

# **Ancient Climate as Inferred by Land Snails at the Brokenleg Bend Locality, Oklahoma**

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## **ABSTRACT**

This project is based on specifically identified terrestrial gastropod (land snail) shells recovered from a series of 12 sediment samples taken at the Brokenleg Bend Locality. Brokenleg Bend is a well-stratified, radiocarbon dated exposure located in Roger Mills County, Oklahoma. The 12 samples cover a temporal span from the Late Pleistocene (=Ice Age) into the Holocene (=Recent) Period. Changes in the relative abundance of individual gastropod species represented in the stratified sample series were used to infer that certain changes have taken place in that local environment and by extension the regional climate with (1) the maximum cold of the Late Pleistocene and (2) the shifts associated with the post-glacial Holocene.

## **INTRODUCTION**

Certain environmental conditions, particularly temperature and precipitation, are factors which limit the geographic range of terrestrial gastropods. As animals that are limited by specific environmental parameters certain gastropod species can be used as proxy indicators analogous to infer past environmental conditions and changes that have occurred in the climate/environment of an area over time. Gastropods can occur at a location due to a variety of reasons. They can be transported to a site by natural methods such as being airbourne, in the viscera of animals (Bobrowsky 1984:82 ; Klippel & Morey 1986:800), attached to the legs or feathers of birds, and as raparian drift (Bobrowsky 1984:81-82 ; Baerreis 1973:46). Gastropods deposited by raparian drift can simply be washed onto a site by themselves or attached to plant material such as logs and branches. In general, the majority of terrestrial gastropods within a site's sediments are present because they were natural inhabitants of the area. According to Bobrowsky (1984:82) most gastropod taxa found in deposits reflect the local environment at the time of deposition. At archaeological sites, gastropods of large size species may also be an indicator of subsistence practices.

Though gastropods can be used as an indicator of human subsistence practices one of their most useful aspects is that of an indicator of changing environmental conditions over time (Baerreis 1973:43-51). Though much about the environment can be learned from gastropod assemblages at a particular site or area, in many reports they are simply listed on a table at the end of the report but their significance to the research is never tabulated. "A substantial number of . . . reports contain an appendix in which a list of molluscan remains found at the site is presented, much as there might also be a list of mammal or other faunal remains. These lists frequently provide neither quantitative data nor

the specific provenience of the specimens tabulated . . . Such specimens then, give the report a facade of scientific accuracy and thoroughness, though in fact their value is quite limited." (Baerreis 1973:43).

In the analysis of gastropods the methods used in collecting and processing the samples are crucial to the outcome of the results. It is also important to examine the current environment and the stratigraphy of the site in order to assess the manner by which the gastropods have accumulated at the site. Are the snails the result of flood deposition, if at a rock shelter are they part of slump that may have fallen from the face above the opening. The method of collection and tabulation of the results from the samples can have a great impact on the analysis. In collecting the samples it is best that the gastropods are taken from all levels of the excavation in which they occur. In order to compare these samples it is important to have samples of like volume, there is not a reasonable manner in which to compare relative abundance between samples that are not of similar volume. In retaining all gastropods from the sediment samples it is important to use geologic sieves with a small size mesh. Much of the sample may be lost due to large mesh size screens thereby giving inaccurate results from the recovered data. ". . . other species of minute size are also missing. Thus while no statement is made as to collecting procedures, it is evident that the only gastropods reported are those which were retained in screens intended for the collection of artifacts. As a consequence, not only do we lack a substantial series of small gastropods, perhaps including some of the most sensitive forms . . ." (Baerreis 1973:48). If done correctly gastropod analysis can yield important information for the reconstruction of past environments.

#### Brokenleg Bend Locality, Roger Mills County, Oklahoma:

The Brokenleg Bend Locality (Figures 5 & 6) is a deep well-stratified exposure located (Fig.7) in Roger Mills County, northwestern Oklahoma. The calcarous soils of the exposure are rich in gastropods making it a prime location for analysis of gastropods. According to Thurmond and Wyckoff (1991) the exposure is located on the west side of Brokenleg Creek at an elevation of 2250 ft. above sea level; the creek itself is 100 feet below the upper surface. The soils at this site provide the opportunity to examine an accumulation that has occurred before, during, and after the last period of Pleistocene glaciation. The sediments at this site have not produced any vertebrate remains that might be used to infer climatic and environmental data but the presence of the terrestrial gastropods does present an opportunity.

## METHODS

A series of sediment samples (Fig. 8) were taken at the Brokenleg Bend Exposure on the Pete Thurmond Ranch located in Roger Mills County, Oklahoma. From these samples, a 1350 gm (=one liter) sediment sub-sample was processed through geologic sieves (mesh size of 0.425 mm) using a water separation technique to allow for the recovery of all gastropod shells. The gastropod shells from a single sample were treated as an assemblage. All complete and potentially identifiable shell fragments were removed from the screen captured sediment of each sample under a low power (10X) binocular microscope. The gastropod shells and fragments were sorted according to taxon for each sample and identified with standard reference manuals (e.g. Burch 1962; Pilsbry 1948). The identified gastropods were counted and placed in glass vials with

Table 1: Gastropods Recovered From Broken Leg Bend Exposure, Roger Mills Co., Oklahoma

Terrestrial Taxa	Snail Sample #	Holocene - Recent Climate									Cool Climate			
		1	2	3	4	5	6	7	8	9	10	11	12	
<i>Carychium exiguum</i>	(Say, 1822)	68	51	26	13	8	--	1	--	--	--	--	7	
<i>Gastrocopta armifera</i>	(Say, 1821)	10	--	15	9	21	6	9	3	2	7	7	8	
<i>Gastrocopta cristata</i>	(Pilsbry & Vanatta, 1909)	--	--	--	--	--	--	--	3	--	--	3	--	
<i>Gastrocopta hobbsperi</i>	(Sienki, 1886)	--	--	--	--	--	--	2	--	--	--	--	4	
<i>Gastrocopta pedicoides</i>	(Pfeiffer, 1941)	4	--	--	--	--	--	--	--	--	--	--	--	
<i>Gastrocopta procera</i>	(Say, 1821)	98	74	70	84	100	2	58	48	126	75	262	142	
<i>Gastrocopta procera</i>	(Gould, 1840)	6	--	2	6	40	13	2	3	--	2	--	--	
<i>Pupilla albaticus</i>	(C.S. Adams, 1841)	3	1	1	1	2	5	1	--	--	--	--	2	
<i>Vertigo gouldi</i>	(A. Binney, 1843)	--	--	--	--	4	--	--	--	--	--	--	--	
<i>Vertigo milium</i>	(Gould, 1840)	160	163	180	352	443	45	405	147	611	575	636	239	
<i>Vertigo ovata</i>	Say, 1822	1	--	--	--	--	2	49	30	25	2	10	21	
<i>Vallonia gracilicosta</i>	Reinhardt, 1883	--	--	--	1	--	--	23	4	53	--	--	--	
<i>Vallonia parvula</i>	A, 12	12	30	37	97	--	--	2	14	--	--	37	24	
<i>Vallonia</i> sp. ( <i>Juveniles</i> )	Sienki, 1893	--	--	23	76	69	1	2	25	--	6	77	1	
<i>Strobilopsis aeneus</i>	Pilsbry, 1926	3	26	16	12	5	--	--	--	--	--	--	12	
<i>Strobilopsis</i> ( <i>Juveniles</i> )	104	77	62	26	15	1	--	--	--	--	--	--	5	
<i>Helicodiscus parallelus</i>	(Say, 1817)	2	--	2	3	3	1	6	--	--	--	--	2	
<i>Helicodiscus singlyanus</i>	(Pilsbry, 1896)	--	--	2	5	--	3	--	--	--	--	--	18	
<i>Succinea</i> sp.	17	27	31	18	46	4	157	61	109	63	64	63	63	
<i>Cochlicopa lubrica</i>	(Muller, 1774)	3	2	--	--	--	--	--	--	109	--	--	--	
<i>Eucopelus</i> sp.	--	2	1	--	2	--	--	1	--	5	7	2	--	
<i>Malvalia minuticula</i>	(A. Binney, 1840)	11	50	76	100	79	5	19	8	--	40	192	76	
<i>Neoviverra electrica</i>	(Gould, 1841)	1	--	1	--	2	--	--	--	--	--	--	--	
<i>Dicopelus laevis</i>	(Muller, 1774)	110	29	44	33	--	1	21	21	20	37	56	--	
<i>Dicopelus</i> sp. ( <i>Juveniles</i> )	1	--	--	--	--	--	--	--	--	--	--	--	--	
<i>Stenotrema leaf alicia</i>	(Pilsbry, 1903)	--	--	--	--	1	--	--	--	--	--	--	1	
<i>Stenotrema</i> sp. ( <i>Juveniles</i> )	(Pilsbry, 1883)	--	1	--	--	--	--	--	--	--	--	--	--	
<i>Pupilla muscorum</i>	(Linnaeus, 1758)	--	--	--	--	--	1	96	13	63	--	--	--	
<i>Pupilla cf. muscorum</i> ( <i>Juveniles</i> )	--	--	--	--	--	--	56	13	148	--	--	--	--	
<i>Pupilla sonorana</i>	(Sienki, 1999)	--	--	--	--	--	--	--	--	--	--	--	1	
Subtotal		626	512	580	776	904	63	915	393	1178	818	1382	628	
Terrestrial Juveniles		236	423	401	1530	443	65	360	241	582	369	448	577	
Aquatic Gastropods		28	72	97	128	127	4	107	142	109	57	308	312	
		Present - 9000 BP Post - Pleistocene Glaciation (Holocene)					12,000 - 18,200 BP Wisconsinan Pleistocene Glacial Maximum				Before 18,000 BP Pre - Late Pleistocene Glacial Maximum			Total: 8760

Taxonomic nomenclature follows Turgeon et al. 1988.  
*Stenotrema leaf alicia* after A.B. Leonard (1959:86).  
 Each sample: 1350 grams = 1 liter.

labels stating their taxa and catalogued. The taxonomic nomenclature used is according to Turgeon et al. (1988).

## RESULTS

In all 16,246 terrestrial gastropods were assignable to 25 different terrestrial taxa and a few as yet unidentified aquatic taxa (Table 1). Of the 25 taxa present, I have narrowed my focus to four individual taxa for this project that indicate changes in the local environment. These individuals are *Carychium exiguum*, *Gastrocopta procera*, *Vallonia gracilicosta*, and *Pupilla muscorum* (Figures 1-4).

*Carychium exiguum* (Fig. 1) requires protection and moist conditions, is found in the detritus of moist deciduous woodlands and/or near spring seeps. Recent populations of *Carychium exiguum* can be found in the eastern United States in areas with these conditions. Pleistocene distribution of this gastropod species include Texas, Oklahoma, and Kansas (Hubricht 1985).

*Gastrocopta procera* (Fig. 2) requires at least 160 frost free days and prefers dry open habitats such as prairie/savanna vegetation communities (Baerreis 1980:108-109) and should not be found during the cooler period of the Pleistocene. The modern distribution of *Gastrocopta procera* is Iowa south to the Gulf of Mexico and running east becoming sparse as its distribution reaches the eastern coast. In Kansas the distribution of *Gastrocopta procera* suggests that this is a drought tolerant species (Taylor 1960). The Pleistocene fossil range is south of Oklahoma into Texas (Hubricht 1985).

*Vallonia gracilicosta* and *Pupilla muscorum* are both indicators of a cooler climate and would have been present in Roger Mills County, Oklahoma during the Pleistocene glacial maximum at circa 18,000 years before present. *Vallonia gracilicosta* (Fig. 3) is a species associated with cooler climates its prefers protected areas. Modern samples are isolated to northern areas such as the Dakotas (Hubricht 1985).

*Pupilla muscorum* is a species that prefers cooler northern climates. Its modern dis-

## Carychium exiguum

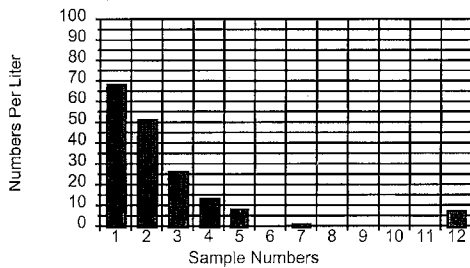


Figure 1

## Gastrocopta procera

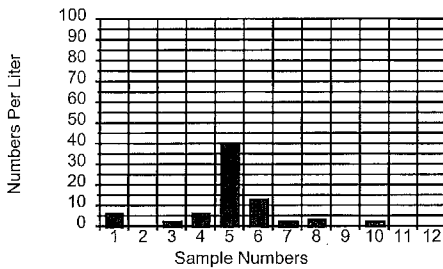


Figure 2

## Vallonia gracilicosta

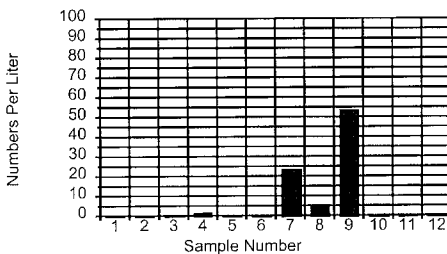


Figure 3

tribution is from Maine west to Michigan. It is usually found in grassy open areas. The fossil distribution of this species like *Vallonia gracilicosta* includes southern localities such as Texas, Oklahoma, and Kansas (Hubricht 1985).

As we can see from figures one through four moving forward in time starting with sample twelve and moving toward sample one the relative abundance of the indicator species changes. In samples six through nine representing the period of the Pleistocene glacial maximum there is the presence of *Vallonia gracilicosta* and *Pupilla muscorum*. As we move forward in time in the sequence with the end of the glacial maximum a warming and drying trend is indicated with the appearance of *Gastrocopta procera*. It is at this point that *Carychium exiguum* also appears.

In addition to the discussed species that point to a shift in climatic conditions throughout the sequence is the presence of *Vertigo milium*. This species lives in moist areas usually along heavily wooded streams or marshes (Frazan & Leonard 1947:367). This would suggest the possibility of a microhabitat that has persisted through time in this area in which *Vertigo milium* has been able to survive. However it is not known if this species still inhabits the local environment at the present time. It would appear that soil sample six in the sequence represents some sort of transitional point, it is at this sample that there is a distinct reduction in the relative quantity of all species of gastropods per sample and also the including *Vertigo milium* species found in marshy areas (Metcalf & Smartt 1997:32) Since this species

Smartt 1997:32) Since this species does not disappear from the sequence it would seem then that there is something unique which maintains the habitat for *Vertigo milium* (Fig. 9). This is perhaps the local spring.

**CONCLUSION**

Though the analysis of gastropods can be a useful tool in the reconstruction of past climates/environments it is becoming more widely recognized as being important archaeologically, paleontologically and geographically. The Brokenleg Bend Locality has afforded a unique opportunity to examine changes at a long well-stratified exposure. Moving forward in time through the sequence and comparing the relative numbers of species per sample it can be seen that change has taken place in the local environment in Roger Mills County, Oklahoma with the appearance and disappearance of certain species. In samples six through nine *Vallonia gracilicosta* and *Pupilla musorum*, two species now found living in more northern climatic zones or as alpine relicts (Hubricht 1985:66-68), are present during what appears in the sequence to represent the glacial maximum (Map 1). In examining sample six the species and their quantities are greatly reduced in number it is probable that this indicates a transition in the climate of the area it is at this point that *Vallonia gracilicosta*, *Pupilla musorum*, and *Vertigo ovata* disappear from the sequence. In samples one through five *Carychium exiguum* and *gastrocopta procera* are more indicative of the recent climatic conditions. With *Gastrocopta procera* inhabiting the open drier prairie environment and *Carychium exiguum* along the protected banks of the local spring feed stream.

**Pupilla musorum**

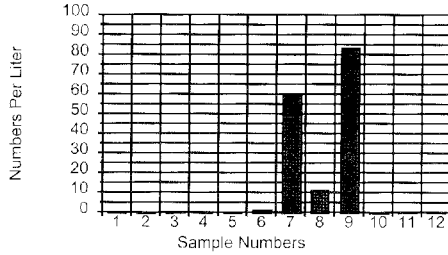


Figure 4

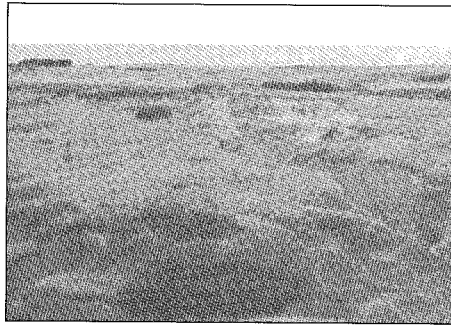


Figure 5: Overview of Brokenleg Bend Exposure

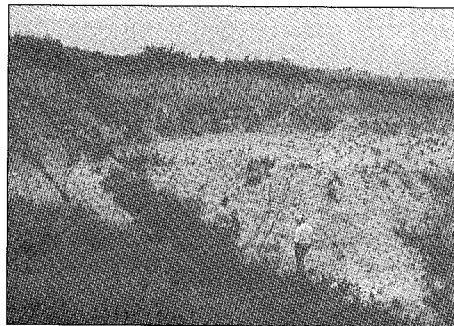


Figure 6: Brokenleg Bend Exposure (people for scale)

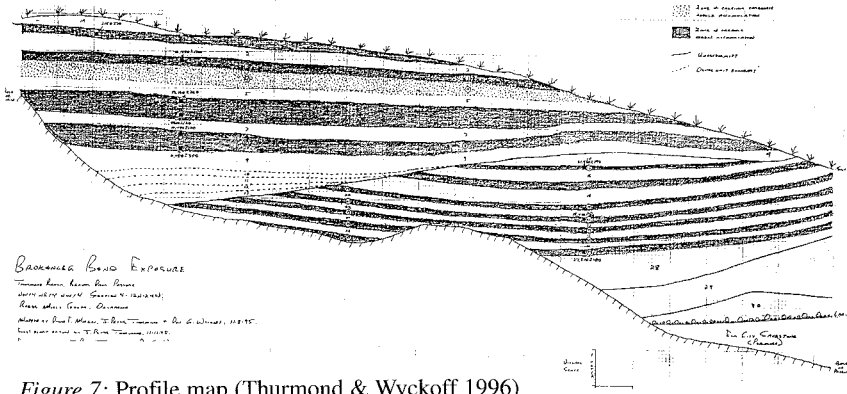


Figure 7: Profile map (Thurmond & Wyckoff 1996)

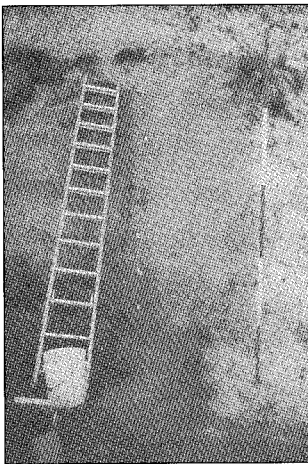


Figure 8: Brokenleg Bend sampling area

### Vertigo milium

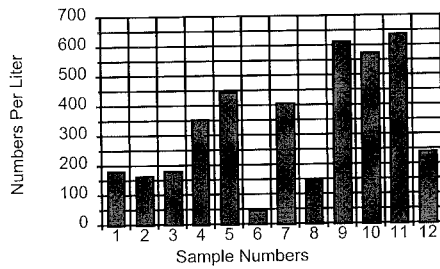


Figure 9

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