ty upland, with a heavy textured soil, high wilting coefficient, filtration rate, has a dominant vegetation of drought-resisting s. The limy upland and breaks site support an abundance of with the short grasses and were found to have soils with low fficients and high rates of water infiltration. However, the pports a dominant vegetation of tall and mid grasses but had high wilting coefficient and a low rate of water infiltration.

resence of the most mesic vegetation on the lowland indicates o soil moisture relation measurements do not completely mea- il moisture variations that exists between the four range sites n this paper. The direction and degree of slope and position e have tremendous influence on runoff and evaporation. The ceives most of the runoff water and thus is able to support a vegetation even though the soils are a little more droughty farther up the slope.

ugh many other characteristics of the habitat influence the n of the vegetation on mixed prairies of western Kansas the efficient of the soil and the rate of water infiltration into the o very important habitat factors influencing plant distribution.

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New Mollusk Records from Oklahoma and Their Zoogeographical Significance

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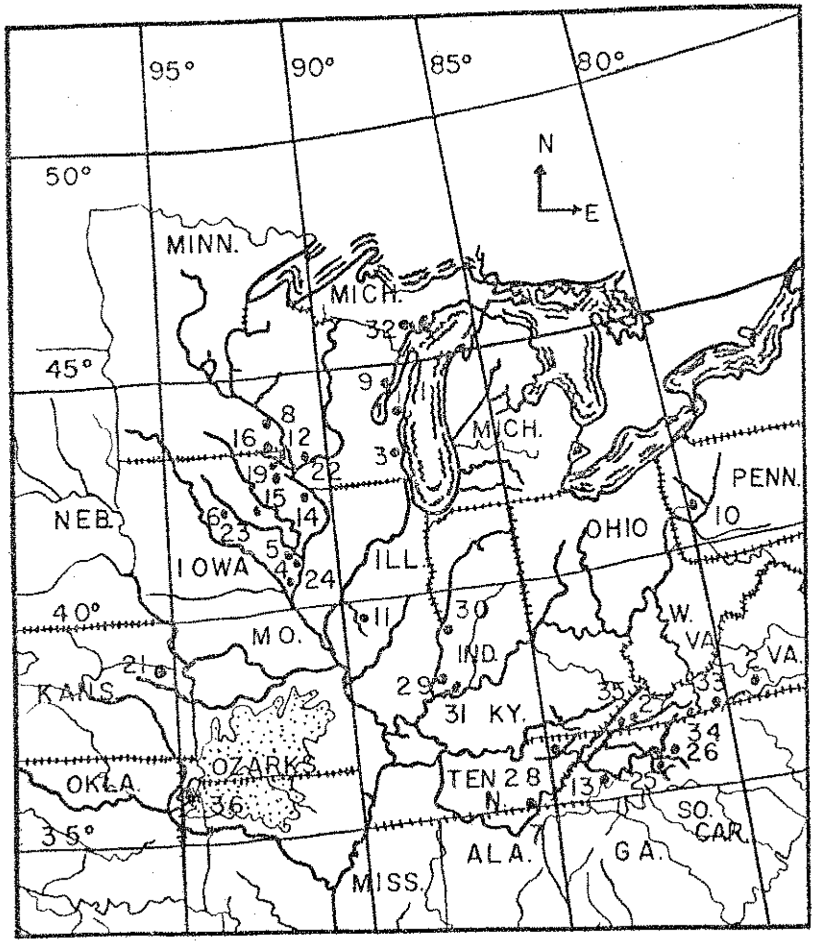
During the last three years the author has made some rather significant molluscan finds in the state of Oklahoma. All of these have important bearing upon the zoogeography of the western Ozarks and perhaps upon the systematics of some of the involved taxa. Oklahoma possesses a very large and diversified vertebrate and invertebrate fauna, a large percentage of which has affinities with the eastern United States. This eastern affinity is primarily the result of the Ozarkian Uplift and numerous west to east and west to southeast-flowing tributaries of the Mississippi River. The forested banks of these streams allow faunal exchange in the terrestrial fauna and the streams themselves offer pathways for the migration of aquatic forms. Five such migratory species are discussed below as examples of this faunal complex in the western Ozarks and Oklahoma in particular.

Hendersonia occulta (Say)

Four living specimens were collected on 14:IX:1962 from beneath forest litter and stones on the south bluffs of Elk River, a tributary of the Neosho, in Delaware County, Oklahoma. This site is located in the northern one-half of the northeastern one-fourth of section 13, township 25 north, range 24 east, approximately at 36° 37′ North Latitude, 90° 42′ West Longitude. This is the most southwestern locality known for living or fossil specimens (Map I) and only that of the specimens taken at Lawrence, Douglas County, Kansas (van der Schalie, 1939) lies any further west. The southernmost limits, as now understood, lie very near the south Tennessee border, but the species is known as a Pleistocene fossil from Latitude 32° 50′ North, Longitude 90° 25′ West, a site near the Zazoo River in Mississippi (Hubricht, 1960). Although the distribution of living *Hendersonia* is nearly all east of the Great Plains, Shimek (1904, 1906, 1913 and 1931) reported numerous Pleistocene fossils in areas much further west than this. As shown by Map I, *H. occulta* has an exceedingly spotted distribution. Pilsbry (1948) lists nine additional localities, all of which lie within the limits set by Map I. The reason that these localities were excluded from the map is that there is some doubt as to the correctness of Pilsbry's locality data.

Transactions of the Kansas Academy of Science, Vol. 66, No. 3, 1963.



Map I. Distribution of Recent Hendersonia occulta in North America (Modified from van der Schalie, 1939). 1, near Lake Michigan, Sheboygan, Wisconsin; 2, James River Drainage, Lexington, Virginia; 3, Whitefish Bay, north of Milwaukee; 4, Iowa River Drainage, Iowa City, Iowa; 5, Six miles north of Iowa City; 6, Iowa River Drainage, Eldora, Hardin County, Iowa; 7, Tennessee River, south of Pittsburg, Tennessee; 8, Mississippi River, Stockton and Winona, Minnesota; 9, Fox River, two miles south of, and on a small creek, 3 miles east of, Depere, Wisconsin; 10, Allegheny River, Wildwood and Cayuga, Pennsylvania; 11, Sangamon River Drainage, Athens, Illinois; 12, Iowa River, Decora, Iowa; 13, Rowan Creek, Cade's Cover, Tennessee; 14, Pine Hollow Creek, DuBuque County, Iowa; 15, Little Turkey Creek, Clayton County, Iowa; 16, Kendallville, Winneshiek County, Iowa; 17, Plymouth Rock, Winneshiek County, Iowa (same as 12); 19, Fort Atkinson, Winneshiek County, Iowa; 20, Whitefish Bay, Wisconsin (same as 3); 21, Kansas (Kaw) River, Lawrence, Douglas County, Kansas; 22, Kickapoo River floodplain, near Trout Creek, Wisconsin; 23, Red Cedar River, Vinton, Iowa; 24, Mississippi River, Fort Madison, Lee County, Iowa; 25, Nolichucky River Drainage, Mount Mitchell, Yancy County, North Carolina; 26, Pigeon Roost, Roan Mountain, Mitchell County, North Carolina; 27, St. Parul, Russell County, Virginia; 28, Emory River, Harriman, Roane County, Tennessee; 29, Wabash River, Vincennes, Knox Counnty, Indiana; 31, Ohio River, Mount Vernon, Posey County, Indiana; 32, Banks Park River, Delta County, Michigan; 33, James River Drainage, Natural Bridge, Rockbridge County, Virginia; 34, Reed Creek, New River Drainage, 12 miles southwest of Pulaski, Wythe County, Virginia; 35, four miles east of Blackwater, Clinch River Drainage, Scott County, Virginia; 36, south shore of Elk River, Neosho River Drainage, 36°37′ N. Lat., 94°42′ W. Long., Delaware County, Oklahoma.

Hendersonia often has been utilized as an index to the conditions existing during times of Pleistocene loess deposition. Shimek (1904) indicated that specimens were invariably found in habitats not subjected to inundation. However, later workers have not always substantiated this finding. Morrison (1929) found the species to be conspicuously absent from ravines lacking permanent streams but to be relatively abundant in the wooded slopes of similar areas with streams. He further indicated that the species was restricted to areas above flood-level marks. Van de Schalie (1939), and workers after him, have often found the species associated with streams and in shaded areas, sometimes below the flood level. In addition, fossil specimens are very often found in association with amphibious species such as *Pomatiopsis* (Hubricth, 1960; van der Schalie, 1939; Shimek, 1913) and even a passing glance at the overall distribution demonstrates that *Hendersonia* has a close association with streams. The conclusion is, then, that the western areas, now prairies, at one time were bisected by forested streams (van der Schalie, 1939).

The specimens herein reported from Oklahoma were taken from a well-shaded area having copious litter and limestone rocks. From the position of flood-deposited debris, this area is obviously sometimes inundated. Found with the *Hendersonia* were specimens of *Mesodon inflecta*, *Polygyra deltoidea*, *Euconulus chersinna*, *Oligyra* (=*Helicina*) *orbiculata* and *Paravitrea simpsoni*, nearly all hydrophiles. The mensurable details of the *H. occulta* are as follows (mm):

Height	*Great Diameter*	*Number of Whorls*
4.0	5.6	slightly more than 4
4.0	5.3	slightly more than 4
3.7	4.3	3¾
3.5	4.0	3½

All of the specimens are light buff in color, darker above, and possess three parallel revolving striae on the upper surface of the second whorl, four on the third and a total of ten (above and below) on the body whorl, the latter whorl being slightly angulated at its periphery. The operculum has about one-half turn. These specimens are deposited in the Zoological Museum of Kansas State College of Pittsburg (KSC 6982).

Close study of Map I, I believe, will point out a significant fact which former workers have failed to discuss. With the exception of two localities, 2 and 33, all of the known localities for *H. occulta* lie in the drainage system of the Mississippi River. The two exceptions lie in headwater tributaries of the James River of the Virginian Appalachian mountain system. In this region, the separation between the Atlantic Drainage and that of the Gulf of Mexico is very narrow, especially if the small tributaries of the Tennessee Drainage are scrutinized. These observations should allow us to make some conclusions as regards the zoogeographic affinities of *Hendersonia*.

The bulk of the Helicinidae lies in the tropics and subtropics. Consequently, this last-named area would seem to be the center of dispersal for these operculated land mollusks. *Hendersonia* is considered to be the most primitive living helicinid (Baker, 1925), its geologic history extending back to at least the Paleocene (Pilsbry, 1948). Utilizing the ecological and geographic distribution and paleontologic history, as now understood, the following is hypothesized. *Hendersonia occulta* probably entered the Mississippi River Drainage through the Gulf Costal Plains sometime during or before the Pleistocene. The first members of the genus may have filtered into the southern part of the Northern Hemisphere from the Old World Tropics (there are several species of Oriental *Hendersonia*) via the old Alaskan-Siberian land connection sometime before the Paleocene. There are early tertiary fossils representing the genus from the Western United States (D. W. Taylor, personal communication). Spreading northward, westward and eastward along the river tributaries of the Mississippi, *Hendersonia* would eventually meet various kinds of barriers. In the eastern United States, if the species is truly restricted to stream margins, its range could seldom extend beyond headwater streams because of mountain barriers. However, in the case of the colonies associated with the James River in Virginia, it is possible, since the Alleghenies are so very narrow at this point, that a faunal exchange occurred. In the west, mountains and lack of streams would again serve as barriers and in the north, frigid temperatures, especially the average lowest ones during the reproductive period, would function as barriers. With the onset of glaciation the northern and northwestern representatives would be extirpated, the species retracting southward, leaving behind isolated pockets. By this time the more advanced *Oligyra orbiculata* would have immigrated into the southern part of the range. The latter species, although often found along stream margins, is not ecologically restricted to them. It can survive for very long periods of time under rigorous conditions, sometimes approaching near dessication. Consequently, the southernmost members of *Hendersonia* probably perished, as have many organisms, because of competition with the better suited form. The great discontinuity between populations of *Hendersonia* seen today is the result of ecological advance and intraspecific competition, each population being a relict in regions where conditions have remained near enough to the ancestral ones to permit continued existance. All of this supports van der Schalie's (1939) contention that we can draw a great deal of insight from living *Hendersonia* as concerns the ecology of relatives and the conditions existing during past geologic stages.

Campeloma decisum (Say)

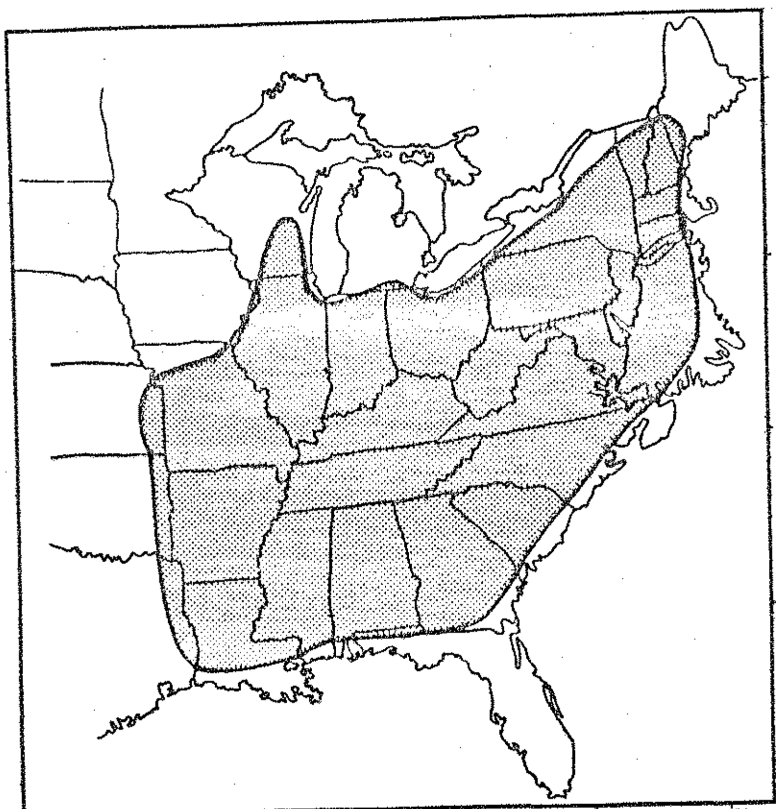
It has been pointed out often that few taxa of North America gastropods are in a more confused taxonomic state than *Campeloma* (Clench and Turner, 1956). A great deal of this confusion doubtless exists because of a lack of understanding of ecologic polymorphism and of geographic and ecologic distribution. *Campeloma*, as a genus, is distributed primarily in southern Canada, eastern United States and in the Mississippi Basin. Before and during Pleistocene glaciation some viviparid snails, possibly *Campeloma*, extended for considerable distances out onto the Great Plains (Taylor, 1960) but have now retracted towards the Mississippi. Members of this genus were considered by Leonard (1959) to be extinct in Kansas, but Branson (1963) found them to be abundant in the southeastern part of that state. In Oklahoma *Campeloma* is restricted to the extreme eastern counties in the south and to the Arkansas River Drainage in the north.

In a recent work Branson (1963) found that *C. decisum* was invariably associated with the mud around the roots of *Dianthera americana* (Linnaeus) in an Ozarkian stream of Kansas and Missouri (Shoal Creek). If the distribution of this plant (Map II) is compared with that of *Campeloma* there is found nearly a 100 percent correlation between the two. This could be coincidental or the result of the same kind of substrate requirements for the two types of organisms. However, in the streams sampled by this worker the plant seems to produce habitats for the snail by accumulating soil about its roots.

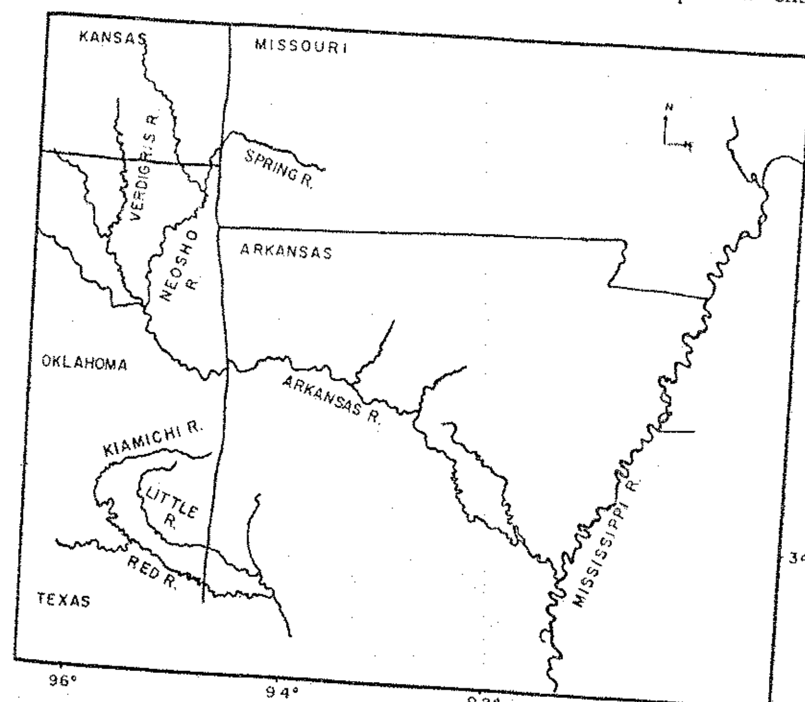
The ancestral home of the genus *Campeloma* is thought to lie somewhere in the lower Mississippi Basin. There are several substantiating reasons for such an assumption. In the first place *Campeloma*, and viviparids in general, although present, are relatively rare in western pleistocene deposits, indicating retraction towards the southeast. This distribution and retraction is very similar to that exhibited by centrarchid fishes. Furthermore, *C. decisum* exhibits definite positive rheotaxis, i. e., moves upstream against the current. Boubjerg (1952) observed marked and released specimens to move upstream, in both experimental and natural conditions, at a rate approaching ten meters per 24-hour period. Since *C. decisum* appears to be a parthenogentic species (Chamberlain, 1958; Mattox, 1938) such a rapid migratory form could rather quickly spread its range upstream, if proper habitats were available. It is known that plants also spread upstream (R. W. Kelting, personal communication) during migratory range extensions. Consequently, if *Dianthera* also originated in the southeastern United States and spread northward, and if *Campeloma* is truly ecologically associated with this plant, then there would be very close geologic rapport between the distribution of these two species of organisms, the snail not being able to advance any faster than the habitat-moderating plant.

From the lower Mississippi Basin *Campeloma* spread north and westward via the main river and its tributaries. As mentioned above, the Oklahoma population is divided into two subpopulations, one south, the other north. Map III shows the distribution of the Red and Arkansas River tributaries in eastern Kansas and Oklahoma. The southern population of Oklahoma *Campeloma* lies in McCurtain and southern LeFlore counties, both in the Kiamichi-Little River Systems, tributaries of the Red. This system is completely separated from the remaining populations by the Ouachita Mountains. The southern population, then, probably immigrated into Oklahoma, as well as east Texas, through the Austroriparian (Gulf Coastal Plains).

The Ouachita Mountains are separated from the Ozarks by the Arkansas River, which extends from the Mississippi Valley all the way through the mountains and across Oklahoma and Kansas. There is some indication that this drainage system was not greatly changed by the Ozarkian Uplift (A. B. Leonard, personal communication), since the river is deeply entrenched in several places. Erosion of the river bed probably took place at approximately the same rate as uplift. If this is true, then the Arkansas has been available for an exceedingly long period of time as a migratory route through the mountains. The next place in Oklahoma from which *Campeloma* is known is the Poteau River System, in Haskell and northern LeFlore counties, a direct tributary to the Arkansas River. This leads me to believe that *Campeloma* entered



Map II. Approximate Distribution of Water Willow, Dianthera americana (Linnaeus).



Map III. Major Tributaries of the Arkansas and Red Rivers in Eastern Kansas and Oklahoma.

Oklahoma through the Arkansas proper. All of the other records in Oklahoma also come from the Arkansas River Drainage. Consequently, it is possible that these northern forms are all the result of immigration through the Arkansas and its clearer tributaries. However, there is possibly a better explanation for at least a part of those from Ottawa County (extreme northeastern corner of the state) in the Neosho and Spring River drainages (Map III).

The Neosho heads in the Flint Hills of Morris County, near Parkerville, Kansas, and empties into the Arkansas 0.9 mile downstream from the mouth of the Verdigris River. The headwaters are, then, east of the central Kansas Uplift and south of the Saline Basin, the mouth lying in the Cherokee Basin (Moore, Frye, Jewett, Lee and O'Connor, 1951). Spring River, the largest tributary to the Neosho, arises near Aurora, Lawrence County, Missouri and become confluent with the Neosho about six miles north of Wyandotte, Ottawa County, Oklahoma. The largest tributary of Spring River is Shoal Creek, which heads near Exeter, Newton County, Missouri and empties five miles west of the east Kansas border, Cherokee County. The aforementioned Elk River is formed by Big and Little Sugar creeks near Pineville, Missouri and empties into the Neosho near the Oklahoma-Missouri line. These relationships are shown in Map IV.

The head of Shoal Creek proper lies at about 94th longitude, the distance between it and one of the main branches of the James River being only three miles. When the numerous small creeks are considered, the separating distance is less than a mile. The same is true of Elk River and the White, the headwaters of the former lying very close to some small tributaries of the latter. Although no one has yet throughly studied stream evolution in the Ozarks there is a very good chance that some sort of stream capture has occurred in this region. From several faunistic studies in the past and other presently in progress it would appear that the Neosho has captured the Spring River-Shoal Creek System, and possibly Elk River as well, from the White River Drainage. Smith (1956) found two specimens of the hellbender, *Crytobranchus alleganiensis* (Daudin), one in the Neosho River, Labette County, and one in Spring River, Cherokee County, Kansas. These specimes are typical *alleganiensis* and doubtless indicate faunal exchange. Moreover, Branson, Moore and Riggs (in preparation) found several fish species that also idicate faunal exchange with the White System.

With these facts in mind it can be seen that the *Campeloma* of northeastern Oklahoma and adjacent Kansas probably entered these regions because of stream capture between the Neosho and White River systems. This might also account for the Elk River population of *Hendersonia* discussed above.

The populations of northern Kansas *Campeloma* are probably the result of upstream migration along the Kansas (Kaw) River System.

Ferrissia rivularis (Say)

Numerous individuals of this limpet were collected on 16:VII:1962 from Warren's Branch on Spring River, ten miles northeast of Miami, Ottawa County, Oklahoma. This species is also abundant in Shoal Creek in Missouri and Kansas, all of these sites representing new distribution records. Again, as with the species discussed above, this is probably the result of immigration through the Spring River Drainage following stream capture. This is a primarily eastern and northern species, a few records being extant from eastern Nebraska.

Proptera Capax (Green)

This peculiar bivalve is generally distributed from the lower Ohio River System to the St. Francis River, a tributary of the Mississippi, in

Map IV. Spring Neosho River Systems Showing Nearness to James-White River Systems.

northeastern Arkansas, and north to eastern Iowa (Baker, 1928 b). However, it appears to be somewhat rare in the more northern areas, such as Indiana (Goodrich and van der Schalie, 1944). There are three more western records for this species. One of these, Elkhorn and Blue rivers in Nebraska (Simpson, 1914), appears to be invalid. The other record consists of a single female from the Neosho River in Lyon County, Kansas (Murray and Leonard, 1962). On 23:VII:1962 the author collected one male from the Verdigris River, two and one-half miles east of Lenapah, Nowata County, Oklahoma. This is the most western site known for the species and a new record for northern Oklahoma.

It is again significant that the Kansas record and that from Oklahoma lie in the Arkansas and Red river drainages. The Verdigris River (Map III), as indicated, empties into the Arkansas very close to the mouth of the Neosho. The route of entry for this mussel most certainly was through the Arkansas River. Since unionid glochidia are parasitic on the gills and skin of fishes it would be expected, if the clam lives in the middle or lower Mississippi Drainage, that sooner or later parasitized fishes would extend its range. The fish host for *P. capax* is unknown but is probably an ictalurid catfish, several species of which are known to range many miles up and down streams.

Eupera singleyi Pilsbry

Eupera, as a Recent genus, occurs in the West Indies, Central and South America, Mexico, southern United States and in Africa (Harrington, 1962), but in Eocene times was distributed in Europe, Western North America and China (Pilsbry and Bequaert, 1927). *Eupera singleyi*, type locality in Hudson County, Texas, is known from northern Florida, adjacent Georgia and westward through southern Louisiana into Texas and southwestward through Mexico (Clench and Turner, 1956).

On 10:VIII:1961, 30 live specimens of *E. singleyi* were collected from Briar Creek, near Willis, Marshall County, Oklahoma. Three of these specimens were deposited with the Department of Zoology, University of Oklahoma, Norman (Dr. Teague Self); the remaining specimens were retained by the author. This interesting species probably entered the United States from tropical America along the Gulf Costal Plains, as have several other mollusks. This may have been a relatively recent entry since the species is essentially restricted to the Austroriparian region. On the other hand, its present distribution may reflect retraction to the south with little or no northern spread in recent times. The Oklahoma site lies in the Red River Drainage, just outside of the Gulf Coastal Plains of that state.

Conclusions

Most of the data presented above indicate a distinct relationship of the western Ozarks, Texas, Oklahoma, Missouri and Kansas with the eastern United States, especially with the Mississippi Basin. The major forces which have molded these faunas have been mountain building, uplifting in general and stream capture followed by immigration and faunal exchange. Immigration of mussels may occur faster than in snails because of their parasitic phase in fishes. A southern element is represented, indicated by the presence of *Eupera* in the Red River Drainage of Oklahoma.

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Residual Premolar Roots in Pock

CHARLES L. DOUGLAS

Forty-seven percent of young specimens of th
that I examined, have a small sliver of dentine imm
least one premolar (P4). Each piece of dentine
of the anterior root of a deciduous P4, and the piec
mens that have recently lost at least one deciduous p
specimens of *Perognathus* examined, 60 were your
which retained a sliver of dentine.

Mice of the genus *Perognathus* have only one p
tooth row, both upper and lower. The milk premol
from its socket by the erupting permanent premolar.
roots of the milk premolars are shorter than the a
anterior root remains in contact with the maxilla c
lateral roots are completely free of the bone. The
premolar appears to exert much of its force direct
root of the deciduous premolar. The anterior root
molar is prevented from anterior movement by the
and from posterior movement by abutment of the
first molar. At this stage, further pressure by th
pressure from the sides during feeding, may cause th
of the anterior root to break off near the surface c
the deciduous premolar and retention, in the bone,
tip follow (Figure 1).

The following specimens in the University of
Natural History illustrate combinations of residual p
in specimens of *Perognathus*.

K.U. 73264 *Perognathus flavescens flavescens*. Sliver
to each upper and lower premolar. These residual premo
mm. externally from the maxillary surfaces, while those in
as stubs broken off even with the surface of the jaw (Fig

K.U. 49883 *Perognathus flavescens perniger*. The
premolar caps the half-erupted permanent premolar, and is
of the anterior root with the maxilla. The upper left d
been lost except for the anterior root that is broken off
the maxillary surface. No residual roots are present in th

K.U. 49886 *Perognathus flavescens perniger*. The ant
uous upper right premolar remains as a stub broken off e