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PLEUROCERIDAE OF THE GREAT BASIN

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DR. Carl L. Hubbs, while studying fishes of the Great Basin in 1934, found a form of *Goniobasis* in two springs of Long Valley, Washoe County, Nevada. To a student of the Pleuroceridae, to which *Goniobasis* belongs, the discovery was startling. For one thing, the Nevada area is so arid that at least parts of it can correctly be spoken of as desert, and pleurocerids are elsewhere occupants of regions of generous rainfall. For another, the waters which the Nevada shells inhabit have no connections with salt water, and this too is unknown to the record of other Pleuroceridae. Furthermore, the Great Basin, over a period of years, has been combed by geologists, paleontologists, and naturalists who were ardent collectors of examples of the recent fauna as well as that of the past. So far as the Mollusca were concerned, it was thought, until 1934, that all species of the Great Basin had been brought to scientific attention long ago.

The 1934 findings have undergone depauperization to such an extent that definite characters are wanting. No hint is provided by the shells as to their relationship with any known group of *Goniobasis,* whether of the near-by Pacific slope or of anywhere else. What is distinctive in the radulae is a reduction of denticles, corresponding to the absence or loss

of clearly cut features in the exo-skeleton. Two or three characteristics of the operculum point also to depauperization. A note was published on the findings (Goodrich, 1935), but it seemed inadvisable to describe the shells as new.

In 1942 Hubbs made a third expedition into the Great Basin. He found goniobases not only in the waters he visited in 1934, but also in two other parts of the area. It seems certain that the mollusks have been isolated for centuries and have gone through evolutionary processes determined by the stark environment, and must be considered, except phylogenetically, to be independent of forms now existing in streams flowing into the Pacific Ocean.

Goniobasis laurae

SHELL.—Conic, bister brown of Ridgway's *Color Standards and Color Nomenclature*. The spire of the type is eroded, four and one-half whorls being left. Matching of young and old specimens indicates that an entire, fully grown individual would be restricted to between seven and eight whorls. The whorls are exceedingly convex and all so alike that the body whorl is not flattened, a frequent occurrence in the genus.

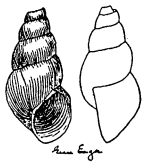

FIG. 1. *Goniobasis laurae.*

There are no carinae, plicae, or any revolving striae, except for a few discontinuous, wavy lines on the base, which, apparently, are adventitious. The axial growth lines are crowded and are rather evenly spaced. No varices exist which would point to a resting period of marked duration. Aperture ovate, small, slightly produced at the base. Columella white, narrow, with a wash of callus at the top. The outer lip is straight.

OPERCULUM.—Thin, reddish brown, broadly ovate, the apex acute, the base regularly rounded. Right margin frayed, the

left margin thickened in the older specimens and tending to be straight. The larger growth lines are not especially pronounced and do not show a change in spacing which commonly follows rest periods of length. The inner spiral lines are very loosely coiled, being suggestive of the paleo-melanian opercula of the *G. catenaria* group of the southeastern United States. The periphery of the last inner spiral just about touches the center of the operculum. The area of attachment is elongate, rounded at the apex rather than acute; in no specimen examined is there more than a slight thickening at the edges.

TYPE.—Height, 17.75 mm.; diameter, 8.50 mm.; aperture, 7.50 mm. measured from the outside, diameter, 5 mm.

TYPE LOCALITY.—Spring west of Home Camp, Long Valley, Washoe County, Nevada. Taken in 1934. Found also in the same year in Boulder Springs, Long Valley; in springs of Grasshopper Valley, Lassen County, California, 1942.

There is little variation in shape or color among the paratypes, and all the material is wanting in the carinae which, with one known exception, is the common feature of all species of *Goniobasis.* What remains of the soft parts, ignoring the operculum, is seen by transmitted light to be shrunken to a film of tissue tightly appressed to the axis. This bears out a general impression of depauperization. The species is named for Mrs. Laura C. Hubbs, who assisted in the collection of the shells.

Goniobasis interioris

SHELL.—Conic, the center of the lower whorls corresponding to the warm sepia of Ridgway (1912), the area bordering the sutures lighter in tone. Viewed under the lens, the type is seen to be somewhat rough and with discontinuous revolving lines in places. The growth lines are slightly erect, crowded, becoming unevenly spaced on the body whorl. Three varices on this whorl give indication of checks in growth in relatively short time. There are no carinae or plicae, and what may be called striae are broken lines probably brought about accidentally during the secretion of shell material. Spire eroded.

The five whorls which remain are decidedly convex. In other words, the sutures are very deep. Aperture ovate, a little produced; columella narrow, delicate, light-colored at the base, a little bluish above. The outer lip of the type is slightly curved.

OPERCULUM.—Larger and darker than in *G. laurae,* not quite so broadly ovate. The spiral lines are open. The left edge of the area of attachment is thickened; the sunken nucleus of the outer side of the operculum shows on this side as a slight mound.

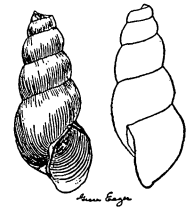

FIG. 2. *Goniobasis interioris.*

TYPE.—Height, 23.50 mm.; diameter, 9.75 mm.; aperture, 9 mm. measured from the outside, diameter, 5.75 mm.

TYPE LOCALITY.—Badger Creek, Bitner Ranch, Washoe County, Nevada. Collected in 1942. The species was found also in the outlet of artesian wells, nine miles west of Gerlach, Washoe County, Nevada.

Matched with entire juveniles, it would appear that an uneroded adult would have ten whorls. There are some differences in color among the adults, the pigment ranging in shades of brown. No signs are indicative of color bands. Because of a change in habit or of station, the young alter in texture from smooth to rough at about the fifth whorl. This is common in more eastern goniobases, particularly in the species of the northern Middle West. These juveniles are proportionally broader of base than the mature shells. The outer lips of all the young are straight. One adult is so malleated as to seem partially striated.

THE RADULAE

The centrals of the radulae of the two species are uniform, their shape varying only with the degree of pressure of the

cover glass of the slide. Their denticle formula is 2-1-2 to 3-1-3, the lower number being at the renewing end of the ribbon. No asymmetry was observed in the seven radulae that were examined. This is to say that no formula such as 2-1-3 or 3-1-2, which is fairly common in southeastern goniobases, was seen. A slight variation in numbers of denticles in the lateral teeth occurs, and this apparently without reference to position in the ribbon. The range is only from four to six, and can hardly be considered significant. The tooth is roughly triangular, twisted at the base and with an irregular lobe in the center. This lobe is more or less a common feature of laterals throughout the genus and is particularly marked in the related American genera *Io* and *Pleurocera* and in *Melanoides* of Japan and the Philippines. The lower parts of the marginals of the Nevada forms are clavate, symmetrical. A detached inner marginal which has retained its natural form is broadly folded at the tops and has three large, talon-like denticles. The denticles of outer marginals are four to five. These in eastern groups are harrow-like and in instances run up to twenty-five or so. Inner marginals or radulae of *G. silicula* of the Pacific slope drainage have five denticles, the outer marginals eight.

If any general conclusion is justified by a study of these interior basin *Goniobasis* radulae it is that the mouth organs have undergone depauperization in company with the exoskeleton.

ECOLOGICAL DATA

The following descriptions of the environment are made up of notes supplied by Dr. and Mrs. Hubbs:

Seepage springs west of Home Camp, Washoe County, Nevada, type locality of *G. laurae,* form a small stream, two to four feet wide, which runs about a mile to an irrigated meadow. The upper part of this discharge is stony and contains algae; the lower part is free of vegetation. Such holes in the stream as there are, are small, the water is swift and rather clear. From Boulder Springs, in the same valley, flows a clear, swift shallow stream about eight feet wide among boulders for about

an eighth of a mile. Lower down, the stream broadens and is floored with sand and mud, becomes warmer, less clear, and is more or less filled with algae and other vegetation. The Pleuroceridae are in the upper part, a robust *Lymnaea* in the lower. "Home Camp and Boulder springs are southern headwaters of the now almost entirely desiccated stream system of Long Valley (which contained a deep Pleistocene lake without outlet during the Pluvial Period). The elevation of Boulder Springs is 5778 feet, that of Home Camp springs about the same. The two are about seven miles apart."

The springs in Grasshopper Valley, Lassen County, California, where *G. laurae* was found in 1942, are on a stony hillside. The discharge is about fifteen inches deep, four feet wide. This stream is alternatingly swift and quiet, running for about a quarter mile. On the hillside are several spring channels, all clear, swift, cold, and of good taste. While there is almost no vegetation on the hillside, the discharges lower down are mostly choked with white water buttercup. Temperature, F. 65°; air, 85°. Two species of gastropods were common on stones and boards. "One kind of dace was common in the small creek fed by springs."

The bed of Badger Creek, Bitner Ranch, Washoe County, Nevada, where *G. interioris* was found in 1942, is firm to soft, of clay to mud. "The underground flow rises to the surface for about a quarter of a mile, due to lava outcroppings." Stream width is one to ten feet, depth up to three feet, the current slow to moderate. The water at the time of the visit was clear and of good taste. Temperature at the head of the flow, F. 65°; below, 69°; air, 78°. The vegetation in general near the spring rise is dense cress, type of *Potamogeton natans*, and algae below. "The stream course is in thirty-three sections above the junction with Fish Creek; the drainage is then north in a straight line ten miles to the Oregon line. The stream is tributary to the Guano Lake basin, a Pleistocene lake system, chiefly in south Oregon. There is evidence that Guano Lake overflowed into Lake Catlow, which had no Pluvial outlet." Shells were common, but not excessively abundant. "One species of fish, a chub, was abundant."

The outlet of artesian wells, nine miles west of Gerlach, Washoe County, Nevada—the locality of a second colony of *G. interioris*—has a run of about two hundred feet, spreading out into a meadow. The water is clear and of good quality, thick with water cress; current none to moderate. The depth is up to ten inches, "generally less." Width of the head pool is about ten feet, that of the stream two to four feet. Temperature, F. 66°; air, 91°. These waters occupy what was once a part of the floor of Lake Lahontan, "at times no doubt connected with the overflow from Deep Holes." This is the Deep Hole Spring that is marked on Russell's 1885 map, Plate VIII.

DISCUSSION

The eggs of the Pleuroceridae are small, flattened, rather cohesive masses that are made fast to stones, sticks, dead clam shells, and companion pleurocerids. They cannot, as is the case with ova of certain pulmonate gastropods, be carried from one drainage system into another unless the object on which deposit is made is taken also. No instance is known where a pleurocerid has crawled among the feathers of wildfowl, recorded of *Succinea,* or been caught on the legs of beetles, as observed in *Pisidium,* and by that demonstrating the possibility of overland transport. One transplantation by man has been registered (H. B. Baker, 1942). If there have been others, no account of them has been set down, nor have collections led to a suspicion of their occurrence. Ignoring the *Goniobasis* of the Great Basin for the moment, it can be said that no other way of distribution except water-borne distribution appears to have taken place.

There are a few instances in which this rule seems, off-hand, not to have governed. *Goniobasis virginica* and *Nitrocris carinata* inhabit Atlantic coastal plain streams that are unconnected. Yet these streams have been involved in intricate captures permitting interchanges of fauna. Stream piracy, reversal of stream flow by lava eruptions and landslides, crustal uplifts and depressions, have worked toward the same ends on the Pacific slope. Dr. Hubbs has suggested stream wanderings

among alluvial fans as another instrumentality in distribution there. Through water connection both Pleistocene and recent it has been possible for the Pleuroceridae of the Mississippi basin to invade the Great Lakes and to make their way down the St. Lawrence River. The range of one Great Lakes species, and perhaps that of a second, have been extended by way of the Erie Canal into the Hudson River. Three species of *Goniobasis* are in headwaters of the Alabama River system and creeks and springs of the near-by Tennessee River. Here again the exchange has been due in every probability to stream capture, and today in one area this appears imminent once more. The Anculosae, which are lower stream forms, have not been involved in the transfer. The Ohio River has acted as a barrier between goniobases of the Green River of Kentucky and of Ohio tributary streams to the east. Still, in two places, near together, the species distinctive of the upper creeks has been found in Green River branches. The area is that called karst, having surprisingly few surface streams, but an extensive underground drainage. It seems beyond question that undersurface piracy has occurred, and it is creditable that the species *G. semicarinata* (Say) did by that means cross from the Salt River into tributaries of the Green. This shell is known to live in an Indiana cave, and cavern life in Kentucky should not be impossible to it.

G. laurae of Grasshopper Valley, Lassen County, California, may have the distributional history of Pleuroceridae in general. The springs it here occupies belong to the basin of Madeline Plains, which has lost a stream to Pit River, inhabited by *Goniobasis*. The area is level, marshy, and stream flow has very likely swung back and forth. For irrigation purposes, a low dam has rediverted it with little trouble into the former direction. Dr. Hubbs's finding in the Madeline Plains supports the hypothesis that *G. laurae* of Grasshopper Valley may have its origin in Pit River of the Sacramento River system. "The only fish now occurring in the springs and limited streams of the Madeline Plains," he says, "are dace . . . . of a type indistinguishable from the local form of the Pit River system. . . .

During the beheading of the creek on the marshy flat there would no doubt have been ample opportunity for the transfer of dace from the Pit River division . . . . into the basin of Lake Madeline" (Hubbs and Miller, MS). If a transfer of fish, then also of mollusks.

The other Great Basin Pleuroceridae are not so readily accounted for. Long Valley, Washoe County, Nevada, in which two colonies were found, contained a pluvial lake that was without discharge. Badger Creek, in the same county, flowed into Guano Lake, which may have discharged into Lake Catlow; that lake failed to rise high enough in Pluvial times to overflow into Malheur basin, which was formerly a part of the Columbia River system (Hubbs and Miller, MS). The locality near Gerlach, also of Washoe County, in Pleistocene times lay under waters of Lake Lahontan that never rose high enough to establish union with the ocean. Either these interior basin shells got to their stations by ways unknown among other Pleuroceridae or are vestiges of a rich pleurocerid fauna of the continental interior traceable as far back as the Comanchean or Lower Cretaceous. Henderson (1935) listed about thirty Tertiary species of *Goniobasis,* a few of which occur in deposits within the Great Basin.

The localities for *G. laurae* herein given are not connected, and the same thing is true of those of *G. interioris.* In the absence of knowledge of ancestral forms, as well as of forms possibly existing which connect the shells with the stocks inhabiting Pacific slope waters, the hypothesis is offered that each separate colony of one of the two species (so recognized) reached its development under identical environmental influences; that is, degeneration in each instance has been brought to the same terms.

The depauperization that the two species have experienced is paralleled by similar phenomena in cold springs and torrent streams of the Appalachian region. This gives an effect of husbanding—as if in a struggle for survival everything superfluous has been discarded. Though perhaps more frequently observed in aquatic mollusks, depauperization occurs among

terrestrial gastropods also. Most commonly it is remarked by a reduction in size, and while the individuals of an impoverished colony may have the usual number of whorls to which a species is limited, each whorl is smaller than in shells of the species in a more suitable environment. *Triodopsis albolabris* (Say) of sandy districts of eastern Michigan in which the growing season is shortened is not only a small phase, but has failed to develop a parietal process. Hubbs (1940) has mentioned a number of forces that in the desert region have determined speciation among fishes—the tendency of waters to become alkaline, reduction of rainfall, reduction of streams to pools and hence a high rate of evaporation, floods following torrential rains, washing in of silt from the thinly vegetated surrounding country, high temperatures, and the roiling of water by cattle and other animals. These same forces work against the welfare of the pleurocerids.

The population of *G. laurae* of the Home Camp colony was very large. That depauperized Pleuroceridae occasionally appear to have an off-setting fecundity has been observed in the southeastern United States. Thus, *G. proxima* (Say) is biologically impoverished, but its colonies are often numerous in individuals. *G. aterina* (Lea) is a highland relative of *G. simplex* of lower altitudes. It is small, short-spired, wanting in easily definable characters. Its preferred habitat is a dashing mountain stream. Until its type locality, Gap Spring, Cumberland Gap, Tennessee, was modified by man, the mollusk was in such numbers that it blackened the rocks of the hillside for two or three hundred yards.

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