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DISTRIBUTION OF THE GASTROPODS OF THE
CAHABA RIVER, ALABAMA

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A FACT well recognized is that the molluscan fauna of a river alters as the stream itself alters in its course from headwaters to mouth. The alteration may be restricted to that of shell configuration within a given species, as in members of the *Lampsilis* group of Naiades of the larger Great Lakes affluents, or to the development of conspicuous sculpture, a striking illustration of which is *Io* of the Tennessee River system. Again, the changes may be within a group of closely related species, one such species succeeding or replacing another in the direction of stream flow. In certain rivers, the Cumberland and Tennessee to name two, an upstream genus, as it may be called, disappears, and its position of dominance is taken by another genus. For these transmutations or substitutions or successions, the term morphologic-geographic chains has been devised, useful and self-explanatory in spite of awkwardness.

The morphologic-geographic chains represent series of adaptations and so are correlated with the individual characteristics of each particular stream in which mollusca have acquired habitation. Examples may be mentioned. The Tennessee River undergoes a rejuvenation at Muscle Shoals, which is to say that the rapids here bring about a situation similar to that

of headwaters. Among responses to the alteration are that riverine forms of *Lithasia*, existing alone above the shoals, are associated in the rapids with small stream forms of the genus; *Goniobasis* which in this basin is a small stream genus succeeds for a short stretch in maintaining existence in the main stream; *Pleurocera* in a measure returns to headwaters proportions. The Coosa River is a nearly continuous juvenile water course from headstreams to Falls Line, a distance of about two hundred and fifty miles; *Goniobasis* is dominant not simply in headwaters, but also in the Coosa River into which they discharge. The Sequatchie River goes through such gradual changes that it is impossible to say where one stream characteristic leaves off and another begins. Measurements taken of three genera of Pleuroceridae inhabiting the river show that in each of them there is a gradual increase of the proportions of diameter to altitude in a downstream direction.

On the basis of pleurocerid distribution, the Cahaba River can be divided into three zones or sections. These zones are:

1. All that part of the river, together with tributaries, in Jefferson and Shelby counties. Most of the zone has a headwaters aspect, that is, the water in midsummer is shallow, fast-moving, and running over rocks and fairly coarse gravel. Aquatic vegetation is in no conspicuous amount. Near Acton is a section of nearly slack water, and elsewhere there are areas relatively deep that are the backwaters of dams. The zone contains a number of springs sufficiently large to harbor populations of Pleuroceridae.

2. The upper end of this zone is Lily Shoals, Bibb County, the lower end a few miles below Centerville, the same county. It has a few tributaries which are like the Cahaba headstreams rather than the second zone of the river itself. The habitats of Lily Shoals will later be described. There are rapids of somewhat heavy current just above Centerville. Below this point the river, although swift, runs between high, close banks which shelve off quickly into deep water. The pleurocerid population of this part of the river is small. The whole section will be spoken of hereafter as the transition zone.

3. This part of the river is below the Falls Line. The stream cuts through old marine and fluvial deposits. Near the lower end the river is bordered by bluffs of the Selma Chalk formation. In all the places seen in this section, the water is fast moving, and in the deeper parts it is difficult to stand up against. The pleurocerid population is virtually that of the Alabama River into which the Cahaba discharges.

The genus *Pleurocera* is of slender conformation in the transition zone of the river and wherever it occurs above it as well as in all tributaries. Below this zone the shells are heavier and of greater relative diameter. Members of *Anculosa* consist of one species and a localized race of it in the two upper zones, of two quite different species in the lowermost zone. (*A. compacta* is left out of the accounting inasmuch as its taxonomic position is not known to a certainty.) One group of *Goniobasis* is represented by a single species above the transition zone, by two in that zone itself, and by a fourth species in the flood plain area. In another group, there is a species of tributaries, one of the transition zone of the river and one of the lowermost section of the river. It may be said of all forms that they are distinct one from another. Forms confusingly bearing mixtures of specific characters have died out if ever they existed.

In parts of the river colonies of rapids-inhabiting pleurocerids are cut off from one another by stretches wherein the water is relatively deep and slow moving. In other parts the current is swift but moving over rolling gravel. Banks of sand had formed in the eddies in 1935. Plainly, conditions in such spots shifted from one shore to the other in time of freshet or took on new phases altogether. These differing environments quite obviously have played important roles in governing the distribution of species. It was found at Lily Shoals that quiet water over a bottom of silt hardly more than a quarter of an inch thick was largely unsuitable as a situation for *Goniobasis* and, apparently, entirely so for *Anculosa*. At the same time, it harbored great numbers of *Pleurocera*. Probably the deciding factors in distribution here had to do

with oxygen and food and adaptations thereto. Below one dam and in the impounded waters of another the living gastropods were old individuals, some of them showing the evidences of senility. Conditions proper either for breeding or for sustaining the young may by these findings be assumed to have been destroyed by the artificial structures. Tests of the hydrogen ion concentration at nine stations showed a marked uniformity throughout the length of the river. Check of alkalinity by the methyl orange method gave returns of 78 to 96 p.p.m. in the river, going downstream. In the Little Cahaba River of Jefferson County, this was as high as 131 p.p.m. Where a visit was made to Buck Creek, Shelby County, it was 133 p.p.m. In both of these last localities the current ran over limestone rock and gravel of limestone pebbles. Admittedly, plausible reasons for the succession of species, the downstream alteration of shell shape, and the intensification of sculpture in some instances in the same direction remain elusive.

The necessity of guarding water supplies for the Birmingham area has kept the Cahaba free of destructive domestic pollution. Yet that this is a potential peril to the aquatic fauna was attested in 1935 by the condition of one tributary in the district. The stream was black with sewage and offensively odoriferous. No living animals were seen in it. Domestic sewage to a certain amount supplies nutrients and does, as in parts of Lake Erie, increase molluscan life rather than decrease it. There is, however, a critical point in the saturation beyond which this kind of pollution acts injuriously. Rains and mine waters bring fine coal dust into upper parts of the Cahaba. A creek in which H. H. Smith found gastropods plentiful twenty-five years ago is no longer tenable for them because of this waste. Wash of cotton and cornfields has caused the river below Centerville in Bibb County to be turbid in the nearly rainless period of midsummer. Soil conservation activities, now in progress, may check this before silting entirely alters the character of stream flow in the flood plain area. As compared with numbers of other rivers, par-

ticularly in the north, the Cahaba is a clean river that can be rated as unusually exempt of man-made perversions.

The first collection of Cahaba River mollusca appears to have been made by E. R. Schowalter who practiced medicine at Uniontown, Dallas County, Alabama. He visited that part of the river where the road to Selma, the county seat, had its crossing. He collected at Centerville, farther upstream, and also at Montevallo in Shelby County, which is upon or within easy reach of several Cahaba tributaries. His shells were sent to Isaac Lea and J. G. Anthony who, with them, maintained a sort of rivalry in writing descriptions and devising names. All this was before, or at the beginning of, the War between the States. About twenty years after this war, R. E. Call was on the river at Lily Shoals in Bibb County. He brought away mollusks almost by the bushel. Unless T. H. Aldrich, whose guest he was, was there before him, Call was the first person to note the huge molluscan populations of Buck Creek, a Shelby County branch stream of the Cahaba. H. H. Smith undertook a systematic survey of the drainage basin, but seemingly did not get below Centerville. H. van der Schalie and W. J. Clench were on parts of the river in 1933, and in 1935 van der Schalie and I went from extreme headwaters to within a few miles of the river discharge.

ZONE 1

The Pleuroceridae consist of the following species:

<i>Goniobasis cahawbensis</i>	<i>Goniobasis cochilaris</i>
<i>Goniobasis carinocostata</i>	<i>Pleurocera vestitum</i>
<i>Goniobasis carinifera</i>	<i>Pleurocera foremanii</i>
<i>Goniobasis bella-crenata</i>	<i>Anculosa ampla</i>
<i>Goniobasis clara</i>	<i>Anculosa compacta</i>
<i>Goniobasis variata</i>	

G. cahawbensis and *carinocostata* are essentially upstream and tributary species. After the first two or three of the collecting stations of the main river they fall away in relative numbers. *G. carinifera* is more a species of the springs than these two. It was fairly common at the first two stations of

Little Cahaba River of Jefferson County below Leeds, but was not seen in the main river in Zone 1. *G. bella-crenata* is even more a form peculiarly adapted to the cold waters and circumscribed means of subsistence of springs. The first appearance of *G. clara* in the river in 1935 was at the second station. It amounted there to 17.2 per cent of all the Pleuroceridae collected. Thereafter, it increased in relative numbers until at the last station of the zone it was 77.7 per cent of the whole. The species is apparently confined to the Cahaba River and the mouths of a few tributaries. *G. variata* was found in small numbers in the Little Cahaba River of Jefferson County. Not many more were taken in the main Cahaba. The populous colonies are in tributaries of Shelby and Bibb counties. The distribution of *G. cochilaris* is confined to springs and spring brooks, and it is irregularly dispersed over the areas represented by the first two zones. The populations of goniobases in tributary streams are duplicates to a degree of those of the upper river. This may be illustrated by comparing the sizes of colonies of Peavine Creek, upstream, with those of Buck Creek, downstream, both in Shelby County.

	Peavine Creek near Pelham Per Cent	Buck Creek Helena Per Cent
<i>Goniobasis cahawbensis</i>	23.1	3.4
<i>Goniobasis carinocostata</i>	8.6	1.9
<i>Goniobasis carinifera</i>	7.2	1.0
<i>Goniobasis variata</i>	60.9	93.6

It will be observed that the relative numbers of the first three species drop away in a downstream direction, those of the fourth species increase.

Pleurocera vestitum appears first in the Cahaba River near Anita, Shelby County. It is nowhere common within Zone 1. *Anculosa ampla* was found in 1935 in the little Cahaba River of Jefferson County, one mile below Leeds, a single specimen being taken. It was not seen again in the upper part of the zone, but was very common in the lower part. *A. compacta* is rather rare among pleurocerids of Zone 1, but it has been collected in small numbers from the main river near Henry

Ellen, Jefferson County, to the Old Tuscaloosa Pike Crossing, Shelby County.

Gastropods other than the Pleuroceridae which have been found in Zone 1 are:

<i>Lymnaea columella</i> Say	<i>Rhodacmea cahawbensis</i> Walker
<i>Lymnaea humilis</i> Say	<i>Somatogyrus nanus</i> Walker
<i>Helisoma antrosom</i> (Conrad)	<i>Somatogyrus obtusus</i> Walker
<i>Gyraulus parvus</i> (Say)	<i>Lioplax cyclostomatiformis</i> Lea
<i>Physa pomilia</i> Conrad	<i>Campeloma lewisii</i> Walker
<i>Ferrissia fusca</i> (C. B. Adams)	<i>Lepyrium showalterii cahawbaensis</i>
<i>Ferrissia rivularis</i> (Say)	Pilsbry
<i>Ferrissia tarda</i> (Say)	

THE TRANSITION ZONE

The Pleuroceridae which inhabit this part of the river are:

<i>Goniobasis annettae</i>	<i>Goniobasis ampla</i>
<i>Goniobasis varians</i>	<i>Pleurocera vestitum</i>
<i>Goniobasis showalterii</i>	<i>Pleurocera foremanii</i>
<i>Goniobasis variata</i>	<i>Anculosa ampla</i>
<i>Goniobasis clara</i>	<i>Anculosa compacta</i>

The pleurocerid assemblance of Lily Shoals, Bibb County, is so plainly marked off from that farther upstream that the locality is assumed to be the head of the transition zone, although it is probable that there is some gradation or intermingling of forms in a part of the river which has not been visited. Lily Shoals occupies a six- or eight-mile section of the main stream, part of it between steep hills constituting what may be termed a gorge. In the part of the shoals which was examined in 1935 are two sets of rapids, one of moderate current and one of heavy. There are also reefs parallel with stream flow which are demarked from one another by clumps of water willow. Some of the depressions between the reefs are pools of slack water. In one place is a flat rock about twenty feet long by twelve feet wide. The water upon it is shallow, slow moving; the rock itself is covered by a film of fine silt. The different situations permitted selective collecting and their description here as distinctive habitats. The occur-

rence of the Pleuroceridae in these varying habitats, together with the relative abundance of species, is herewith recorded.

Shallow rapids, with scattered stones, current moderate:

	Per Cent
<i>Goniobasis annettae</i>	2.3
<i>Goniobasis clara</i>	2.3
<i>Goniobasis showalterii</i>	38.4
<i>Anculosa ampla</i>	55.9
<i>Anculosa compacta</i>	0.7
<i>Pleurocera vestitum</i>	0.2

Rapids of strong current, continuous from reef to left bank, deep in center:

	Per Cent
<i>Goniobasis annettae</i>	66.6
<i>Goniobasis clara</i>	7.0
<i>Goniobasis showalterii</i>	7.0
<i>Anculosa ampla</i>	16.2
<i>Pleurocera vestitum</i>	3.0

Pools between reefs, water slack or very slow moving:

	Per Cent
<i>Goniobasis annettae</i>	63.0
<i>Pleurocera vestitum</i>	37.0

Backwater, nearly currentless:

	Per Cent
<i>Goniobasis annettae</i>	48.1
<i>Pleurocera vestitum</i>	51.9

Scattered rocks near bank, water slow moving:

	Per Cent
<i>Goniobasis annettae</i>	43.9
<i>Pleurocera vestitum</i>	56.0

Flat, silt-covered limestone rock, current scarcely perceptible:

	Per Cent
<i>Goniobasis annettae</i>	41.5
<i>Goniobasis showalterii</i>	0.5
<i>Pleurocera vestitum</i>	57.9

It will be observed that *G. annettae* occupies all of the habi-

tats, that *G. clara* is confined to rapids, and that *G. showalterii*, in only one place and in small numbers, occurs in a silty, nearly currentless situation. The two Anculosae are inhabitants of rapids, the most flourishing colony of one of them being in rapids with strong current. *Pleurocera* is to be considered as normally suited to slack water, but capable of maintaining a foothold even in a vigorous current.

A box of unsorted shells taken by H. H. Smith in the river near Piper was sent to me for examination by the Alabama Museum of Natural History. The species are those of Lily Shoals with the addition of *G. ampla*, amounting to about 5 per cent of all the Pleuroceridae. At Pratt's Ferry, farther downstream, Smith took *G. varians*, belonging to the group of *G. cahawbensis* as *G. annettae* does, and in course of supplanting this latter form. *G. clara* is here in relatively few numbers. At Centerville, it is altogether absent, *G. showalterii* is the commonest species, and *G. varians* 17.1 per cent of the pleurocerid population.

Of the ten species known to occur in the transition zone, eight are definitely of riverine type. *G. variata*, rarely found in the main Cahaba, is probably a straggler from smaller streams, *P. foremanii* a phase of *vestitum* explainable as a reversion.

Pleuroceridae of the tributaries of this zone of the river consist of:

<i>Goniobasis cahawbensis</i>	<i>Goniobasis cochlearis</i>
<i>Goniobasis cahawbensis fraterna</i>	<i>Goniobasis variata</i>
<i>Goniobasis carinocostata</i>	<i>Pleurocera vestitum</i>
<i>Goniobasis carinifera</i>	<i>Anculosa ampla mimica</i>
<i>Goniobasis bella-crenata</i>	

Seven of the species are almost exclusively small stream or spring inhabitants. *P. vestitum* has established small colonies in a few creeks, but a large one in one of the tributaries. The race of *A. ampla* in the Little Cahaba River of Bibb County is uniformly of the phase named *mimica*. This form appears as variants among the main river Anculosae.

Other gastropods than Pleuroceridae which are known to inhabit the transition zone and its tributaries are:

<i>Lymnaea humilis</i> Say	<i>Campeloma lewisii</i> Walker
<i>Lymnaea columella</i> Say	<i>Campeloma ponderosum coarctatum</i>
<i>Rhodacmea filosa</i> (Conrad)	(Lea)
<i>Physa pomilia</i> Conrad	<i>Lepyrium showalterii cahawbaensis</i>
<i>Somatogyrus nanus</i> Walker	Pilsbry
<i>Lioplax cyclostomatiformis</i> Lea	

ZONE 3

The Pleuroceridae of this, the lowermost, zone are:

<i>Goniobasis pupoidea</i>	<i>Anculosa taeniata</i>
<i>Goniobasis olivula</i>	<i>Anculosa picta</i>
<i>Pleurocera prasinatum</i>	

Faunistically, this zone is more sharply cut off from the transition zone just above it in the river than this latter zone is differentiated from the section inhabited by Pleuroceridae of headwaters footing or guise. Taxonomically, the relationships are closer than might be indicated by the specific names. *G. pupoidea* belongs to the same group as *G. cahawbensis*, *annettae*, and *varians*; *G. olivula* to the same group as *G. showalterii* and *variata*. The alteration of *P. vestitum* to *prasinatum*, so far as shell characters alone show, is mainly from a shell of relatively narrow diameter to relatively wide diameter. The two species of *Anculosa* appear to be invasions from the Alabama River into which the Cahaba discharges.

The numbers of *G. pupoidea* taken amounted to 33.4 per cent of all the pleurocerids collected at the uppermost station of the zone. They increased progressively downstream until at the last station they were 98.1 per cent of all the Pleuroceridae. *G. olivula* represented 10.1 and 40.6 per cent of the first two stations respectively, but thereafter dropped away rapidly. The greatest number of *P. prasinatum*, 15.6 per cent, was collected at the second station. *A. taeniata* was seen only at the first station, *A. picta* at the last only.

The only known tributary pleurocerid of the zone is *G. cahawbensis*. Gastropods other than Pleuroceridae which have been collected in the river in the area are *Campeloma ponderosum coarctatum* and an *Amnicola*, species unknown.

THE SPECIES INDIVIDUALLY CONSIDERED

Pleurocera vestitum (Conrad)

Melania vestita Conrad, *New Fresh Water Shells of the United States*, 1834, pp. 57, Pl. 8, Fig. 12.

The genus *Pleurocera* represents one of the instances, not rare in the taxonomy of the Mollusca, wherein the absence of clearly cut, easily described characters brings about a multiplicity of confusing names. The synonymy of *P. vestitum* might be made long and formidable. Indeed, it might be replaced by some earlier named and described species. The work, however, would be vain until a proper system of nomenclature is devised to care for species, so-called, that, by every indication, are no more than examples of responses to environmental conditions. The name here used has been selected because it is that given to the mollusk most nearly resembling the one under immediate consideration and the type locality, of which, small streams of Greene County, Alabama, is not far from the Cahaba River basin.

P. vestitum was found in 1935 in the Cahaba first at Nunley Ford, Shelby County, but there are records of its occurrence above this station. The largest numbers were collected on Lily Shoals. The distribution there by habitat was found to be:

	Number of Specimens
Rapids above bridge, moderate current	1
Rapids below bridge, heavy current	3
Pools above bridge	98
On stones in slow water below bridge	74
Pools below bridge	82
On broad flat rock below bridge	106

The preferred habitat plainly is in slowly moving water and where there is an accumulation of silt.

Measurements show that the diameter of the shell relative to altitude increases slowly in a downstream direction. The index of obesity is as high as 81.6 per cent in the material taken by H. H. Smith near Piper, Bibb County, the figure contrasting with 69.2 per cent which is the index of obesity of twenty-five

shells from Town Creek, Montevallo, Shelby County. An irregular but definite increase in the relative number of banded shells as collections were made downstream was noted.

The range of *P. vestitum* in the main Cahaba River is from above Acton, Jefferson County, to two miles east of Harrisburg, Bibb County. The mollusk is present in creeks of Shelby and Bibb counties, but more rarely in those of Jefferson County. The Alabama Museum of Natural History has specimens from a creek near Selma, Dallas County.

Pleurocera foremanii (Lea)

Melania foremanii Lea, *Proc. Amer. Phil. Soc.*, 2(1842): 242.

The most striking character of this pleurocerid is the development of nodulous sculpture on the maturing and adult whorls. Less conspicuous is a somewhat elongate body whorl which is the outward token of an elongate-ovate aperture. *P. foremanii* in the Coosa River bears no sign of very close relationship with the associated *P. prasinatum*, but in the Cahaba River it appears to be only a mutation of *P. vestitum*. If speculation is warranted in the instance, the nodulous sculpture may be taken to be an ancient character, evolved from plicate sculpture, that in the Cahaba represents reversion. The only known Cahaba locality is Pratt's Ferry, Bibb County. The specimens were collected by H. H. Smith.

Pleurocera prasinatum (Conrad)

Melania prasinata Conrad, *Amer. Journ. Sci.*, 25(1834): 342, Pl. 1, Fig. 14.

This is a thick-shelled *Pleurocera* of relatively wide diameter. Beyond shape and size, it is lacking in definite characters. It was seen first in 1935 in the Cahaba River eight miles north of Sprott, Perry County, and appeared at all the stations below this point. *P. prasinatum* of the Cahaba is to be considered a downstream extension of *P. vestitum*. The same form occurs in downstream habitats of the Coosa, Tombigbee, and Black Warrior rivers. In each river, it merges with less ponderous up-river forms. It has not been seen in tributaries of the Cahaba River, although in the Coosa River basin it has penetrated a few tributaries for a short distance above the mouths.

Goniobasis carinocostata (Lea)

Melania carinocostata Lea, *Proc. Amer. Phil. Soc.*, 4(1845): 165.

Melania textilosa Anthony, *Annals Lyc. Nat. Hist. New York*, 6(1854): 101, Pl. 2, Fig. 20.

Melania scabrella Anthony, Reeve, *Monograph Melania*, 1861, Sp. 388.

Goniobasis strenua Lea, *Proc. Acad. Nat. Sci. Phila.*, 14(1862): 267.

The species amounted to 47.6 per cent of the whole number of pleurocerids found at the uppermost station of the Cahaba River. It decreased rapidly, although irregularly, as collections were made downstream. At Nunley Ford, Shelby County, where it was last seen in the river, *carinocostata* constituted only 1.9 per cent of all the Pleuroceridae taken. A similar decrease in a downstream direction was observed in the collections of the species in Little Cahaba River of Jefferson County. *G. carinocostata* was not seen in the Little Cahaba River of Bibb County, but H. H. Smith found it to be fairly plentiful in tributaries of the stream at and around Montevallo. The species, therefore, is to be considered a headwaters and small stream *Goniobasis*. It has been seen also in springs and brooks of the upper Alabama River system.

No correlation appears to exist between the index of obesity and position in stream so far as the collections of 1935 are concerned. In the matter of banding, there is an increase downstream in the Cahaba River, but the reverse is true of the shells of the Little Cahaba River of Jefferson County. As a whole, the species is fairly uniform in shape, color, banding, and sculpture. It may be said here that this is observable in many headstream goniobases of other drainage basins.

Tryon (1873) lists *Melania scabriuscula* Brot among the synonyms of *carinocostata*. It occurs as a nude name in *Matériaux pour servir à l'étude de la famille des Mélaniens* (Geneva, 1862, p. 36). I cannot find that it has ever been described.

Goniobasis cahawbensis (Lea)

Melania cahawbensis Lea, *Proc. Acad. Nat. Sci. Phila.*, 13(1861): 121.

Melania tenera Anthony, Reeve, *Monograph Melania*, April, 1861, Sp. 407 (preoccupied).

Melania paula Lea, *Proc. Acad. Nat. Sci. Phila.*, 13(1861): 122.

Goniobasis intercedens Lea, *Proc. Acad. Nat. Sci. Phila.*, 14(1862): 265.
Goniobasis quadricincta Lea (in part), *Proc. Acad. Nat. Sci. Phila.*,
16(1864): 112.

This is essentially a small stream species. In the Cahaba River at Trussville, 52.4 per cent of the goniobases taken were *cahawbensis*. The percentage rose to 64.6 at the next station below, but thereafter the species dropped off rapidly in relative numbers. It amounted to only 0.4 per cent in the Cahaba at the Old Tuscaloosa Pike crossing. A single specimen was found in the locality eight miles north of Sprott, and a rolled and worn individual turned up in one of the Dallas County collecting spots. It appears certain that in both of these instances the shells had been washed in from nearby creeks or brooks. The species is a common one of Cahaba tributaries, especially the northern ones, and it has been taken in a few instances in springs.

The ratio of diameter to altitude varies within a narrow range, and nowhere appears to be correlated with position in stream. Shells of the upper river and those of its creeks are banded in about equal numbers, but among specimens taken from two spring branches no individual was found which had these stripes of pigmentation.

G. cahawbensis may possibly be replaced by *Melania cinnamomea* Anthony, Reeve (*Monograph of Melania*, March, 1861, Sp. 379). The figure resembles *cahawbensis*, but the type, according to the description, is "sculptured with longitudinal close-set striae and transverse keel-like wrinkles," an ornamentation which, if it occurs in *cahawbensis*, is exceedingly rare. *G. quadricincta* is described as from both the Coosa and Cahaba rivers. The Coosa shells are the same as *Melania fascians* Lea, 1861. *G. cahawbensis* has been distributed through error as *G. vicina* (Anthony), the types of which proved on re-examination to be one of the forms of *Lithasia obovata* (Say) of Kentucky.

Goniobasis cahawbensis fraterna (Lea)

Goniobasis fraterna Lea, *Proc. Acad. Nat. Sci. Phila.*, 16(1864): 111.

Shells sent to Lea by Schowalter, examples of which are in the Alabama Museum of Natural History, appear to be identi-

cal with this subspecies. They differ from the more typical *cahawbensis* in having much more loosely coiled juvenile whorls, and in their uniform smallness. In occasional specimens, the carinae of the spire are continued as a keel or angulation to the body whorl. The museum material is assigned to a branch of the Cahaba River in Bibb County. The locality has not been rediscovered. Somewhat similar specimens occur in Murphy's Creek, Blount County, Alabama. This is in the drainage basin of the Black Warrior River.

Goniobasis annettae Goodrich

Goniobasis annettae Goodrich, *Occ. Papers Mus. Zool. Univ. Mich.*, 426(1941): 1.

As *G. cahawbensis* disappears from the river, *G. annettae* takes its place. It is like the earlier species in having a loosely coiled spire, a small aperture and a sinuous outer lip. The operculum of the two shells is the same. *G. annettae* is cylindrical in shape, whereas the other is uniformly conic. Occasional shells are striate over the whole disk and, in the collections made by Call in the 1880's, have been separated erroneously as *G. sulcata* Lea. The species was taken in all six of the habitats into which Lily Shoals at the place visited in 1935 could be divided, the greatest numbers being between the locality having a heavy current and the one of slack water and muddy bottom.

Goniobasis varians (Lea)

Melania varians Lea, *Proc. Acad. Nat. Sci. Phila.*, 13(1861): 120.

This is a heavy, rather rough species with much the same general aspect of Coosa River goniobases. Lea, in fact, gave Coosa River as the type locality, but his shells, preserved in the United States National Museum, are labeled as from "Cahawba River." The mollusk is elongate to ventricose, usually striate, but not always. The aperture is ovate and small as compared with length of shell. The young are pyramidal, and while much like the juveniles of *cahawbensis* they tend to be tightly coiled as well as loosely coiled. The average index of obesity for shells of four localities is 74.6 per cent, but differences in

this matter do not appear to be correlated with position in stream. There is a small increase in numbers of banded specimens, as compared with those without bands, in a downstream direction. The range is from Pratt's Ferry to seven miles below Centerville, both stations being in Bibb County.

Melania gravida Anthony (*Proc. Acad. Nat. Sci. Phila.*, 12 [1860]: 59) may be this species. If so, it would have precedence over the name *varians*. Help toward a decision is unobtainable from the original description and the two figures of *gravida* which have been published.

Goniobasis pupoidea (Anthony)

Melania pupoidea Anthony, *Annals Lyc. Nat. Hist. New York*, 6 (1854): 104, Pl. 3, Fig. 3.

Melania propinqua Lea (in part), *Proc. Acad. Nat. Sci. Phila.*, 13 (1861): 119.

Melania lita Lea, *Proc. Acad. Nat. Sci. Phila.*, 13 (1861): 121.

Melania luteola Lea, *Proc. Acad. Nat. Sci. Phila.*, 13 (1861): 119.

Melania corneola Anthony, *Proc. Acad. Nat. Sci. Phila.*, 12 (1860): 61.

G. pupoidea is the down-river member of the group of which *G. cahawbensis* is the Cahaba up-river representative. The shell passes from a youthful pyramidal or conic shape into a cylindrical form at maturity. Specimens taken in the river eight miles above Sprott, Perry County, show no signs of bearing plicae. At the station immediately below, faint plicae are to be seen. This sculpture was plain in all the shells taken at the last station in the river whereof spires were entire. A down-stream decline in index of obesity was brought out by the measurements taken—70.6 per cent above Sprott to 61.8 per cent among shells collected to the west of Selma, Dallas County. The fact that this last lot, although numerous in individuals, was depauperate probably explains this contrast. The percentage of banded shells increases slightly in a down-river direction. *G. pupoidea* occurs in the Alabama River in the vicinity of Selma. It has been taken also in Black Warrior River. The species is allied with *G. haysiana* of the Coosa River.

Goniobasis carinifera (Lamarck)

Melania carinifera Lamarck, *Histoire naturelle des animaux sans vertèbres*, 6 (1822), Pt. 2: 167.

Melania bella Conrad, *New Fresh Water Shells of the United States*, supplement, 1835, p. 6, Pl. 9, Fig. 4.

Melania perangulata Conrad, *Proc. Acad. Nat. Sci. Phila.*, 4(1849): 154.

Melania percarinata Conrad, *Proc. Acad. Nat. Sci. Phila.*, 4(1849): 155.

Melania nebulosa Conrad, *Proc. Acad. Nat. Sci. Phila.*, 4(1849): 155.

Melania symmetrica Conrad, *Proc. Acad. Nat. Sci. Phila.*, 4(1849): 155.

Melania vittata Anthony, *Annals Lyc. Nat. Hist. New York*, 6(1854): 89, Pl. 2, Fig. 7.

Melania imbricata Anthony, *Annals Lyc. Nat. Hist. New York*, 6(1854): 105, Pl. 3, Fig. 5.

Melania conradi Brot, *Matériaux a l'étude de la famille des mélaniens*, 1862, p. 36.

Goniobasis anthonyi Lea, *Proc. Acad. Nat. Sci. Phila.*, 14(1862): 264.

This is a common pleurocerid of springs, brooks, and creeks of the Alabama River drainage basin. It has crossed into the basin of the Tennessee River for short distances. In Alabama, it has been collected from near the northern border of the state to the vicinity of Claiborne, Monroe County. The extensive synonymy is a reaction to variability, which appears to be correlated largely with the varying habitats that the mollusk occupies. I am indebted to Mr. W. J. Clench for examining Anthony's types for me and for establishing the true positions of *M. vittata* and *imbricata*. The expedition of 1935 did not find the shell in the main Cahaba River except at Centerville, where a single specimen was collected. It doubtless was washed into the larger stream from a nearby spring or run. One mile south of Leeds, *G. carinifera* was 21.0 per cent of all the pleurocerids taken. It is perhaps of significance that it was not seen in the two disturbed sections of this stream, two miles above Leeds and six miles below. In Buck Creek, Shelby County, the species was only 1.0 per cent of the whole pleurocerid collection there, but amounted to 7.2 per cent in Peavine Creek, about five miles farther upstream. H. H. Smith collected it extensively in tributaries of the Cahaba in Jefferson and Shelby counties.

Goniobasis bella-crenata (Haldeman)

Melania bella-crenata Haldeman, *Monograph Limniades*, p. 3 of cover of No. 4(1841).

Goniobasis macella Lea, *Proc. Acad. Nat. Sci. Phila.*, 14(1862): 270.

The species, although plainly allied to *carinifera*, appears to be distinct. It is remarkably slender, of fine slow growth, and when fresh usually jet black. So far as the information at hand indicates, it is confined to springs and spring-fed brooks and creeks. The expedition of 1935 found it only in the narrowed outlet of Limestone Spring, Montevallo, Shelby County. It there amounted to 94.2 per cent of the pleurocerids collected. This is proof rather of its adaptiveness to altered environmental conditions, the spring having been brought within the municipal water supply system, than to its normal fecundity. The species has been collected by T. H. Aldrich in Davis and Clear creeks, Shelby County; by Smith in Spring Creek, Shelby County, besides Miller and Woodstock springs, Bibb County; by H. van der Schalie in springs of Tuscaloosa County—all tributary to the Cahaba River.

Goniobasis cochilaris (Lea)

Goniobasis cochilaris Lea, *Proc. Acad. Nat. Sci. Phila.*, 20(1868): 152.

This is one of the four members of the group of *G. catenaria* (Say) which occur in Alabama, each of which is distinctive and occupies a different river basin from the others. The whorls of *G. cochilaris* are very loosely coiled. It has a small aperture. These are characteristics of depauperization. The shell shows the steps of development from plicate to nodulous sculpture. Material from a spring branch of Little Cahaba River of Bibb County may be taken as an example. Of the 93 specimens of the lot, 63 have plainly marked plicae, 30 are ornamented simply with small nodules. These nodes are the vestiges of the elevations formed where the axial plicae intersect the revolving striae. The species has been taken in three springs and a spring branch of Jefferson County, a spring at Tannehill, Tuscaloosa County, and the spring brook of Little Cahaba River cited above.

Goniobasis clara (Anthony)

Melania clara Anthony, *Annals Lyc. Nat. Hist. New York*, 6(1854): 119, Pl. 3, Fig. 19.

Melania virens Anthony, *Annals Lyc. Nat. Hist. New York*, 6(1854): 93, Pl. 2, Fig. 11.

‡*Melania brunnea* Anthony, *Annals Lyc. Nat. Hist. New York*, 6(1854): 92, Pl. 2, Fig. 10.

‡*Melania excavata* Anthony, *Annals Lyc. Nat. Hist. New York*, 6(1854): 99, Pl. 2, Fig. 18.

Melania opaca Anthony, *Proc. Acad. Nat. Hist. Phila.*, 12(1860): 58.

Goniobasis bridgesiana Lea, *Proc. Acad. Nat. Hist. Phila.*, 14(1862): 265.

Lithasia wheatleyi Lea, *Proc. Acad. Nat. Hist. Phila.*, 18(1866): 133.

Lithasia purpurea Lea, *Proc. Acad. Nat. Hist. Phila.*, 20(1868): 153.

Goniobasis clara was first seen in the Cahaba River at the second collecting station, which was near Roper, Jefferson County. It continued in the river to Centerville, Bibb County. The species has been taken in Shades and Buck creeks, but so near their discharges that the habitats can be considered riverine. The upstream form of *clara* is conic; the whorls are closely coiled, the aperture is large, the outer lip straight. The last whorl is usually twice as large as the earlier whorls together. There is no sculpture except the closely set growth lines. Downstream, at about Lily Shoals, the shell becomes cylindrical as it nears maturity. The alteration is made with small alteration in the ratio of diameter to altitude. Only about 15 per cent of the specimens of *clara* from Roper have the revolving bands of pigment. The percentage increases to about 40 at the next downstream station, and thereafter varies from about 50 to 60. *Lithasia wheatleyi* was founded upon a specimen with a slightly deformed columella. *L. purpurea* was a melanistic individual. Some of the synonyms of *clara* have page precedence, but are not so clearly and definitely described.

Goniobasis ampla (Anthony)

Melania ampla Anthony, *Annals Lyc. Nat. Hist. New York*, 6(1854): 96, Pl. 2, Fig. 12.

Melania ambusta Anthony, *Annals Lyc. Nat. Hist. New York*, 6(1854): 94, Pl. 2, Fig. 13.

The shell is large, conic, roughly textured; the aperture large and produced. No very young have been seen, but the number of whorls of an adult would seem to be no less than eight. The body whorl is constricted just below the suture. The operculum represents a stage of development between paleo- and neomelanian.

G. ampla resembles *G. clara* in texture, shape of whorls, and in the characters of the operculum. Apparently, it is also without plicae or revolving striae. Specimens that came to Anthony were probably collected in the Cahaba River at or near Centerville. Call found the species on Lily Shoals and Smith at the foot of these rapids. It has not been come upon in recent years, and no one has taken it in large numbers. The very narrow range of the occurrence of *ampla*, together with the relative rarity of individuals, suggests that the mollusk may simply be an enlarged and conic phase of the *G. clara* of the transition zone.

Tryon (1873) makes *G. hartmaniana*, 1861, of the Coosa River a synonym of *G. ampla* under the impression that the latter is a partly grown shell, *hartmaniana* being the adult form. The two are distinct.

Goniobasis showalterii (Lea)

Lithasia showalterii Lea, *Proc. Acad. Nat. Sci. Phila.*, 12(1860): 188.
‡*Melania purpurea* Lea, *Proc. Acad. Nat. Sci. Phila.*, 13(1861): 120.

Lea obtained his specimens of *showalterii* from the Cahaba River at Centerville. He described the mollusk as smooth, meaning that it lacked axial and revolving sculpture. Nevertheless, the spire is strongly plicate. This character is much less pronounced in the material taken on Lily Shoals. It becomes prominent first in the colonies ten miles above Centerville. Many of the shells are subnodulous at the shoulder, a feature doubtless developing out of plicate sculpture and observable also in *Io* and *Lithasia*. Occasional specimens of juvenile individuals have obscure revolving folds. Indexes of obesity as between colonies vary from 70.3 to 79.3 per cent, the higher figure belonging to certain low-spired shells that were collected by Smith near Piper, Bibb County. The greatest relative numbers of banded shells were taken in the rapids of light current above the bridge at Lily Shoals, the smallest number ten miles above Centerville. The only melanistic examples, corresponding probably to Lea's *M. purpurea*, were all at two stations, ten miles and seven miles above Centerville. The species is confined to the transition zone, its range being from Lily Shoals to two miles east of Harrisburg, Bibb County.

Goniobasis olivula (Conrad)

Melania olivula Conrad, *Amer. Journ. Sci.*, 25(1834): 342, Pl. 1, Fig. 13.

?*Melania bitaeniata* Conrad, *New Fresh Water Shells of the United States*, 1834, p. 52, Pl. 8, Fig. 6.

Melania inflata Haldeman, *Monog. Limniades*, 1841, cover of No. 3.

Melania proteus Lea (in part), *Proc. Amer. Phil. Soc.*, 4(1845): 166.

Melania basalis Lea, *Proc. Amer. Phil. Soc.*, 4(1845): 166.

Melania oppugnata Lea, *Proc. Amer. Phil. Soc.*, 5(1852): 252.

Melania midas Lea, *Proc. Acad. Nat. Sci. Phila.*, 13(1861): 119.

Melania straminea Lea, *Proc. Acad. Nat. Sci. Phila.*, 13(1861): 121.

Melania gibberosa Lea, *Proc. Acad. Nat. Sci. Phila.*, 14(1862): 266.

Goniobasis sulcata Lea, *Proc. Acad. Nat. Sci. Phila.*, 20(1868): 151.

G. olivula in the Cahaba River is confined to the third zone. It is possibly an invader from the Alabama River, in which it has been found as far downstream as Claiborne, Monroe County. Upstream in the Cahaba, it is replaced by *G. showalterii*. It was first found in 1935 in the river eight miles north of Sprott, Perry County. These shells are short-spined, have elongate-ovate apertures, and, in old specimens, deposits of callus at the top of the columellae. The young are plicate and indistinguishable from juvenile *G. showalterii*. The colony ten miles west of Selma, Dallas County, consists of small specimens, all of them short-spined and cylindrical. At the station immediately above Sprott, *G. olivula* was 10.1 per cent of all the pleurocerids found, at the station farthest downstream, 29.1 per cent. The ratio of diameter to altitude was found to decrease in a downstream direction, but the numbers of banded individuals increased in the same direction from 65.8 per cent to 86.0 per cent. The only melanistic specimens of *G. olivula* which were collected were at the station above Sprott.

For a time, *G. sulcata* was thought to be the rare striate form of the shell to which the name *G. annettae* is given in this paper. A more thorough study of description and figure leads me, however, to believe that Lea's shell, of which he had only one, was with examples of *G. olivula* which Schowalter collected in the Cahaba River in Dallas County.

Goniobasis variata (Lea)

Melania variata Lea, *Proc. Acad. Nat. Sci. Phila.*, 13 (1861): 119.

The most variable character of this species is the axial sculpture. This consists of longitudinal plicae that may, in different locations, be distinct, microscopic, or entirely absent. Shells of Peavine Creek, for illustration, are very lightly sculptured, but those of Buck Creek, the downstream extension of Peavine Creek, are boldly marked with plicae. *G. variata* is of relatively high obesity. The spire is short, the whorls tightly coiled. The outer lip is usually straight although sometimes slightly sinuous. Certain specimens taken in Town Creek at Montevallo, Shelby County, are very much like small examples of *G. showalterii*. In this complex, it would appear, small stream forms are pyramidal or conic; the large stream forms more nearly cylindrical. The same alteration of shape has been remarked in *G. clara*.

This mollusk was found in small numbers in Little Cahaba River of Jefferson County. It has been found in the main river near the mouth of Buck Creek, at the Old Tuscaloosa Pike crossing and on Lily Shoals. In all three instances, the colonies were small, and the belief is that these were mere chance or casual inhabitants of the Cahaba. It is in the creeks of Shelby and Bibb counties that the species flourishes. *G. variata* amounted to 93.6 per cent of the goniobases taken in Buck Creek at Helena, Shelby County. It was on rocks and in gravel below the dam at this place, entangled in aquatic vegetation and high on the wall of the dam where seepages occurred. The index of obesity in the species is from 75.1 to 78.0 per cent. The occurrence of bands shows no correlation to position in stream. Melanistic specimens among the shells taken in 1935 were never more than 5 per cent of the total numbers collected except in Little Cahaba River of Bibb County, where they amounted to 16 per cent.

Lea gives the Coosa River at Wetumpka as one of the two type localities, but the types appear to be of the Montevallo phase.

Anculosa ampla (Anthony)

Anculosa ampla Anthony, *Annals Lyc. Nat. Hist. New York*, 6(1854): 158, Pl. 5, Figs. 22-23.

Anculosa elegans Anthony, *Proc. Acad. Nat. Sci. Phila.*, 12(1860): 69.

A single specimen was taken in the Little Cahaba River of Jefferson County, one mile south of Leeds. The species was not seen elsewhere in this stream, nor was it collected in the main Cahaba River until Nunley Ford, Shelby County, was reached. Thereafter, it was common as far downstream as Centerville, Bibb County. No *Anculosa* was found in the pools and slow-moving water of Lily Shoals, but in the rapids of moderate current *ampla* made up 55.9 per cent of all the Pleuroceridae taken, yet only 16.2 per cent of the collections in the rapids of heavy current. Sculpture, where it occurs, consists of low plicae or irregular transverse folds on the shoulder of the shell. This character is absent in specimens of the more upstream colonies. It is most pronounced at the extreme downstream stations of Bibb County. Not less than 90 per cent of any given lot have revolving bands on the body whorls. This pigmentation, apparently, is not correlated with position in stream. The species inhabits the Little Cahaba River of Bibb County, but only two or three of the smaller tributaries of this and Shelby County.

Anculosa ampla mimica (H. H. Smith)

Anculosa mimica H. H. Smith, in Goodrich, "The Anculosae of the Alabama River Drainage," *Misc. Publ. Mus. Zool., Univ. Mich.*, 7(1922): 39, Pl. 2, Figs. 27-28.

This is a race of small shells in which the sculpture is somewhat conspicuous, the intersection of axial plicae and transverse folds sometimes forming nodes. The type locality is Little Cahaba River, three miles east of Piper, Bibb County. Examples of the same phase were taken in this stream at Allen Ford in 1935.

Anculosa taeniata (Conrad)

Anculotus taeniatus Conrad, *New Fresh Water Shells of the United States*, 1834, 63.

This species is as distinctive of the third or flood plain zone of the Cahaba River as *A. ampla* is, for the most part, of the lower headstream and transition zones. It was seen in 1935 first at the station eight miles north of Sprott, Perry County. It amounted to 55.1 per cent of all the pleurocerids collected there. Later, it was found at two lower collecting spots. The habitat of the species in the Cahaba River is in slowly moving water on small stones upon which a small amount of silt has accumulated. This corresponds to the environment in the Alabama River at Claiborne where Conrad found his shells, but not to that of the lower Coosa River, where *taeniata* lives on rock bars over which currents rush almost with violence.

Anculosa picta (Conrad)

Anculosa picta Conrad, *Amer. Journ. Sci.*, 2(1834): 342, Pl. 1, Fig. 15.

Anculosa zebra Anthony, *Proc. Acad. Nat. Sci. Phila.*, 12(1860): 69.

A single specimen of this species was found among the pleurocerids taken by Clench and van der Schalie in the Cahaba River twelve miles west of Selma, Dallas County. The locality is probably the same, or near it, that was visited by Schowalter in the 1850's and wherein *picta* was collected plentifully. The type locality is Alabama River at Claiborne, Monroe County. It has penetrated the Coosa River to the foot of the last rapids, which are at Wetumpka, Elmore County.

Anculosa (?) *compacta* (Anthony)

Melania compacta Anthony, *Annals Lyc. Nat. Hist. New York*, 1854, p. 122, Pl. 3, Fig. 22.

Melania fuscocincta Anthony, *Annals Lyc. Nat. Hist. New York*, 1854, p. 120, Pl. 3, Fig. 20.

Melania germana Anthony, *Proc. Acad. Nat. Sci. Phila.*, 12(1860): 61.

Melania nuclea Lea, Reeve, *Monograph Melania*, 1861, Sp. 423.

The shell is thick, smooth, and shining; the columella projecting; outer lip retrorse. It has no sculpture except the closely set growth lines. Old specimens are conic to cylindrical rather than pyramidal to quadrate, which is the shape of the young. The taxonomic position of *compacta* is uncertain. The centrals of three radulae which have been examined are 5-1-5 and 4-1-4, which conforms to certain centrals of *Anculosa*, but

the laterals are five-toothed, and this is altogether unlike the laterals of any radulae of *Anculosa* so far seen. There is not sufficient resemblance with the radulae of *Nitocris* to warrant placing *compacta* in that genus. It is possible that the species, like the *Lepyrium showalterii* of the same drainage system, is a relic of a fauna now almost vanished.

H. H. Smith took *compacta* in the Cahaba River near Henry Ellen, Jefferson County. It was not seen when this locality was visited in 1935. Another of Smith's localities for the species is the river near Anita, farther downstream. The first finding in 1935 was at Nunley Ford, Shelby County. It appeared again at the Old Tuscaloosa Pike crossing. On Lily Shoals, a few specimens were collected in the rapids of moderate current above the bridge. Call's collections at Lily Shoals show the occurrence there of *compacta* in immense numbers. The question is raised whether he found a habitat more suitable for the species than was found in 1935 or the whole population of *compacta* has undergone decimation in the course of fifty years.

RELATIONSHIPS

Recapitulating, it is seen that the different pleurocerid species fall into groups, the kinship within which is close indeed, so close that the specific or subspecific differentiation appears to be determined wholly by ecological factors.

One of these groups is made up of:

<i>Goniobasis cahawbensis</i>	<i>Goniobasis varians</i>
<i>Goniobasis cahawbensis fraterna</i>	<i>Goniobasis pupoidea</i>
<i>Goniobasis annettae</i>	

The first of the species is a headwaters and tributary form, its subspecies a restricted spring branch or brook phase of it. *G. annettae* and *varians* are transition zone successors of the upstream *cahawbensis*, and *G. pupoidea* is a species of the low-ermost or flood plain section of the Cahaba River. Associated with *G. cahawbensis* in head streams is *G. carinocostata*, which in the Cahaba stands alone, but has affiliations with species of the Coosa River basin.

A group more confined to small streams than the above is:

Goniobasis carinifera

Goniobasis bella-crenata

The second of these is a modification of the first and this is determined apparently by its occupation of cold springs and their discharges.

Making up a third group are:

Goniobasis clara

Goniobasis ampla

These species are confined to the river proper or to short stretches of creeks at their discharges. *G. ampla* has been found only in the transition zone of the river.

A group with Alabama and Coosa river relationships is:

Goniobasis olivula

Goniobasis variata

Goniobasis showalterii

Reversing this order, *G. variata* is a species of tributaries of the transition zone, *G. showalterii* of the river in this zone, and *G. olivula* of the extreme downriver section.

A thirteenth distinctive species is *G. cochiliaris*, occupant of springs. It belongs to the most widespread group of the genus, namely that of *G. catenaria*, which ranges from Virginia to Texas.

For convenience, the three representatives of the genus *Pleurocera* are considered here as species. They are:

Pleurocera vestitum

Pleurocera prastinatum

Pleurocera foremanii

P. vestitum occurs in the headstream and transition zones, but most commonly in the latter. *P. foremanii* is known from a single locality of the transition zone, and *P. prastinatum* is the form belonging to the lowermost section of the Cahaba River.

The Anculosae are easily differentiated into:

Anculosa ampla

Anculosa taeniata

Anculosa ampla mimica

Anculosa picta

Only the first two of these may be said to constitute a group. *A. ampla* flourishes particularly in the transition zone and

does not go below it. Its subspecies is a tributary form that so far has been found in pure colonies nowhere else than in the Little Cahaba River of Bibb County. The two last species, not closely related, are quite evidently intrusions or invasions from the Alabama River. They do not go upstream above the flood plain section.

A fifth species, herein termed *Anculosa compacta*, may prove to deserve generic differentiation. It was found in the Cahaba River headwaters by H. H. Smith, but by all others only in the lower part of the headstream section and in the transition zone.

POLYMORPHISM IN THE PLEUROCERIDAE

Goniobasis cahawbensis has the configuration of a cone of narrow base and elongate spire. The protoconch is tightly coiled, the juvenile phase loosely coiled. The mechanism is this: New growth of the adolescent shell forms beneath the periphery of the earlier growth, and this is accented by sharp carinae. As the mollusk matures, new growth forms over the periphery, and the carinae disappear. The spire of *G. cahawbensis fraterna* is somewhat more loosely coiled than it is in the typical shell, and the carinae are more pronounced. The shape and manner of growth are also that of *G. carinocostata* and *G. carinifera*, other headwaters and tributary inhabitants. *G. bella-crenata* and *G. cochilaris*, adapted to life in springs and spring branches, are more nearly cylindrical than are the preceding mollusks, but they have the same loose coiling.

G. annettae, the successor of *G. cahawbensis* in the Cahaba transition zone, has a loosely coiled spire exactly like this latter species, but the body whorl has lengthened and flattened, the aperture has narrowed from ovate to elongate-ovate. In *G. varians*, the second transition zone member of the *cahawbensis* group, new growth on the spire has crowded against the periphery of the preceding whorl or has overlapped it. The shell as a whole is more cylindrical than is *G. annettae*. For convenience, the young can be called pyramidal as distinguished from the elongate-conic form of juvenile *cahawbensis* and *annettae*. This pyramidal form is that of all the young of

G. pupoidea which have been seen. The adult shell is uniformly cylindrical. To summarize: the group alters its manner of growth and its shape in a downstream direction.

G. clara is pyramidal both in young and adult phases throughout its occurrence in the upper Cahaba River. The spire is tightly coiled. At Lily Shoals in the transition zone, the shell has grown larger, the body whorl relatively more flattened. The short spire has become a more conspicuous character. Until the species disappears from the river in a downstream direction, the shell has a cylindrical rather than a pyramidal form. The related *G. ampla*, confined to the transition zone, has retained the juvenile shape into adult age.

The three Cahaba basin members of the group of *G. olivula* are all pyramidal, tightly coiled in the young. The tributary species *G. variata* does not alter its shape as it matures, but in *G. showalterii* and *olivula* the pyramidal form of the immature is succeeded by a cylindrical form in the mature.

Loosely coiled spires are characteristic of the young of *Pleurocera vestitum* and *prasinatium*. Alteration in shape in a downstream direction is simply an increase in the relative diameter.

The up-river *Anculosa ampla* is broad in proportion to altitude. The down-river *A. taeniata* is much more narrow in proportion to altitude. The differences in shape are those also of *Anculosa* of tributaries of the Ohio River system as compared with the genus in the main streams. For example, *A. umbilicata* and *harpethensis*, small stream inhabitants, are the broadest species of the genus; *A. praerosa*, living in the main rivers, is much higher than these in proportion to diameter. A correlation appears to exist here between form of shell and position in stream. The animal living in swift rapids requires a broad foot in order to cling to rocks in the current, the one living in less tumultuous waters is in less need of broad, clinging surface. It is the shell of broad foot that is of pronounced diameter.

By sculpture in the Pleuroceridae is meant the axial ridges or ribs that usually are called plicae, the transverse or revolving raised lines and folds which herein are spoken of as striae and

nodes, spines, and beads. The axial sculpture is a very ancient and persistent character. Where, as in certain goniobases and most pleuroceras, it is absent, the instance probably represents obsolescence. Striae are of irregular development. They may occur in individuals of a given colony and not in others, in all members of a colony and not in any member of another colony of the same species. In such a species as *Goniobasis troostiana*, involving all shells, striae are doubtless genetic, but in most instances they can be traced to adventitious folds in the shell-secreting parts of the mantle, and so can be considered mechanical and of secondary importance. Nodular sculpture develops out of axial sculpture.

G. carinocostata, a headwaters and tributary species, has a stable and apparently unvarying plicate sculpture. *G. cahawbensis*, with which *carinocostata* is frequently associated, is as unvaryingly unplicate, but occasionally is striate. Strong striae appear on a few specimens of *annettae* and *varians*, the transition zone members of the *cahawbensis* group. The fourth member of the group in the Cahaba basin, *G. pupoidea*, is slightly plicate at the head of its range, conspicuously so at the foot of it. In the group of *G. olivula*, the extreme upstream forms of *variata* are nonplicate. The sculpture appears in colonies farther downstream. *G. showalterii*, of this same group, is inconspicuously plicate at Lily Shoals and strongly plicate below this locality. The character is pronounced in the extreme downstream member, *olivula*. *Anculosa ampla* progresses from a nonplicate phase in upstream mollusks to a plicate state downstream yet the shell in the tributary Little Cahaba River of Bibb County is a plicate one.

In the case of the spring and small stream species, *G. carinifera*, there exists a variation from plicate-striate sculpture to simple nodulous sculpture represented by rows of beads. This is true as well of the examples of *G. bella-crenata* that have been seen. In *G. cochlearis*, both plicae and minute nodes or beads are present in the same colonies. The nodules of the body whorl of *Pleurocera foremanii*, a shell that in the Cahaba River does not appear to be more than a phase of *P. vestitum*, probably represents an instance of reversion.

PIGMENTATION

The deposit of coloring material, darker than the ground color, in the form of revolving bands of capillary lines is common in the Pleuroceridae as it is also in many other families of the Gastropoda. The bands may be faint as though the pigment secretion was slight, or the pigmentation may involve the whole shell, presumably because of oversecretion. A study of this character as it manifests itself in the Cahaba River pleurocerids was made in order to learn whether or not the presence or absence of the bands was correlated with position in stream.

The first station at which *Goniobasis clara* was seen in the river was near Roper, Jefferson County. Of the specimens collected 15 per cent were found to be banded. At the next station downstream, the number increased to 40 per cent. Thereafter, the percentage varied irregularly from 50 to 60 per cent. An increase in banding in a downstream direction was observed in *G. varians*, *pupoidea*, and *olivula*, and *Pleurocera vestitum*. The relative numbers of banded individuals in *G. carinocostata* increased downstream in the main Cahaba River, but the reverse was true of shells of the Little Cahaba River of Jefferson County. In the case of *G. annettae*, appearing in greatest numbers in Lily Shoals, a larger percentage of banded specimens was taken from pools than from rapids. No correlation between banding and position in stream was observable in *G. variata* and *showalterii*, or in *G. cahawbensis* of the main river, but the last species where it occurred in two spring branches was entirely without bands. The proportion of banded to non-banded shells of *Anculosa ampla* of the main river appeared to be unrelated to habitat. On the other hand, few of the shells of the species that were taken in Little Cahaba River of Bibb County bore these stripes of pigment.

Shells wherein pigmentation involved the entire crystalline material and epidermis were almost wholly absent in the extreme upriver and downriver sections of the Cahaba. They were commonest in the parts between Lily Shoals, Bibb County, and eight miles above Sprott, Perry County. The phenomenon occurred among all the species of the Pleuroceridae, and in one of them much more than in any other.

