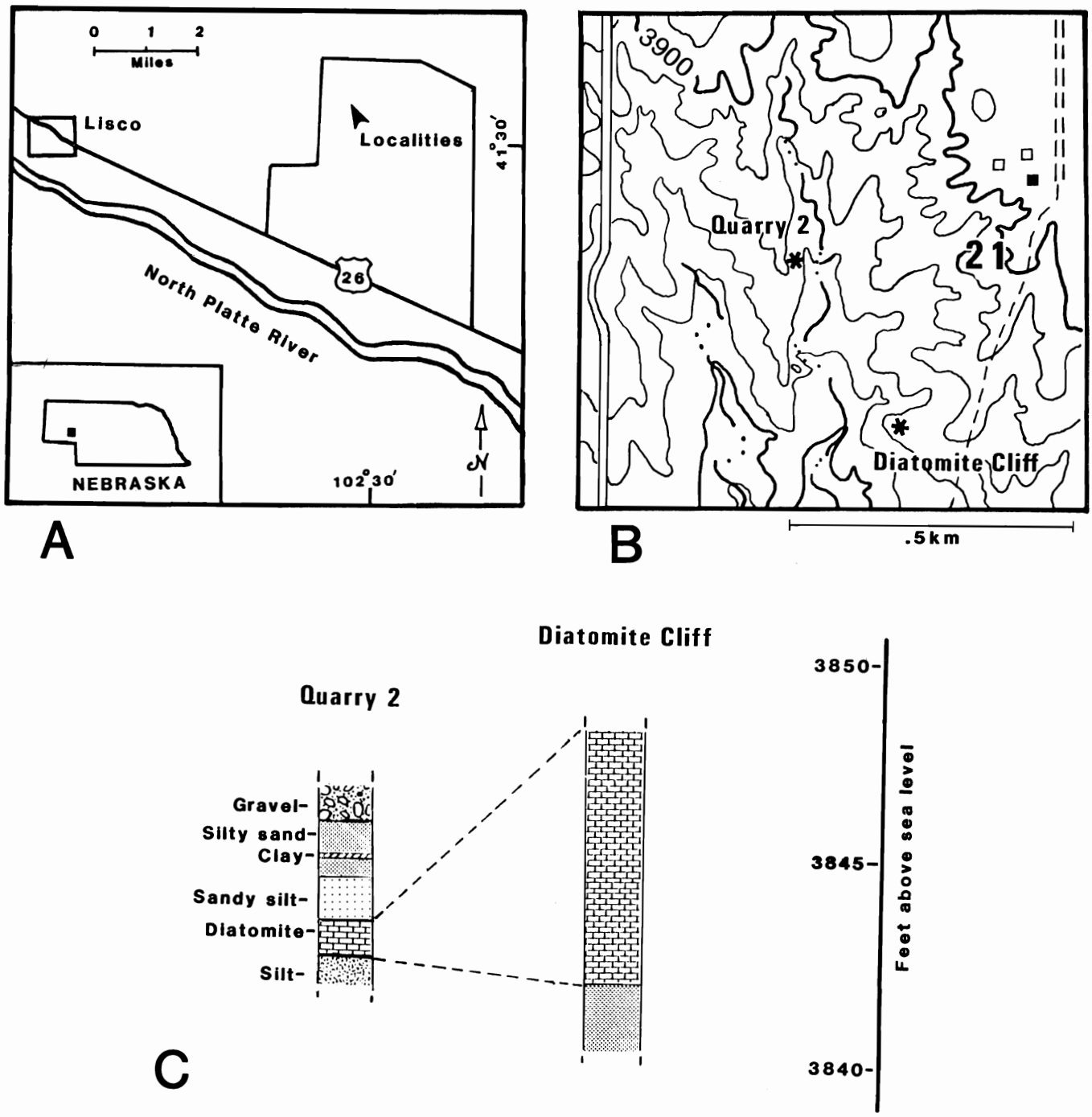

Figure 1. A, location of Lisco C quarries in western Garden County, Nebraska. B, topographic map of Quarry 2 and Diatomite Cliff area in Section 21, T 18 N, R 45 W, 20 foot contour interval. C, stratigraphic sections of Quarry 2 and Diatomite Cliff sites.

sites. A 15 X 30 m extension of the original Quarry 2 Site was excavated in 1986 for the purpose of a taphonomic study by the junior author. The new excavation revealed an unsuspected abundance of microvertebrate fossils. Some apparently associated and/or articulated individuals were found during the new excavation and these were collected individually in plaster jackets (e.g. *Thamnophis radix*). But most small specimens were recovered by screen washing. The location of each washed matrix sample was mapped on a 3 X 3 m grid system covering the entire quarry. In this way, several possible associated individuals were recognized. Approximately 12 tons of diatomaceous silty sediment from a 70 cm thick section of Quarry 2 was wet-screened by UNSM and by the United States National Museum (USNM) field crews. An additional 50 kg of matrix was processed from the Diatomite Cliff Site.

Other Nebraska Blancan Herpetofaunas

Three other Blancan herpetofaunas from Nebraska also occur along the Pliocene drainage system (Fig. 2). They are the Sand Draw fauna (Holman, 1972) and the Big Springs and Hornets' Nest faunas (Rogers, 1984). Comparison of these faunas with the present one are included here.

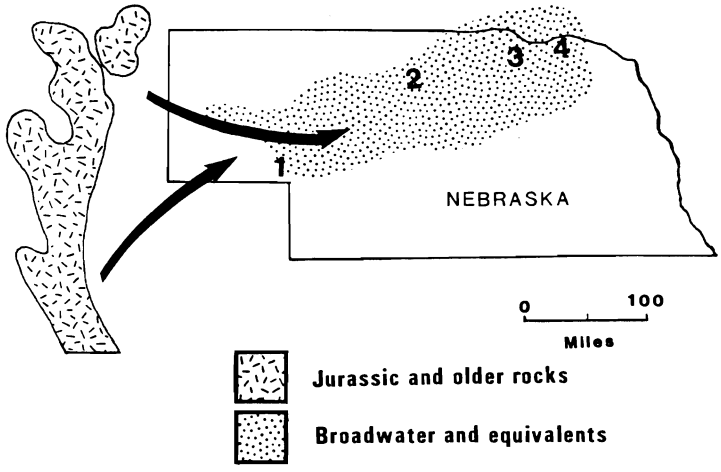

Figure 2. Location and geologic context of Blancan herpetofaunas in Nebraska. Map of Blancan-age sediments adapted from Swinehart et al. (1985). 1, Lisco C; 2, Sand Draw; 3, Big Springs; 4, Hornets' Nest.

SYSTEMATIC PALEONTOLOGY

Class Amphibia Linnaeus, 1758
Order Anura Rafinesque, 1815

An important paper (Böhme, 1977) that was relatively unavailable to western workers until recently, has dealt in a detailed way with the identification of European anuran species on the basis of isolated skeletal elements. Böhme has applied a standard terminology (Fig. 3) to features on the ilium, the element we believe is the single best element upon which to base anuran species or species group identifications when only individual fossil bones are available.

In large part, the structure of the ilium relates to the mode of locomotion of the animals. Burrowing anurans, climbing anurans, walking anurans, short-hopping anurans, dashing anurans, and leaping forms all have differences in ilial structures, especially in the posterior part of the bone where important ligaments and tendons attach.

Other elements beside the ilium that Böhme (1977) found useful in the identification of anuran species and species groups were the frontoparietal, the sphenethmoid, and the sacrum. These elements may have somewhat limited use in the study of North American anurans, but a full discussion of this is beyond the scope of the present paper. We have been able to utilize the scapula (see Hallock et al., 1990) to distinguish *Bufo* from *Rana*.

Family Bufonidae Gray, 1825
Genus ***Bufo*** Laurenti, 1768

The scapula of *Bufo* may be separated from that of *Rana* on the basis that it lacks the strong medial ridge that is present on the coracoidal side of the bone in the latter genus (Hallock et al., 1990).

Bufo sp. indet.

MATERIAL—Right scapula USNM 75408 from Diatomite Cliff Site.

REMARKS—We are unable to identify this small, fragmentary scapula to the specific level. At present, two species of *Bufo* occur in Garden County, Nebraska: *B. cognatus* (Lynch, 1985: *35, fig. 5*) and *B. woodhousii* (Lynch, 1985: *36, fig. 6*). Rogers (1984) has reported *B. cognatus* from the Blancan Big Springs and Hornets' Nest localities in Nebraska. She has also reported the extinct forms *B. repentinus*, *B. rexroadensis*, and *B.* cf. *B. spongifrons* from the Big Springs locality and B. *repentinus* from the Hornets' Nest locality.

Family Ranidae Gray, 1825
Genus ***Rana*** Linnaeus, 1758

The ilium of the genus *Rana* has a raised bladelike structue, the vexillum, and normally has a smoothly flattened, ovaloid tuber superior (Fig. 3) that allows the genus to be separated from other anuran genera of the Holarctic Region. Some genera of the Leptodactylidae have a vexil-

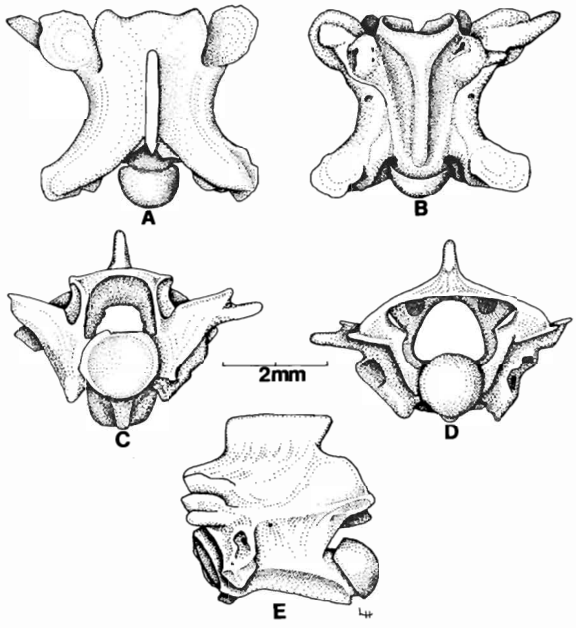

Figure 5. Trunk vertebra of subadult *Elaphe vulpina* UNSM 75406 from Quarry 2. A, dorsal; B, ventral; C, anterior; D, posterior; E, lateral. The scale line applies to all figures.

Genus *Heterodon* Latreille in Sonnini and Latreille, 1801

Heterodon sp. indet.

MATERIAL—Two vertebrae UNSM 75404 from Quarry 2 and one vertebra UNSM from the Diatomite Cliff Site. One vertebra USNM 442307 from Quarry 2.

REMARKS—The vertebrae are identified as *Heterodon* based on their short vertebral form; depressed neural arches; moderately high and thin neural spine; and wide, flat hemal keel. The specimens are too fragmentary to identify to the specific level. Two species of *Heterodon* occur in Nebraska today: *H. platyrhinos* which has not been recorded from Garden County (Lynch, 1985: *49, fig. 43*) and *H. nasicus*, which occurs there (Lynch, 1985: *48, fig. 42*). *Heterodon nasicus* was reported from the Blancan Big Springs Fauna of Nebraska by Rogers (1984).

Genus *Lampropeltis* Fitzinger

Lampropeltis triangulum (Lacepede, 1788)

MATERIAL—Nine vertebrae UNSM 75405 from Quarry 2.

REMARKS—The vertebrae of *L. triangulum* are very distinctive in having a relatively short, wide vertebral form, a low but not obsolete neural spine, a depressed neural arch; and a moderately distinct haemal keel. Williams (1988) includes a color photograph of *L. triangulum* from Ash Hollow, Garden County, Nebraska. I can find no other locality records for this species from Garden County, although this snake occurs in adjacent Arthur County (Lynch, 1985: *50, fig. 46*). This species is mainly found along major stream courses in a variety of situations. *Lampropeltis triangulum* has been recorded from the Blancan Big Springs Fauna of Nebraska (Rogers, 1984).

Genus *Nerodia* Baird and Girard, 1853

Brattstrom (1967) has discussed general criteria for separating the vertebrae of *Nerodia* from those of the genus *Thamnophis*.

Nerodia sipedon (Linnaeus, 1758)

MATERIAL—Eleven vertebrae UNSM 75411 from Quarry 2. Forty-eight vertebrae USNM 442308 from Quarry 2.

REMARKS—Holman (1967) has given characters to separate the vertebrae of *N. sipedon* from those of other moderately large and large species of the genus. There are no records of *N. sipedon* from Garden County today, but there are several records for adjacent Keith County (Lynch, 1985: *50, fig. 48*). This species lives in marshes and along streams and rivers in Nebraska today. It has been recorded from the Blancan Sand Draw Fauna of Nebraska (Holman, 1972) and has tentatively been reported from the Blancan Big Springs and Hornets' Nest faunas of Nebraska (Rogers, 1984).

Genus *Pituophis* Holbrook, 1842

Auffenberg (1963) gives vertebral characters of this genus and its species.

Pituophis catenifer (Blainville, 1835)

MATERIAL–An associated specimen of 30 vertebrae and vertebral fragments USNM 442309 from Quarry 2.

REMARKS–Lynch (1985: *51–52*) makes a convincing argument that the bull snake (*Pituophis catenifer*) and the pine snake (*P. melanoleucus*) are distinct species rather than being subspecies of *P. melanoleucus*. *Pituophis catenifer* vertebrae have much lower neural spines than those of *P. melanoleucus* and the Lisco C fossils resemble *P. catenifer* in this character. *Pituophis catenifer* occurs throughout Nebraska today and has been recorded in Garden County (Lynch, 1985: *51, fig. 50*). It is a commonly-seen snake in most dry habitats. Surprisingly, this is the first record of this snake from the Blancan of Nebraska.

Genus *Storeria* Baird and Girard, 1853

This genus was heretofore known as a fossil only from the Irvingtonian to the Recent of North America. Auffenberg (1963) and Holman (1984) have discussed the identification of *Storeria* based on isolated vertebrae.

Storeria sp. indet.

MATERIAL—One vertebra UNSM 75412 from Quarry 2. Four vertebrae USNM 442310 from Quarry 2.

REMARKS—We have been unable to identify these vertebrae to the specific level. Today, two species of *Storeria* occur in Nebraska. *Storeria dekayi* is confined to extreme southeastern Nebraska (Lynch, 1985: *52, fig. 53*). *Storeria occipitomaculata* is known from three isolated localities: one in extreme eastern-central Nebraska without specific data and one from Buffalo County in southern-

central Nebraska (Lynch, 1985: *53, fig. 54*); and one from near Gothenberg in Dawson County (Peyton, 1989). The 17 Dawson County specimens look similar to *S. o. pahasape* found in isolation in the Black Hills of South Dakota; thus it is possible that isolated populations could occur in or near Garden County, Nebraska, today. This is the first record of *Storeria* from the Blancan of Nebraska.

Genus *Thamnophis* Fitzinger, 1843

Thamnophis radix (Baird and Girard, 1853)

MATERIAL—Twenty-two isolated vertebrae UNSM 75403 from Quarry 2. The following UNSM numbers represent groups of vertebrae that were found associated in the field, and each group probably represents an individual: four vertebrae from an articulated specimen about 10 cm in length UNSM 75413 from Quarry 2; nine associated vertebrae UNSM 75414 from Quarry 2; two associated vertebrae UNSM 75415 from Quarry 2; eight associated vertebrae UNSM 75416 from Quarry 2. Two isolated vertebrae UNSM 75417 from Diatomite Cliff Site. Twenty-four isolated vertebrae USNM 442311 from Quarry 2.

REMARKS— Holman (1984) has discussed characters for the identification of *T. radix* based on isolated vertebrae. Today, *T. radix* is the most common snake in Nebraska and occurs statewide (Lynch, 1985: *54, fig. 58*). This species is common in most habitats in Nebraska today except along rivers where *T. sirtalis* is more abundant. *Thamnophis radix* has been reported from the Blancan Big Springs and Hornets' Nest faunas of Nebraska (Rogers, 1984).

Thamnophis sirtalis (Linnaeus, 1758)

MATERIAL—Two isolated vertebrae UNSM 75418 from Quarry 2. The following UNSM numbers represent groups of vertebrae that were found associated in the field, and each group probably represents an individual: 25 associated vertebrae UNSM 75419 from Quarry 2; nine associated vertebrae UNSM 75420 from Quarry 2. Two isolated vertebrae UNSM 75421 from Diatomite Cliff Site. Fifty-seven isolated vertebrae USNM 442312 from Quarry 2.

REMARKS—Holman (1984) has discussed the identification of *T. sirtalis* on the basis of isolated veetebrae. Today, the species occurs statewide and is one of the most common snakes in Nebraska in many habitats, especially along river courses, where it is more abundant than *T. radix* (Lynch, 1985: *54, fig. 59*). *Thamnophis sirtalis* has been reported from the Blancan Big Springs and Hornets' Nest faunas of Nebraska (Rogers, 1984).

Family Viperidae

Genus *Crotalus* Linnaeus, 1758

Auffenberg (1963) discusses characters for the identification of the genus on the basis of isolated vertebrae.

Crotalus sp. indet.

MATERIAL—A vertebra UNSM 75422 from the Diatomite Cliff Site.

REMARKS—This vertebra is too fragmentary for specific determination. Only one species of *Crotalus*, *C. viridis*, occurs in western and central Nebraska today (Lynch, 1985: *47, fig. 37*). *Crotalus horridus*, the only other Nebraska species of the genus, is confined to the extreme southeastern portion of the state (Lynch, 1985: *47, fig. 36*). *Crotalus horridus* has been reported from the Blancan Big Springs and Hornets' Nest faunas of Nebraska (Rogers, 1984).

Table I. Blancan sites with herpetofaunas. Dates are from Repenning (1987) except for the Hornets' Nest, Nebraska (M. R. Voorhies, pers. comm.) and Big Springs, Nebraska (Voorhies, 1987).

Site	Age in Ma
Hornets' Nest Nebraska	2.0
White Rock, Kansas	2.3
Big Springs, Nebraska	2.5
Red Corral, Texas (unstudied)	3.1
Beck Ranch, Texas	3.3
Sand Draw, Nebraska	3.5
Hagerman, Idaho	3.5
Rexroad 2, Kansas	3.7
Lisco C, Nebraska	3.8
Rexroad 3, Kansas	3.9

DISCUSSION

North American Blancan sites (Table I) that have produced important herpetofaunas range in age from about 2.0 to 3.9 Ma. The Lisco C (3.8 Ma) herpetofauna is of considerable interest because it differs from the three other Nebraska Blancan herpetofaunas (all younger) that occur along the same Pliocene drainage system (Fig. 2). The Sand Draw herpetofauna (3.5 Ma, Repenning, 1987) of Brown County, Nebraska, is nearest in age to the Lisco C herpetofauna, whereas the Big Springs herpetofauna (2.5 Ma, Voorhies, 1987) from Antelope County, Nebraska, and the Hornets' Nest Herpetofauna (2.0 Ma, Voorhies, pers. comm.) from Knox County, Nebraska, are considerably younger.

The herpetofaunas of the four sites are compared in Table II. Extinction percentages of the four herpetofaunas are compared in Table III. Extinction percentages are low in all four faunas. The Lisco C has one of 18 forms (6%) extinct; the Sand Draw two of 19 (11%) extinct; the Big Springs five of 31 (16%) extinct; and the Hornets' Nest one of 18 (6%) extinct. The misleading difference between the 6% rate of extinction in the older Lisco C herpetofauna and the 16% rate in the younger Big Springs herpetofauna reflects the fact that three *Bufo* were identified as

Table II. Amphibians and reptiles from Blancan sites in Nebraska. Taxa for B modified from Holman (1972); taxa for C and D from Rogers (1984). Extinct forms are indicated by an asterisk.

TAXON	A Lisco C	B Sand Draw	C Big Springs	D Hornets' Nest
AMPHIBIA				
URODELA				
AMBYSTOMATIDAE				
Ambystoma maculatum	0	0	0	+
Ambystoma tigrinum	0	+	+	+
ANURA				
BUFONIDAE				
Bufo cognatus	0	0	+	+
**Bufo repentinus*	0	0	+	+
**Bufo rexroadensis*	0	0	+	0
**Bufo* cf. *spongifrons*	0	0	+	0
Bufo sp. indet.	+	0	+	0
PELOBATIDAE				
Scaphiopus bombifrons	0	+	0	0
RANIDAE				
Rana catesbeiana	0	+	0	+
Rana pipiens complex	+	+	+	+
Rana sylvatica	0	0	0	+
Rana sp. indet.	+	0	0	0
REPTILIA				
TESTUDINES				
CHELYDRIDAE				
Chelydra serpentina	+	0	0	0
EMYDIDAE				
Chrysemys picta	0	+	+	+
Emydoidea blandingii	0	0	+	0
Graptemys sp. indet.	0	0	+	0
Trachemys scripta	0	+	0	0
KINOSTERNIDAE				
Kinosternon flavescens	+	+	0	0
TESTUDINIDAE				
**Geochelone oelrichi*	0	+	+	0
**Geochelone* (giant sp.)	0	+	0	0
TRIONYCHIDAE				
Apalone sp. indet.	0	+	+	0
SQUAMATA				
IGUANIDAE				
Phrynosoma cornutum	0	+	+	0
**Sceloporus* cf. *robustus*	+	0	0	0
Sceloporus undulatus	+	0	0	0

Table II, continued

TAXON	A Lisco C	B Sand Draw	C Big Springs	D Hornets' Nest
SQUAMATA, continued				
SCINCIDAE				
**Eumeces* cf. *striatulus*	0	0	+	0
Eumeces obsoletus	0	+	0	0
Eumeces sp. indet.	+	0	0	+
TEIIDAE				
Cnemidophorus sexlineatus	+	+	0	0
COLUBRIDAE				
Coluber constrictor	0	0	+	0
Coluber sp.	+	+	0	0
Elaphe guttata	0	0	+	+
Elaphe vulpina	+	+	+	0
Heterodon nasicus	0	0	+	0
Heterodon platyrhinos	0	+	+	0
Lampropeltis calligaster	0	+	+	0
Lampropeltis getulua	0	0	+	0
Lampropeltis triangulum	+	0	+	0
Lampropeltis sp. indet.	0	0	+	0
Masticophis flagellum	0	0	+	0
Nerodia sipedon	+	+	0	0
Nerodia sipedon or **Nerodia hibbardi*	0	0	+	+
Nerodia sp. indet.	0	0	+	+
Pituophis catenifer	+	0	0	0
Regina grahami	0	0	+	+
Rhinocheilus lecontei	0	0	+	0
Storeria sp. indet.	+	0	0	0
Thamnophis proximus	0	0	+	+
Thamnophis radix	+	0	+	+
Thamnophis sirtalis	+	0	+	+
Thamnophis sp. indet.	0	+	+	+
VIPERIDAE				
Agkistrodon cf. *contortrix*	0	0	+	+
Crotalus horridus	0	0	+	+
Crotalus sp. indet.	+	0	0	0
Sistrurus catenatus	0	0	+	0

extinct in the Big Springs (Rogers, 1984), whereas only *Bufo* sp. indet. was identified in the Lisco C.

More importantly, the three younger Nebraska Blancan herpetofaunas have forms that occur well south of the fossil localities today, but the Lisco C has no southern extralimital forms. Holman (1972) states that giant tortoises (*Geochelone* sp.) in the Sand Draw fauna would indicate that the area was relatively frost free during the time of the deposition of the bones. Moreover, the remainder of the Sand Draw herpetofauna would be typical of Kansas rather than of Nebraska. Rogers (1984) states thatthe herpetofauna of both Big Springs and the Hornets' Nest localities would be characteristic of southern Kansas today.

Table III. Extinction percentages in Blancan herpetofaunas from Nebraska. *Nerodia sipedon* or *N. hibbardi* is counted as *N. sipedon*.

Site	Age in Ma	Taxa identified	Extinction %
Hornets' Nest	2.0	18	6% (1)
Big Springs	2.5	31	16% (5)
Sand Draw	3.5	19	11% (2)
Lisco C	3.8	18	6% (1)

In contrast, the Lisco C herpetofauna has no members that occur south of the area today, the only extralimital members being the eastern *Elaphe vulpina* and possibly *Storeria* sp. (see remarks in the *Storeria* sp. section above). This leads us to speculate that the Lisco C had a cooler, moister climate (3.8 Ma) than the younger ones (Sand Draw, 3.5 Ma; Big Springs, 2.5 Ma; Hornets' Nest 2.0 Ma). Nevertheless, speculations such as this can always be changed by finding additional fossil material such as giant *Geochelone* at the Lisco C Quarry.

Reconstructing an exact paleoenvironment on the basis of 18 herpetological taxa may be somewhat tenuous, nevertheless it would appear that the Lisco C herpetofauna would be one that could be found today in an oxbow pond or lake surrounded by a marshy area and giving way to a more xerophytic terrestrial habitat. Forms of the oxbow pond would be *Chelydra serpentina*, *Kinosternon flavescens*, and *Nerodia sipedon*. Forms of the marsh would be *Rana pipiens* complex and *Thamnophis sirtalis*. Forms of the drier terrestrial habitat would be *Bufo* sp. indet., *Cnemidophorus sexlineatus*, *Eumeces* sp. indet., *Sceloporus* cf. *S. robustus*, *S. undulatus*, *Coluber* sp. indet., *Elaphe vulpina*, *Heterodon* sp. indet., *Lampropeltis triangulum*, *Pituophis catenifer*, *Storeria* sp. indet., *Thamnophis radix*, and *Crotalus* sp. indet.

Holman (1972) depicted the ecological setting of the Sand Draw herpetofauna as being a slowly moving stream with marshy edges and surrounded by sandy flats. Rogers (1984) states that the Big Springs herpetofauna was probably deposited in a tall-grass prairie. She believed that the Hornets' Nest herpetofauna represents a more wooded environment than the Big Springs.

The high proportion of terrestrial forms in the Lisco C herpetofauna probably indicates transportation to the site of deposition, possibly during local flooding. But considering the lack of abrasion on most of the fossils, it appears that the fauna was derived from some nearby area. We would suggest a small oxbow pond rather than a large oxbow lake as the site of deposition based on the habitat preferences of *Kinosternon flavescens*.

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