THE SANDAHL MOLLUSCAN FAUNA (ILLINOIAN) FROM McPHERSON COUNTY, KANSAS[1]

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ABSTRACT

An early- or middle-Illinoian-age molluscan fauna containing 63 species is reported from sediments deposited by ancestral Smoky Hill River in McPherson County, Kansas. The fauna contains four species, *Lampsilis ventricosa*, *Pleurobema cordatum catillus*, *Strophitus rugosus*, and *Bulimulus dealbatus*, not previously reported as fossils in the state.

The relative diversity of unionid species, which includes *Quadrula quadrula*, *Pleurobema cordatum catillus*, *Strophitus rugosus*, *Lasmigona complanata*, and *Lampsilis ventricosa*, together with the abundance of *Probythinella lacustris*, imply the former existence of a river substantially larger than the present Smoky Hill River. The paucity of strictly woodland forms and the abundance of terrestrial species preferring or capable of tolerating relatively dry, open conditions, suggest that only scattered stands of trees bordered the river. Much of the valley slope and upland were probably covered with scattered trees, shrub, and open grass meadow.

The present distribution in Kansas of the extant species of unionids from this fauna suggests that, at the time the Sandahl fauna lived, the upper Smoky Hill River may have been tributary to the Arkansas River by way of the Cottonwood-Neosho system.

The climate at the time the Sandahl mollusks lived apparently combined average summer temperatures of between 65° to 70°F, cooler than those now characterizing the McPherson County area, with average winter temperatures of between 30° to 35°F. Precipitation was not necessarily any greater than that now characteristic of the east-central Kansas area (20–30 inches). Lower summer temperatures probably greatly reduced evapotranspiration rates and contributed to a significant increase in groundwater recharge and surface runoff.

INTRODUCTION

During the summers of 1962 and 1963, University of Michigan Museum of Paleontology field parties collected Illinoian-age fossils from six localities in the McPherson Formation of northwestern McPherson County, Kansas. The fossil vertebrates from these collections have been described by Semken (1966) and designated the Sandahl local fauna. His report contains an excellent review of previous work, discussion of the stratigraphy, and a geologic map of the area.

An abundant molluscan fauna was recovered at two localities of the Sandahl local fauna, the Flohr gravel pit (NE¼ SW¼ sec 7, T 18S, R 4W) (Fig. 1), and Sandahl gravel pit (SE¼ SW¼ sec. 29, T 18S, R 4W). The purpose of this paper is to report the molluscan elements of the fauna, and to present an interpretation of their ecologic and climatic significance.

I would like to thank the following individuals whose efforts were instrumental in making this study possible: Dr. Claude W. Hibbard, University of Michigan, and Dr. Holmes A. Semken, University of Iowa, who collected the fauna and made it available for study; Dr. Henry van der Schalie, University of Michigan, who checked the unionid identifications and granted me access to the collections under his supervision; and Mr. H. B. Herrington, Westbrook Heights, Ontario, for his help in the identification of the sphaeriids. The Sandahl Molluscan fauna was collected under NSF Grant (G19458) awarded to Dr. Claude Hibbard. Study of the collections at the University of Michigan was made possible by a travel grant from the Kent State University Research Council.

FAUNAL COMPOSITION AND ANALYSIS

The sixty-three species of mollusks identified from the Sandahl local fauna are presented in Table 1. Material examined in the University of Michigan

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Museum of Zoology collections, together with records published by Leonard (1959), and by Murray and Leonard (1962), indicate that thirty-one of these species occur in the present fauna of McPherson County or in the immediately adjacent counties of Ellsworth, Rice, Reno, Harvey, Marion, Dickinson, and Saline. Two of the Sandahl mollusks, *Omalodiscus pattersoni* and *Deroceras aenigma*, are known only as fossils. There are four species, *Lampsilis ventricosa*, *Pleurobema cordatum catillus*, *Strophitus rugosus*, and *Bulimulus dealbatus*, which have not previously been reported as fossils in Kansas.

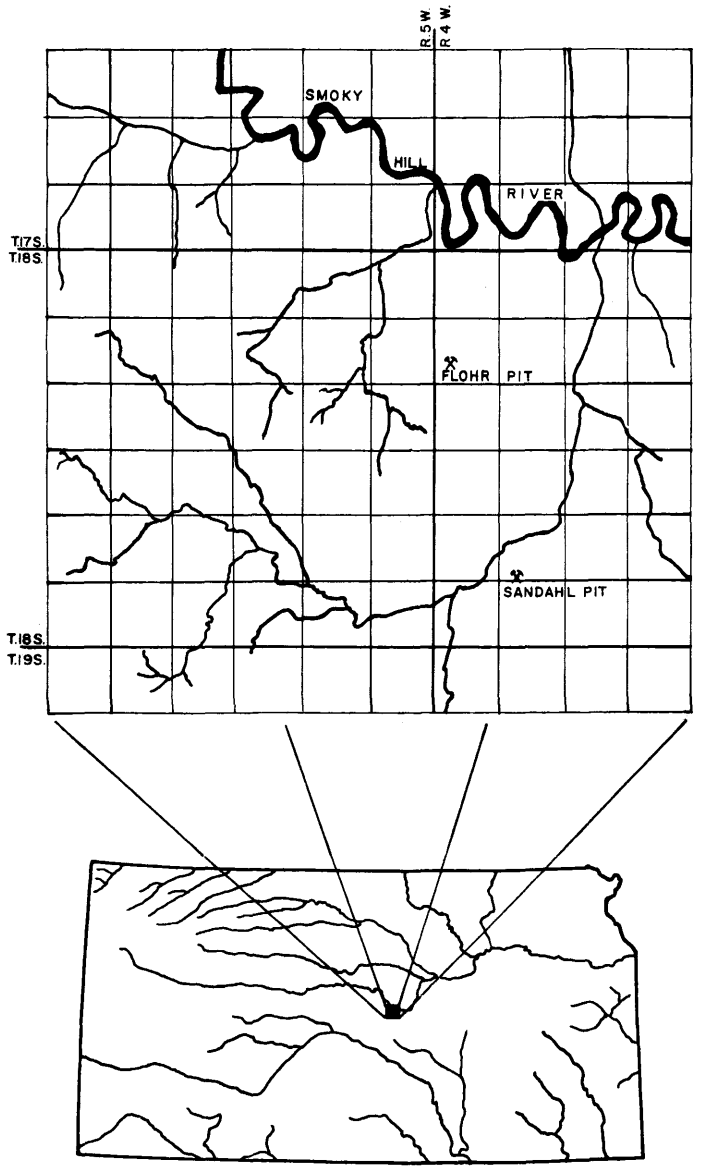

FIGURE 1. Index map showing location of the Flohr gravel pit and Sandahl gravel pit localities of the Sandahl local fauna, in northwest McPherson County, Kansas.

The presence of *Acella haldemani* in the Pleistocene fauna of Kansas has been the subject of some controversy (Miller, 1966, p. 226). A portion of the spire from one individual, consisting of two and a half whorls, now confirms its occurrence in the state.

Abundant representation of *Bulimulus dealbatus* in the Sandahl fauna indicates that it has at least been an intermittant member of the molluscan fauna of Kansas since Illinoian time. This does not supprt the conclusion reached by Leonard (1959), that it is probably a recent immigrant into the state.

TABLE 1

Mollusks of the Sandahl local fauna. University of Michigan Museum of Zoology catalog number and quantity of specimens follow each species name. Separate pelecypod valves are listed as fractions. Quantities in excess of 100 have generally been estimated volumetrically. All of the unionids, with the exception of one left valve of Quadrula quadrula, *are from the Flohr gravel-pit locality. The remainder of the mollusks are from the Sandahl gravel-pit locality. The numerals heading the eight columns on the right side of the table refer to the following habitats frequented by each species: (1) shaded areas; wet to moist ground-debris (2) forest; dense shade; moist ground-debris (3) scattered trees and shade; moist ground-debris (4) scattered trees, brush, meadow; occasional areas with moist ground-debris (5) marginal situations near water (6) temporary ponds, streams, or sloughs (7) ponds, streams, or sloughs not subject to significant seasonal drying (8) perennial river or lake (modified from Miller, 1966).*

Name	Catalog Number	Quantity	Habitat							
			1	2	3	4	5	6	7	8
Lampsilis ventricosa (Barnes)	230680	1+3/2								X
Pleurobema cordatum catillus (Conrad)	230681	1+1/2								X
Lasmigona complanata (Barnes)*	230682	1+3/2								X
Strophitus rugosus (Swainson)*	230683	1+7/2								X
Quadrula quadrula (Rafinesque)*	230684	8+6/2								X
Sphaerium partumeium (Say)*	230685	7/2							X	
S. simile (Say)*	230686	47/2								X
S. striatinum (Lamarck)*	230687	12/2								X
S. transversum (Say)*	230688	75/2							X	X
Pisidium casertanum (Poli)*	230689	12/2						X	X	X
P. compressum Prime*	230690	500/2							X	X
P. nitidum Jenyns	230691	14/2							X	X
P. ventricosum fm. *rotundatum* Prime	230692	4/2						X	X	X
P. variabile Prime	230693	11/2							X	X
Valvata tricarinata (Say)	230694	1500							X	X
Probythinella lacustris (Baker)	230695	86							X	X
Amnicola limosa (Say)	230696	117							X	X
Carychium exiguum (Say)*	230697	5	X							
Stagnicola caperata (Say)	230698	200						X		
S. cockerelli (Pilsbry & Vanatta)*	230699	250						X		
S. reflexa (Say)	230700	67						X	X	
Acella haldemani (Binney)	230701	1								X
Fossaria dalli (Baker)	230702	28					X			
Omalodiscus pattersoni (Baker)	230703	1						?	?	
Armiger crista (Linneaus)	230704	1						X	X	
Gyraulus circumstriatus (Tryon)	230705	100						X		
G. deflectus (Say)	230706	18							X	
G. parvus (Say)*	230707	2400							X	
Helisoma anceps (Menke)	230708	63								X
H. trivolvis (Say)*	230709	35						X	X	X
Planorbula armigera (Say)	230710	150							X	
Promenetus exacuous fm. *exacuous* (Say)	230711	162						X	X	
P. umbilicatellus (Cockerell)	230712	89						X	X	
Ferrissia parallela (Haldeman)	230713	200							X	
Physa anatina Lea	230714	54							X	X
P. gyrina (Say)	230715	32						X	X	
Cionella lubrica (Müller)*	230716	9	X	X						

TABLE 1—(*Continued*)

Name	Catalog Number	Quantity	Habitat							
			1	2	3	4	5	6	7	8
Strobilops labyrinthica (Say)	230717	2	X	X						
Gastrocopta armifera (Say)*	230718	2100		X	X	X				
G. contracta (Say)*	230719	114		X	X					
G. cristata (Pilsbry & Vanatta)*	230720	375		X	X	X				
G. holzingeri Sterki*	230721	150		X	X					
G. procera (Gould)*	230722	580		X	X	X				
G. tappaniana (Adams)*	230723	43	X	X						
Pupilla blandi Morse	230724	200	X	X	X	X				
Pupoides albilabris (Adams)*	230725	1600		X	X	X				
P. inornatus Vanatta	230726	87				X				
Vertigo milium (Gould)*	230727	2	X	X						
V. ovata (Say)*	230728	26	X	X						
Vallonia gracilicosta Reinhardt	230729	1260		X	X	X				
V. parvula Sterki*	230730	185		X	X	X				
cf. *Succinea**	230731	550								
Bulimulus dealbatus (Say)*	230732	159			X	X				
Discus cronkhitei (Newcomb)	230733	200	X	X						
Helicodiscus parallelus (Say)*	230734	320		X	X					
H. singleyanus (Pilsbry)*	230735	86				X				
Punctum minutissimum (Lea)	230736	29		X						
Deroceras aenigma Leonard	230737	21	?	?						
Euconulus fulvus (Müller)	230738	1		X	X					
Nesovitrea electrina (Gould)	230739	100		X	X					
Hawaiia minuscula (Binney)*	230740	375		X	X	X				
Zonitoides arboreus (Say)*	230741	154	X	X	X					
Stenotrema leai (Binney)*	230742	50	X	X						

*These species have been reported in McPherson County or in the immediate adjacent counties of Ellsworth, Rice, Reno, Harvey, Marion, Dickinson, and Saline (Leonard, 1959; University of Michigan Museum of Zoology collections).

PALEOECOLOGY

Interpretation of mollusks in the Sandahl local fauna is predicated on the generally accepted principle that fossil shells referable to living species are indeed the same species, and reacted to their environment in a manner similar to that of their extant analogs. The bases for accepting this principle as a working hypoth-

TABLE 2

Summary of the local habitats represented by the Sandahl Local Fauna mollusks

Habitat	Species	Percentage by habitat group
Shaded areas, under and on moist, to wet ground-debris; usually not far from water.	*Carychium exiguum* *Vertigo milium* *V. ovata* *Gastrocopta tappaniana*	1.3%
Woodland, with dense shade; damp areas beneath ground-debris; on floodplain.	*Cionella lubrica* *Stenotrema leai* *Discus cronkhitei* *Zonitoides arboreus* *Nesovitrea electrina* *Euconulus fulvus* *Helicodiscus parallelus* *Punctum minutissimum* *Strobilops labyrinthica*	6.0%

TABLE 2—(*Continued*)

Habitat	Species	Percentage by habitat group
Open woodland and shrubs on valley slopes and upland, under damp debris; these species can tolerate less shade.	*Gastrocopta armifera* *G. contracta* *G. holzingeri*	16.4%
Scattered trees, brush, grass; these species are not restricted to woodlands and can tolerate drier conditions among short grass in unshaded areas.	*Gastrocopta cristata* *G. procera* *Pupilla blandi* *Pupoides albilabris* *P. inornatus* *Vallonia gracilicosta* *V. parvula* *Bulimulus dealbatus* *Hawaiia minusula* *Helicodiscus singleyanus*	34.0%
Marginal situations; wet mud along water's edge.	*Fossaria dalli*	0.1%
Shallow, quiet water; subject to seasonal drying; small streams, ponds or sloughs on the floodplain, with areas of rooted aquatic vegetation.	*Pisidium casertanum* *Stagnicola cockerelli* *S. caperata* *S. reflexa* *Armiger crista* *Gyraulus circumstriatus* *G. deflectus* *Physa gyrina*	4.7%
Shallow, quiet water not subject to severe seasonal drying; may have been part of main stream or small ponds, streams or sloughs on the floodplain; with soft mud bottom and areas of rooted aquatic vegetation.	*Sphaerium partumeium* *S. simile* *S. transversum* *Pisidium ventricosum* form *rotundatum* *Gyraulus parvus* *Helisoma trivolvis* *Promenetus exacuous* form *exacuous* *P. umbilicatellus* *Planorbula armigera* *Physa anatina* *Ferrissia parallela*	21.3%
Perennial medium-sized stream; at least four to six feet deep; shallow quiet water pools with stable, soft substrate of sand or mud; areas of rooted aquatic vegetation.	*Quadrula quadrula* *Strophites rugosus* *Pleurobema cordatum catillus* *Lampsilis ventricosa* *Lasmigona complanata* *Sphaerium striatinum* *Pisidium compressum* *P. nitidum* *P. variabile* *Valvata tricarinata* *Probythinella lacustris* *Amnicola limosa* *Acella haldemani* *Helisoma anceps*	16.2%

esis are succinctly presented by Taylor (1960). Interpretations based on this principle generally are not in conflict with conclusions reached independently from studies based on associated elements of the biota. The harmonious results in many such studies made in the southern Great Plains (e.g. Hibbard and Taylor, 1960) strongly suggest that this approach is basically valid.

Habitat

A summary of inferred local habitats represented by the Sandahl mollusks is presented in Table 2. The presence of a medium-sized river, probably larger than the present Smoky Hill River in the McPherson County area, is indicated by: (1) the diverse microhabitats implied by the relatively large number (five) of unionid species; (2) the presence of *Strophitus rugosus* and *Pleurobema cordatum catillus*, species that characteristically inhabit medium-sized to large-sized streams (Murray and Leonard, 1962) and; (3) *Probythinella lacustris*, a species which is almost exclusively confined to water depths in excess of five feet (Hibbard and Taylor, 1960). The articulated condition of some individuals in each of the unionid species recovered from the Flohr pit locality suggests that they were buried at or near the site of the ancestral river bed in which they lived.

Portions of the river contained deep, quiet pools, with a stable substrate of mud and sand, which provided suitable habitats for *Quadrula quadrula*, *Pleurobema cordatum catillus*, *Lasmigona camplanata*, and *Strophitus rugosus*. The ecologic requirements of *Lampsilis ventricosa* suggest that there were also sections of the river with shallow water and a sandy gravely bottom.

The ecologic preferences and relative abundances of the three aquatic species, *Pisidium compressum*, *Valvata tricarinata*, and *Gyraulus parvus*, representing about 30 percent of the individuals in the fauna, suggest that the river at the Sandahl gravel-pit locality was almost lake-like. The river, in this segment of its course, was probably characterized by a slight current, and a sandy, firm substrate that supported beds of aquatic vegetation such as *Scirpus* and *Potamogeton*.

Less than five percent of the fauna consists of species typically associated with ephemeral bodies of water. Included in this group are *Pisidium casertanum*, *Stagnicola caperata*, *S. cockerelli*, *S. reflexa*, *Armiger crista*, *Gyraulus circumstriatus*, *G. deflectus*, and *Physa gyrina*. Their presence is probably indicative of temporary ponds or streams on the floodplain near the site of deposition.

Relatively few of the terrestrial species (less than six percent) are strictly woodland forms. Species tolerant of open, drier conditions compose a much larger element in the fauna, representing 34 percent of all the individuals. These abundance data suggest that the woodland habitat was not well developed and probably consisted only of discontinuous stands of trees along the river valley. The majority of the terrestrial species probably dwelled in areas of scattered patches of trees, shrub, and open grass along the valley slopes and upland.

The ecologic implications of the Sandahl mollusks, therefore, basically support the habitat interpretation of the Sandahl local fauna made by Semken (1966) in his study of the vertebrates.

Climate

The geographic distribution and habitat requirement of extant molluscan species are the basis for climatic interpretations of the species represented by the fossil shells. The limitations and potentialities of this method are discussed in Taylor (1965).

At least four different distributional patterns are recognized among the Sandahl local-fauna mollusks. A predominantly northern distribution is represented by *Sphaerium simile*, *Pisidium nitidum*, *P. variabile*, *P. ventricosum* fm. *rotundatum*, *Valvata tricarinata*, *Stagnicola caperata*, *Gyraulus circumstriatus*, *G. deflectus*, *Armiger crista*, *Ferrissia parallela*, *Discus cronkhitei*, and *Vallonia gracilicosta*. Although some of these species may extend farther south at higher elevations in the Rockies and/or Appalachians, they all occur well to the north of Kansas in the Great Plains region. High summer temperature appears to be the limiting factor controlling the southern limits of this group (Miller, 1966; Hibbard and Taylor, 1960).

A second group of species that is essentially restricted to moister areas to the

north and/or east of Kansas includes *Acella haldemani*, *Probythinella lacustris*, *Pleurobema cordatum catillus*, *Lampsilis ventricosa*, and *Strobilops labyrinthica*. None of these species now occurs in the Great Plains. Some of these species, however, do extend as far west in Kansas as the Central Lowland and Ozark Plateau. All of these species, with the possible exception of *Acella haldemani*, extend south of the latitude of the Sandahl fauna locality in the more humid regions to the east of McPherson County. The distributions of these species appear to be controlled by available moisture and frequency of drought, as suggested by Taylor (1960).

A distinct western element is represented in the fauna by *Pupoides inornatus* and *Pupilla blandi*. These species are known primarily from the Rocky Mountains and Black Hills. Their few scattered records in the Great Plains are from areas far to the northwest of Kansas (Hibbard and Taylor, 1960, p. 130–131).

A fourth group with predominantly southern distributions includes *Gastrocopta cristata*, *Physa anatina*, *Helicodiscus singleyanus*, and *Bulimulus dealbatus*. The first three of these species reach the northern limits of their range in northeastern Nebraska and southeastern South Dakota (Miller, 1966). *Bulimulus dealbatus* does not extend north of the 40th latitude (Pilsbry, 1946). The northward restriction in range of these species suggests that they are limited to areas with short, relatively mild winters.

No one geographic area known to the writer now contains the association of molluscan species found in the Sandahl local fauna. Fifty-three of the extant species occur within the rather large region encompassing southeastern South Dakota, northeastern Nebraska, and northwestern Iowa. *Pupoides inornatus*, *Pupilla blandi*, *Acella haldemani*, and *Bulimulus dealbatus* have not been reported from this area and probably do not occur there. Three other species, *Pisidium variabile*, *P. ventricosum* fm. *rotundatum*, and *Physa anatina* reach the periphery of their range in this area. *Pisidium variabile* occurs in South Dakota and eastern Iowa (Miller, 1966) and might reasonably be expected in northwestern Iowa. *Pisidium ventricosum* fm. *rotundatum* reaches the southern limits of its range in the Great Plains in South Dakota. *Physa anatina* has been reported from Nebraska and Michigan and probably inhabits all of the intervening area (Crandall, 1901).

The coexistance in the Sandahl local fauna of species, some of which now have geographic ranges separated by many hundreds of miles (e.g., *Pupoides inornatus* and *Acella haldemani*), appears to be most reasonably explained by assuming that climatic changes since the time the fauna lived have brought about the present disjunctions. The climate implied by the Sandahl mollusks differs from that now occurring in McPherson County (Semken, 1966, Table 2) and the tri-state border area of Iowa, Nebraska and South Dakota in that it was characterized by greater equability. Northern species which now appear to have their southern range in the Great Plains restricted by high summer temperatures, were able to coexist with southern and eastern species which now seem to be constrained by low temperatures and by lengthy winters, respectively; and by availability of moisture and frequency of drought. The climate at the time the Sandahl fauna lived probably combined cool summer temperatures, similar to those in the general tri-state area of sympatry for most of the molluscan species (65° to 70° F — Miller, 1966, Table 4), with winters no more severe than those now occurring in east-central Kansas (30° to 35° F — Kincer, 1941). Precipitation need not have been greater than that now characteristic of McPherson County (20 to 30 inches). Lower summer temperatures would greatly reduce evapotranspiration rates and result in significant ground-water recharge and surface runoff.

The ecologic requirements of some of the mollusks and associated fish remains (Semken, 1966) suggest a river with greater discharge than now occurs in the Smoky Hill River in the McPherson County area. This increase in discharge appears to be related to climate, rather than to hydrologic factors. Downward

erosion by the ancestral Smoky Hill River into previously untapped aquifers does not seem to be a reasonable explanation for this increase in discharge. If such aquifers existed, numerous springs and seepage areas along the valley walls might be expected, but the relative scarcity of hygrophilous forms, such as *Carychium exiguum* and *Vertigo milium*, which would have thrived under such conditions, suggests that this type of local habitat was not common. Increased discharge was probably related in this case to lower temperatures and lower evapotranspiration rates.

These conclusions do not differ significantly from those reached by Semken (1966), who concluded that the climate, during the time the Sandahl mammals lived, differed from that of the present climate in McPherson County only by being 10° F. cooler, with a reduction in annual precipitation of approximately five inches.

AGE AND CORRELATION

Semken (1966, p. 172) states that the Sandahl local fauna comes from sediments that are . . . "stratigraphically above the Late Kansan Pearlette ash member of the Meade Group. Topographically lower terrace deposits of Wisconsin age, dated by *Bison bison*, are entrenched into the McPherson Formation." The ecologic and climatic implications of the vertebrates and mollusks suggest that the organisms lived during an interval of cooler summers and more surface runoff than now occurs in this area. The stratigraphic position of the fauna indicates that these climatic conditions most likely occurred during the Illinoian glacial stage. A chronocline based on the muskrats led Semken (1966) to conclude that the Sandahl fauna is probably early or middle Illinoian in age.

The Rezabek local fauna of Lincoln County, Kansas, although considered to be Illinoian in age (Hibbard, 1943; Semken, 1966) is not included in this discussion of possible correlatives of the Sandahl fauna because of uncertainties involving the mollusks. Most of the shell material in the University of Michigan Museum of Zoology collections that was examined consists of broken, abraided, and etched specimens. This is in marked contrast with the generally well-preserved condition of the shells from the other Illinoian faunas studied from the Great Plains (Miller, 1966; Hibbard and Taylor, 1960). There seems to be a rather good possibility that some of the mollusks in the Rezabek fauna may have been reworked from older deposits, as suggested by Taylor (1965).

Comparison of the Sandahl mollusks with Illinoian assemblages from southwest Kansas-northwest Oklahoma (Table 3) indicates that the greatest taxonomic similarities are with the Berends local fauna (Table 4). The climatic implications of the Sandahl mollusks, however, imply conditions more similar to those represented by the Mt. Scott local fauna.

No precise correlation is now apparent between the Sandahl mollusks and those from southwest Kansas and northwest Oklahoma. Many more Illinoian-age faunas will have to be collected from east-central Kansas and studied before more exact correlations between these two regions can be made. At the present time, it is not possible to evaluate the causal factors controlling the observed differences between the molluscan assemblages of these two areas. Implied climatic differences, possibly related to geographic separation of the faunas (e.g., McPherson County is about 1,000 feet lower in elevation and 180 miles east-northeast of Meade County), cannot be distinguished from those differences which might result from these assemblages having lived during different portions of the Illinoian stage.

PALEOGEOGRAPHIC SIGNIFICANCE OF THE SANDAHL MOLLUSCAN FAUNA

The occurrence of *Pleurobema cordatum catillus* in sediments deposited by the ancestral Smoky Hill River, together with recent distribution records for this species in Kansas, published by Murray and Leonard (1962), provides some interesting new data pertinent to the origin of the present Smoky Hill-Kansas

TABLE 3

A comparison of Illinoian-age molluscan faunas from Kansas and Oklahoma

	Sandahl	Berends*	Doby Springs*	Adams*	Butler Spring*	Mt. Scott*
Anodonta grandis			X		X	
Lampsilis ventricosa	X					
Lasmigona complanata	X			X		
Ligumia recta					cf	
Pleurobema cordatum catillus	X					
Quadrula quadrula	X			X		
Strophitus rugosus	X					
Uniomerus tetralasmus			X			X
Sphaerium lacustre		X				X
S. occidentale			X			X
S. partumeium	X					X
S. rhomboideum			X			X
S. securis		X				
S. simile	X	X	X			X
S. striatinum	X		X		X	X
S. transversum	X	X			X	X
Pisidium casertanum	X	X	X		X	X
P. compressum	X	X	X		X	X
P. nitidum	X	X	X		X	X
P. subtruncatum						X
P. variabile	X	X	X			X
P. ventricosum form *rotundatum*	X	X	X			X
P. walkeri					?	X
Amnicola limosa	X					
Probythinella lacustris	X		X		X	
Valcata tricarinata	X	X	X	X	X	X
Carychium exiguum	X	X	X		X	X
Acella haldemani	X					
Lymnaea stagnalis jugularis			X		X	
Stagnicola caperata	X	X	X	X	X	X
S. cockerelli	X					
S. exilis		X				X
S. reflexa	X	X	X		X	X
Fossaria dalli	X	X	X	X	X	X
F. obrussa		X	X		X	X
Armiger crista	X	X	X			X
Gyraulus circumstriatus	X	X	X		X	X
G. deflectus	X		X			
G. parvus	X	X	X	X	X	X
Helisoma anceps	X	X	X		X	X
H. trivolvis	X	X	X		X	X
Omalodiscus pattersoni	X				X	
Planorbula armigera	X	X				
Promenetus exacuous exacuous	X					X
P. e. kansasensis		X	X	X	X	
P. umbilicatellus	X		X		X	X
Ferrissia fragilis			X		X	X
F. parallela	X					
Laevapex fuscus			X		X	X
Physa anatina	X	X	X	X	X	X
P. gyrina	X	X	X		X	X
P. skinneri		X	X		X	X
Aplexa hypnorum		X	X		X	X
Cionella lubrica	X		X			X
Bulimulus dealbatus	X					
Strobilops labyrinthica	X	X	X			X
Gastrocopta armifera	X	X	X		X	X

TABLE 3—(*Continued*)

	Sandahl	Berends*	Doby Springs*	Adams*	Butler Spring*	Mt. Scott*
Gastrocopta contracta	X		X		X	X
G. cristata	X	X	X	X	X	X
G. holzingeri	X	X	X		X	X
G. pelucida hordeacella						X
G. procera	X	X	X	X	X	X
G. tappaniana	X	X	X	X	X	X
Vertigo elatior			X		X	
V. milium	X	X	X	X	X	X
V. ovata	X	X	X	X	X	X
Pupilla blandi	X		X	X	X	X
P. muscorum			X	X	X	
P. sinistra				X	X	
Pupoides albilabris	X	X	X		X	X
P. inornatus	X				X	
Vallonia cyclophorella				X	X	
V. gracilicosta	X	X	X	X	X	X
V. parvula	X	X	X		X	X
Oxyloma sp.		X	X		X	X
cf. *Succinea*	X	X	X	X	X	X
Discus cronkhitei	X		X	X	X	X
Helicodiscus parallelus	X	X	X			X
H. singleyanus	X			X	X	X
Punctum minutissimum	X					X
Deroceras aenigma	X	X	X			X
Euconulus fulvus	X	X	X			X
Nesovitrea electrina	X		X			X
Hawaiia minuscula	X	X	X	X	X	X
Zonitoides arboreus	X		X		X	X
Z. nitidus						X
Stenotrema leai	X	X	X		X	X
Total number of species	63	45	59	22	53	63

*Based on data from Miller, 1966.

TABLE 4

Taxonomic similarities based on Table 3, by $\frac{100C}{N_1}$, *where C = number of species shared in common and* N_1, *the number of species in smaller fauna*

	Sandahl (N = 63)
Berends (N = 45)	82
Doby Springs (N = 59)	73
Adams (N = 22)	73
Butler Spring (N = 53)	70
Mt. Scott (N = 63)	76

drainage system. *Pleurobema c. catillus* does not presently occur in the Smoky Hill-Kansas drainage, but is restricted in Kansas to the Neosho-Verdigris drainage, which is tributary to the Arkansas River (Fig. 2). The ancestral Smoky Hill River during Kansan time flowed south through McPherson Valley and eventually joined the ancestral Arkansas River (Bayne & Fent, 1963). The Sandahl local fauna, recovered from sediments deposited by one of the younger stages of the ancestral Smoky Hill River, has been dated by Semken (1966) as early or middle Illinoian, on the bases of stratigraphy and chronoclines in some of the microvertebrates. Gravels of unknown age, lithologically similar to those found

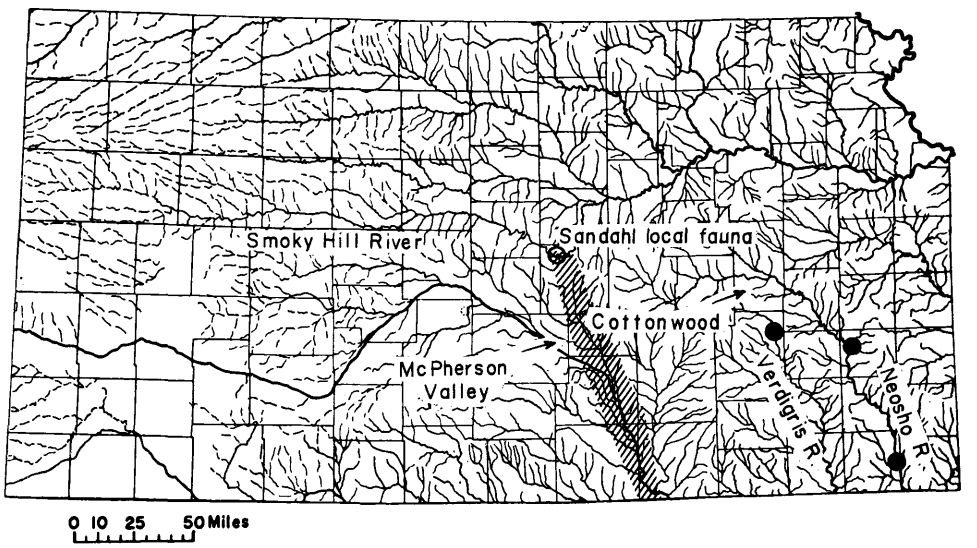

FIGURE 2. The recent distribution records of *Pleurobema cordatum catillus* in the Neosho-Verdigris drainage of Kansas, are indicated by black circles. The diagonal-lined pattern shows the drainage of the lower portion of the Smoky Hill River during the Kansan stage (after Bayne and Fent, 1963).

in McPherson Valley, occur along the headwaters of the Cottonwood River in McPherson and Marion counties (Charles K. Bayne, personal communication, 1968). The disjunct occurrence of *Pleurobema cordatum catillus* in the Sandahl fauna, together with these gravels, suggests that the upper Smoky Hill River may have drained to the south through the Cottonwood-Neosho system, possibly during Yarmouth or early Illinoian time.

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