

## ZOOGEOGRAPHIC IMPLICATIONS OF HOLOCENE MAMMAL REMAINS FROM ANCIENT BEAVER PONDS IN OKLAHOMA AND NEW MEXICO

WALTER W. DALQUEST, FREDERICK B. STANGL, JR.,  
AND M. JOHN KOCURKO

*Department of Biology and Department of Geology,  
Midwestern State University, Wichita Falls, TX 76308*

**ABSTRACT**—Some sediments exposed in cutbanks of streams in canyons in northeastern New Mexico and adjacent Oklahoma are considered to be filled-in beaver ponds and associated fringing meadows. Exposures rich in mollusk remains yielded small but important late Pleistocene and Holocene faunas. Five localities, approximately 31,000 to 500 YBP, were sampled. We present our hypothesis for the genesis of the valley fills, and discuss the zoogeographic significance of *Thomomys bottae*, *Sigmodon hispidus*, *Microtus ochrogaster*, and *Microtus pennsylvanicus*.

The Cimarron River and its tributaries flow through the north-central corner of the Oklahoma Panhandle and adjacent parts of New Mexico. The river has cut through Tertiary basalts and Mesozoic strata (Schoff and Stovall, 1943) to form a rugged, dissected topography of mesas and canyons. The land is semi-arid, and level areas support short-grass prairie. Rough and broken land is clothed in juniper and Colorado pinyon (*Pinus edulis*).

In this region, the Cimarron River is a small stream, shown on some maps as the "Dry Cimarron." The river has a low volume but high gradient, and many of the intermittent tributary streams are bordered by relatively broad alluvial fill that forms almost level grasslands. Alluvium fills the bottoms of the valleys, bordered by steep hillsides and cliffs of the canyon walls. Streams are entrenched through the alluvium, forming narrow arroyos. The level grasslands are important in a land devoted to cattle raising, forming meadows for grazing and hay for winter feed.

The valley fills are not typical alluvial terraces or fans. A significant amount of the fill results from the activity of beavers that probably have trapped sediments in their ponds and fringing meadows since the late Pleistocene. We present our hypothesis for the genesis of the valley fill of Tesesquite Canyon (spelling of the name of the

canyon follows that on U.S. Geological maps), in Cimarron Co., Oklahoma. Mammalian fossils found in such fills aid in understanding the past distribution of some species. We also present supporting evidence for this genesis from materials collected in adjacent Union Co., New Mexico.

Tesesquite Canyon, in the extreme northwestern corner of the Panhandle of Oklahoma, has attracted the attention of biologists and geologists since the early 1900s. Black Mesa, a few kilometers to the northwest, is the highest point in Oklahoma. Basalt flows from adjacent New Mexico and Colorado enter the state in this area. Here, the pinyon-juniper zone of the southeastern fringes of the southern Rocky Mountain foothills supports numerous vertebrates not otherwise found in Oklahoma.

We distinguish between Tesesquite Canyon, a valley cut through Mesozoic strata, and Tesesquite Arroyo, a narrow ditch-like channel through the alluvial fill of the canyon bottom, and the drainage of Tesesquite Creek. Tesesquite Canyon differs little from other short tributary canyons that enter the Cimarron River to the north and west. However, Rothrock (1925) paid special attention to this canyon, and provided a photo of the grassy canyon floor. Prior to 1925, Tesesquite Creek was a permanent stream, lacking an entrenched channel and meandering over the grass-

land of the valley fill. Eighteen years later when Schoff and Stovall (1943) reported on the geology of Cimarron Co., Tesesquite Creek had been reduced to an intermittent stream, deeply entrenched through the alluvium of the valley floor.

There is some disagreement as to when the arroyo appeared. Schoff and Stovall (1943) state that it developed after heavy floods in 1914 and 1924, but it was not mentioned by Rothrock (1925) or shown in his photograph. B. Davis (pers. comm.) lived in the area and remembers that the entrenchment took place in or just after the dust-bowl days of the 1930s. Generally, deep entrenchment is caused by the lowering of the water table rather than simple flooding. Whatever the time of origin of the arroyo, the cause was of regional extent. We have found similar arroyos cut through level valley fills of canyons in New Mexico, Colorado, and elsewhere.

Dalquest and Stangl (1989) described a late Pleistocene (radiocarbon date approximately 31,000 YBP) mammalian local fauna from the base of a cutbank in Tesesquite Arroyo. The abundance of mollusk shells indicates that deposition occurred in a pond or lake. The pond probably existed for many years as indicated by the thickness of the fossiliferous, sandy, clay layer (1.5 m). However, local physiography precludes the long existence of a pond or lake of normal type. The steep canyon walls and high gradient insure rapid runoff, and landslide dams or log jams would have easily washed out during floods.

Evidence indicates that the sediment containing the fossils might have accumulated in a beaver pond. Beavers are persistent "engineers," repairing or replacing dams when they are damaged. Dams thus maintained would preserve the beaver pond and its sediments.

The exposed arroyo sections unconformably overlay Mesozoic strata. The basal unit of the sections is a mixture of gravel, cobbles, and boulders derived from the sandstones and shales of the canyon walls. The layer of coarse material averages 1 m in thickness and is abruptly replaced above by fine sediments (clay, silt, or sandy silt). Coarse materials probably represent the original stream load, and the abrupt transition to fine materials marks the time when beavers invaded the stream and created ponds which trapped fine sediments. The virtual elimination of gradient kept most coarse material from washing from the canyon walls onto the valley fill.

Beaver activities involve three elements: the dam, comprised of rocks, logs, branches, and other vegetation; the resultant pond; the meadow, or "vega" as it is termed through the Southwest. A vega results when sediments fill a pond, usually from the margins inward. Vegas are rarely marshy, though the water table is only a few centimeters deep. Beavers construct canals through the vegas as they develop, both for protection from predators while foraging and to permit the floating of logs and tree limbs from the margin of the vega to the pond. These canals effectively drain the vegas.

Sediments deposited in ponds and vegas differ markedly. Vega sediments, after the initial shallow pond margins are filled, are deposited above the water table, where swift decomposition of organic materials occurs. Deposits in the study area tend to be pale in the absence of humus and unstratified. Vega-derived sediments seen in cutbank walls are well consolidated and form vertical cliffs. Vertical fissuring is prominent. Examination reveals scattered fossil shells, and no vertebrate remains were found, though no matrix of vega type was washed for fossils. The shallow, marginal parts of the original pond probably filled swiftly.

In contrast, sediments formed in the deeper parts of the beaver ponds tend to be stratified, dark in color, and rich in fossil shells. Vertebrate remains were found in every ancient beaver pond sampled. In searching for beaver pond deposits we looked for concentrations of fossil mollusk shells. Some such accumulations of shell, thought to be from ancient beaver ponds, were too small to justify excavation.

Vega deposits, especially at their lateral margins, often contain stringers of pebbles, isolated cobbles, and small groups of cobbles lying close together on a single level. The clast probably were transported during spring floods or deposited by ice during spring thaws.

The uppermost stratum studied in cutbanks is the "prairie soil." This loose, unstratified, sandy layer is somewhat yellowish in color. Wind has reworked this top layer since extermination of beavers by trappers more than a century ago. The Santa Fe Trail, a major highway of fur trappers, passed near Tesesquite Canyon, and beavers were completely exterminated from the area (e.g., Findley et al., 1975).

The level valley fill results largely from the

activities of beavers. Pioneering beaver colonies established dams that allowed fine sediments to gather in their ponds and on the vegas. As ponds filled with sandy silt, the beavers were forced to make new dams at higher levels with resultant broader vegas, and this continued until the advent of the mountain men.

The beaver pond origin of the fossiliferous sediments described must remain hypothetical, though we feel that the evidence at Tesesequite Creek is convincing. Ponds and lakes are simply closed depressions filled with water, differentiated primarily by the closure of the depression (e.g., landslide, ox-bow, fault). Bottom sediments are variable and probably not diagnostic. However, the presence of numerous lacustrine deposits in cutbanks of several small, high-gradient streams, where empondment other than by beaver dams does not, or only rarely, occurs today, suggests that our hypothesis is correct.

**MATERIALS AND METHODS**—We were limited in our studies by access to property and sometimes to the bed of the arroyos. Some arroyos are quite deep, but occasional cattle trails or cuts bulldozed by landowners permit passage. We selected sites where water was available and mollusk shells were concentrated. On no occasion did we note charcoal in the arroyo wall until after excavation. Charcoal was, however, present at all four Holocene sites, presumably derived from beaver dams or food logs stored in the pond bottoms.

Matrix was collected from zones 40 cm thick, and approximately 500 kg were obtained at each sample site. Matrix was screen-washed near the site and, thus, reduced to approximately 10% of its original weight. The resultant concentrate was dried and screen-washed by the method designed by Hibbard (1949) and, thus, reduced to <1 kg of pebbles and fossils.

Charcoal and shell were saved separately. Charcoal at the 101 Ranch, however, was so disseminated that it could not be saved. The amount of charcoal obtained at the Wiggins Ranch was insufficient for radiocarbon dating. Radiocarbon dates for these sites are based on fossil shell material. All radiocarbon dates were provided by Beta Analytic Inc., Miami, Florida.

**RESULTS AND DISCUSSION**—Vertebrate remains recovered include fishes, reptiles, amphibians, and mammals. C. W. Hibbard considered Pleistocene fossil sites worthy of collecting if samples yielded one mammal tooth to 100 pounds of matrix and one jaw to the ton. By this criterion, the Holocene sites reported here qualify as barely worth working. However, each collecting locality

furnished information about species of mammals that no longer live in the area.

**Tesesquite Pleistocene Local Fauna**—The Tesesequite local fauna was collected near the base of the cutbank of Tesesequite Arroyo, 6 km SSE of Kenton, Cimarron Co., Oklahoma (T4N, R1E, Sec. 4), and is described by Dalquest and Stangl (1989). Shell from the fossiliferous zone was radiocarbon dated at  $31,360 \pm 570$  YBP (Beta-22875). The following taxa were identified: *Notiosorex crawfordi*, *Sorex palustris*, *Mammuthus* or *Mammut*, *Sylvilagus* sp., *Tamias quadrivittatus*, *Spermophilus franklinii*, *Cynomys ludovicianus*, *Thomomys bottae*, *Perognathus* cf. *flavus*, *Peromyscus maniculatus*, *Neotoma* sp., *Microtus ochrogaster*, *Microtus pennsylvanicus*, *Microtus* sp., *Equus conversidens*.

This Pleistocene local fauna indicates marshy streamside habitat, perhaps narrow woodland along the stream, but the prairie dog and Franklin's ground squirrel show a prairie habitat at Tesesequite Canyon approximately 31,000 years ago and a fauna not greatly different from the modern fauna.

**Wiggins Ranch Subfossil Faunule**—The term "local fauna" was used by Wood et al. (1941) for assemblages of vertebrate taxa found as fossils at one geographic site and representing one short interval of time. We suggest the use of "subfossil fauna" (or faunule when faunal lists are small) for similar assemblages of <10,000 years in age. Subfossil faunas are probably more abundant than fossil local faunas and it seems desirable to separate them from local faunas, based on "true" fossils and from modern, living faunas.

The Wiggins Ranch lies 4 km S of the Colorado-Oklahoma boundary on the road (not on Oklahoma Highway System) leading north from the small town of Kenton. The collecting site is on Carrizozo Creek, 4.83 km N of the Cimarron River (T6N, R1E, Sec. 20) in a 35-cm thick seam of silt rich in mollusk shells. Sediments are unusually calcareous, and charcoal consists of fragments only. Shell material yielded a radiocarbon date of  $3,860 \pm 80$  YBP (Beta-27211). Vertebrate remains were largely of fishes, and only two mammals were identified (*P.* cf. *flavus*, *M.* cf. *ochrogaster*).

**Leighton Ranch Subfossil Faunule**—The Leighton Ranch is in Union Co., New Mexico (for account of geology see Baldwin and Muehlberger, 1959), south of the Cimarron River, 17 km W

and 3 km N of Kenton, Oklahoma, and 70 km E and 5 km N of Folsom, New Mexico (NE quarter, T31N, R35E, no section mapped).

We gathered matrix from the south cutbank of a small tributary of the Cimarron River, 3 km W of the Leighton ranch house. Two major strata are apparent in the cutbank: a younger, paler zone of vega sediments about 4 m thick and a harder, lower stratum of brown clay with many pebbles and abundant shells. In places, the vega stratum has been eroded away, leaving the lower stratum as a 3-m thick shelf. Our sample was taken 40 cm beneath the upper layer where shells were especially abundant. An agate hide scraper was found in place in the wall of the cutbank 1 m above the contact of upper and lower zones. Charcoal gave a radiocarbon date of  $3,770 \pm 70$  YBP (Beta-27210). Subfossil faunule included *Sylvilagus* sp., *Peromyscus* cf. *boylitii*, *Sigmodon hispidus*, *M. pennsylvanicus*, and *Microtus* sp.

**101 Ranch Subfossil Faunule**—The 101 Ranch subfossil faunule was recovered from a sample of matrix taken in the south wall of Tesesquite Arroyo, 4 km downstream (T4N, R1E, Sec. 26) from where the Tesesquite local fauna was collected. Mollusk shells and charcoal were abundant, but the charcoal was too finely disseminated to be used for radiocarbon analysis. Mollusk shells gave a radiocarbon date of  $2,630 \pm 80$  YBP (Beta-22876). Two archaeological artifacts, a dart point and part of a scraper (identifications by F. Wendorf, Southern Methodist University) were found in situ in the cutbank 2 m higher than and 50 m upstream from the collecting site. Isolated bones of fishes were common in the concentrate. Subfossil faunule consisted of *T. bottae* and *M. ochrogaster*.

**Carter Ranch Subfossil Faunule**—The Carter Ranch is located on Trampiros Creek in the bottom of a deep canyon cut through rolling short-grass prairie 50 km SW Clayton, Union Co., New Mexico (T22N, R35E, Sec. 32). The creek crosses into Hartley Co., Texas, as a tributary of the Canadian River. Outbanks are mostly low, rarely >5 m high. Charcoal from the site gave a radiocarbon date of  $530 \pm 60$  YBP (Beta-22877). Subfossil faunule consisted of *T. bottae*, *Neotoma* sp., *M. ochrogaster*, and *Bison bison*.

**Zoogeographic Implications**—The Pleistocene-aged Tesesquite local fauna, with 15 taxa, is largest in number of species but is based on 1,300 kg of matrix collected. The four subfossil faunules

were based on only 500-kg samples collected incidental to other studies. Nevertheless, taxa recorded from these sites add some information about the distribution of mammals during Holocene time. Four species merit special comment.

Remains of Holocene *T. bottae* were taken at the Carter Ranch and at the 101 Ranch. Both sites included lower premolars definitely referable to *T. bottae*. *Thomomys* does not presently occur at these sites. The species is found west of Rabbit Ear Mountain, Union Co., New Mexico (Best, 1973), which is 50 km SW of the 101 Ranch and 50 km NE of Trampiros Creek. Pocket gophers presently living at or near the 101 Ranch and the Carter Ranch are *Geomys bur-sarius* and *Cratogeomys castanops*, neither of which was found in the Holocene deposits. Additional holocene deposits must be investigated before the absence of these larger gophers can be proven. Our sample indicates that they did not occur there as recently as 500 YBP. Until that time, *T. bottae* occurred there, with the record at Tesesquite Canyon extending back to 31,000 years ago.

Goldman and Gardner (1947) described the cotton rats of southeastern Colorado as an endemic subspecies (*S. hispidus alfredi*) and speculated that the population in southeastern Colorado was relict, long isolated from the main range of the species. Mohlhenrich (1961) studied the cotton rats of New Mexico and thought the *Sigmodon* from Union Co. and adjacent Colorado were probably recent emigrants to the area. Mellott and Fleharty (1986) reported additional records from the range of the subspecies but pointed out two equally acceptable alternatives (recent emigrant and relict population) to explain the presence of *S. h. alfredi*. The discovery at the Leighton Ranch of a cotton rat maxilla with the three molars in deposits 3,370 YBP indicates that the latter postulate is correct and that cotton rats were present more than 3,000 years ago.

Pleistocene records of *M. ochrogaster* show a much wider past distribution than today (Graham and Semken, 1987). Presumably relict populations in southwestern Kansas, northeastern New Mexico, and eastern Colorado, all of which have been thought by some workers now to be extinct, nearly surround our Pleistocene and Holocene records from Tesesquite Creek and Union Co. Recent records from the Oklahoma Panhandle east of Cimarron Co. (Reed and Choate, 1988) and the northern Texas Panhandle (Jones et al.,

1988) indicate a wider distribution today than previously believed. Although we also found *M. ochrogaster* living in the Oklahoma Panhandle, we did not find them in Union Co.

The absence of teeth identifiable as *M. pennsylvanicus* at Holocene sites younger than the Leighton Ranch seems significant. The meadow vole prefers damp soil and lush vegetation, exactly the habitat existing along the margins of beaver ponds. Had meadow voles been present in Union Co. in the later Holocene (after 3,700 YBP), we would expect to have found their remains in our samples. *Microtus ochrogaster*, in contrast, prefers dry soils and shorter grasses. The more distant vegas would have been ideal habitat for this species, and its remains were found at all but the Leighton Ranch site. Fragments of vole teeth not identifiable to species were found at the Leighton Ranch and may have included *M. ochrogaster*. The record of the prairie vole extends back without apparent interruption for >30,000 years in northwestern Oklahoma and northeastern New Mexico.

Since remains of animals living along pond margins would be more likely to be preserved than those of vegas and *M. pennsylvanicus* was not found where teeth of the prairie vole were common, the meadow vole probably was absent at sites where we did not find its teeth.

Davis (1987) did not find *M. pennsylvanicus* in the numerous Archaic and Woodland age mammalian local faunas and faunules from Oklahoma and Kansas. Graham and Semken (1987) reported no meadow voles from 3,000 to 6,000 YBP Holocene faunas from Texas (latest record: Lubbock Lake Site, 6,000 to 8,000 YBP).

**CONCLUSIONS**—Sediments of beaver ponds may contain remains of vertebrates, including mammals, in direct association with mollusk remains and charcoal that can supply radiocarbon dates. Study of the vertebrate remains gives evidence for the past distribution of species during the Holocene. Sediments of ancient beaver ponds probably occur throughout the original geographic range of the beaver in North America. The sediments are buried but are often exposed in cutbanks where they may be recognized by sedimentary relations, the abundance of mollusk shells, and charcoal. We did not sample more than one Holocene site at any locality although we did note places where two or more beaver

pond deposits lay at different levels of the same cutbank. Superimposed layers of beaver pond deposits may yield long-term histories of mammal occupation. The extermination of beavers and elimination of their ponds a century ago must have had strong effect on the subsequent distribution of mammals in the study area.

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