

UNIVERSITY OF MICHIGAN
MUSEUM OF ZOOLOGY

Miscellaneous Publications No. 7

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BY
CALVIN GOODRICH

Published in Co-operation with the Geological Survey of Alabama

ANN ARBOR, MICHIGAN
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ALEXANDER G. RUTHVEN,
Director of the Museum of Zoology,
University of Michigan.

THE ANCULOSAE OF THE ALABAMA RIVER DRAINAGE

BY CALVIN GOODRICH

This study deals with a collection of Anculosae made by Mr. Herbert H. Smith within the drainage of the Alabama River between the years 1901 and 1918 for the Alabama Geological Survey. The new species, with one exception, were named by him. The classification follows that which he had in mind. After a year's examination of the collection, the writer feels toward Mr. Smith only the greatest respect for his industry in the field and the keenness of his observations. It was Mr. Smith's intention to prepare this paper himself. Death directed otherwise. His life spared, errors which possibly have crept into this paper would most certainly have been avoided.

The Anculosae vary exceedingly. They give the student the impression of an adaptive family that is constantly struggling with an altering environment. They are recommended to the scientist particularly as objects for tracing the geographical distribution of life in middle North America. I believe them to be no less valuable in this regard than the mammals, the crayfishes and the Naiades.

For help with this paper, the writer is indebted to Mrs. Daisy Smith, of the Alabama Museum of Natural History, who supplied a great deal of information about her husband's work and performed most of the thankless labor connected with handling the collection; to Miss Mina Winslow for the illustrations of the shells; to Dr. Bryant Walker for unwearying counsel.

THE GROUP AND ITS ENVIRONMENT

The Anculosae of the Alabama River system represent a distinct section of the genus. No species of Anculosa within the drainage occurs also outside of it. No species which is spoken of as an Atlantic, Ohio, a Cumberland or Tennessee form occurs within it.

The existence of this faunal cleavage was not suspected or was not believed in by Lea, Tryon and some of the other naturalists of their times. Lewis was convinced of it and laid emphasis on the fact as he glimpsed it. So far as can be learned from the literature his remarks passed unnoticed. It has remained, after many years, for Mr. Smith to demonstrate through his collections and studies that the dispersal of the Anculosae, however general it has been within the area of their habitat, has kept separate completely two main lines of development. This is the more remarkable because there has been an interchange of stream flow through piracy between the Tennessee tributaries and the Conasauga, and opportunities for the transfer of species, other than by means of stream capture, must have occurred repeatedly farther to the west. A glance at the map will show that Wills Creek and Little River of the Coosa today very nearly touch Lookout Creek of the Tennessee. The latter is known to be inhabited by a typi-

cal Tennessee Anculosa. Branches of Black Warrior River, belonging to the Alabama system, and Flint Creek of the Tennessee, both having Anculosae, come within a little distance of each other. If the means of dispersal such as carriage by birds, mammals, wind, tornadoes and such floods as on a plateau bring streams of different drainage systems together—if such means were operative in the case of the Anculosae the forms of the Alabama and Tennessee rivers would long since have mingled. This study has made plain that intermingling has not taken place in recent geological time.

The manner of life of the Anculosae has undoubtedly had a great deal to do with restricting the means of distribution. I have not visited the Alabama streams and therefore cannot say with exactness just what are the habits of the genus there. It may be supposed, though, that these habits do not differ appreciably from those of the Anculosae of the Tennessee and Ohio systems. In the Clinch and Powell rivers of the Tennessee, the Anculosae are found on stones usually far from the shores and in the strongest current. The same thing is true of the two species at the Falls of the Ohio. After spring floods a fine coating of silt is left on the stones and in this medium the fresh water animal life leaves the chronicle of its movements as plainly as the marks of a pen upon paper. Now while Pleurocera and Goniobasis are seen, for mollusks, to move about fairly actively, Anculosa moves scarcely at all. It seems to be content to find a place in the heavy current and to stay there, changing its position little except when change of water level or accident compels it.

There is not sufficient mud in such locations to serve as a carrier for mollusks on the legs of birds even if the mud present were of the kind to serve that end, which it isn't. As the eggs are laid in the same environment, being probably glued to stone surfaces, they too would be little likely to be carried away by birds. If the animal falls and is swept into still water the chances are against its surviving. Logs that might carry Anculosae down stream would come to rest as a rule in the quiet water rather than upon stones in swift water, and falling from such carriers must mean generally that the Anculosae perish. In the light of the record, the chances of such animals changing their habitat from one drainage into another when floods float logs across low land barriers seem exceedingly remote.

We must understand the dispersal of these creatures to be very slow, very restricted as to means and as being governed very largely by changes in the character of a stream—advantageous situations for the life of Anculosae arising and disappearing only over great periods of time.

The variability of the Pleuroceridae is notorious. Because of this, probably more than for any other one thing, the family has been neglected. Almost everyone who has had anything to do with it has hoped that as collecting became more extensive so many connecting links would be found that the number of species now recorded might be greatly reduced. Almost everyone has tried to avoid adding to the catalogue. One student, bold perhaps but more likely just impatient, did undertake a prodigious labor of lumping and he brought the number of species down to a meager dozen or so—deriving in the end, it must be feared, very little satisfaction for himself and certainly advancing the knowledge of systematic zoology not a

particle (Hannibal, 1912). As Mr. Smith saw it, and as I see it myself now, the undesirable conclusion is forced on one that there are far more existing species than have been described, that it may be a very long time before the last one has been found and the books closed.

The reason lies in the manner of life of the Pleuroceridae for one thing and for another in the apparent fact that the family is in the active ferment of evolution. The greater number of the species, in other genera as well as the Anculosae, inhabit rocks and gravel bars in swift-moving streams. The migrating impulse is absent. Observation leads to the conviction that in the case of a species of the Anculosa, as already mentioned, every moment of living may be spent upon a single spot of a single stone. Not only do the ordinarily recognized barriers restrict the spread of the animals, but the deep water of a river turns back creek forms, the deep water between bars in the same stream interrupts dispersal, in instances quite narrow rifts on a single group of shoals serve as effectual barriers.

The influences of isolation working from without thus exercise their greatest powers. Working from within the forces of evolution carry on differentiation still farther.

Speaking of one group of this family, Dr. Lewis (1873) made the despairing remark: "One cannot tell where to assign limits. Limits are apparently obliterated and species have no existence. They are a confused mass and must be referred to one type." I believe it is true that species in this family, except occasionally, do not exist as Dr. Lewis and his contemporaries wished to define the word species. One is lost who tries to think of these animals as having any such fixity of characters as occur in other families and orders. We have rather to think of the characters as overlapping from one race to another, even from genus to genus. That collection of individuals in the Pleuroceridae may be called a species whose predominant characters are not the predominant characters of another collection of individuals. If we see only a few specimens of a single species its own peculiar characters may often seem to be submerged by characters linking it with another species. But in a long series the individual characters stand out, and we are compelled then to recognize the existence of definable differences and to proceed to describe them and provide the label of a name. If we adopt the policy—the tempting course—of referring all these many collections to one or several types we surrender whatever value there is in the defining of local races and lose with it the means of tracing geographical distribution. Dr. Lewis' "confused mass" would become more confused than ever. All the tribes of American Indians—to go far afield for an analogy—are alike in certain regards, tribal characters overlap tribal characters, yet it is possible to differentiate tribe from tribe, and the right and necessity of the scientist and historian to speak of these collections of individuals as separate, distinct, differentiated, are not to be questioned.

With the method of evolution in this family, the writer is incompetent to deal. There has been so far no intensive study of the anatomy, no broad inquiry into the rules or rhythm of variation if any such things exist, no breeding and interbreeding to discover whether known rules of heredity apply here. It is a field still fallow for the experimenter.

THE GEOLOGICAL PROBLEM

In Cretaceous times, Georgia from Columbus northward and part of eastern and northern Alabama constituted a peneplain. The line westward from Columbus, Georgia, to Wetumpka and thence northwest through Centerville, Tuscaloosa and Fayetteville was the shore of the gulf which stretched as far as Cairo, Illinois, covered the western thirds of Tennessee and Kentucky, the greater part of Mississippi, part of Arkansas and the whole of what is now Louisiana. A stream of which the Coosa is now an existing part rose south or southeast of Chattanooga and emptied into the sea at or close to Wetumpka.

C. C. Adams describes the streams of the era in this region as in a condition of fine balance. In such a condition slight crustal changes might have brought about profound changes in stream course, diverting and re-diverting flow, lending force to extensive piracy. A differentiated fauna necessarily experienced alterations with these changes. Parts of it were possibly left isolated, to retain characteristics, to intensify them or to lose them—all within itself. Other parts possibly suffered through competition or else interbred with forms of life with which hitherto they had not been in contact.

M. R. Campbell and C. W. Hayes, in 1894 and 1895, put forth the contention that as late as Tertiary times a river comprising the upper Tennessee and the Coosa flowed continuously southward to the sea, and that—at some period in the Tertiary—a confluent of the Tennessee and one of the Sequatchie to the west formed a connection through Walden Ridge at Chattanooga and diverted the Tennessee section of the river into an entirely new course. D. W. Johnson reviewed this work ten years later. From studies upon the ground he came to a very decisive opinion that the "Tennessee River acquired its present course across the mountains some time before the close of the Cretaceous period when the present flat top of the mountains was continuous with the rest of the Cretaceous peneplain." To this view C. C. Adams was apparently won.

The theory of a Coosa-Tennessee River is not necessary to account for the dispersal of the Anculosae. Nor is it needed to explain the existing differentiation. A stream balance prevailing upon the Cretaceous peneplain such as Adams describes would permit of innumerable captures of tributaries and the transfer and dispersal of their molluscan species. Further there have been opportunities possibly in fairly recent times, geologically speaking, for an interchange of the fauna through stream piracy both to the east and the west of the mountains. Forms of Pleuroceridae in the Hiwassee, highly suggestive of Georgian forms, seem to point to captures by that stream from the Conasauga of the Coosa, the confinement of these forms to the Hiwassee and its vicinity pointing to a time of capture so recent that wide dispersal has not yet come about. There is reason, indeed, to believe that not only did the Hiwassee make captures from the Conasauga but that this latter stream also acquired tributaries which originally belonged to the present Tennessee confluent.

We are to imagine the Cahaba as a small stream in the Cretaceous times, flowing directly to the sea. The Black Warrior existed, if at all, either

as an extension of the Sequatchie River or as a small stream that now is a northern branch of the river. A question may be raised as to whether the valley containing both the Sequatchie and this northern reach of the Black Warrior ever was occupied by a single stream flowing its full length. It may be that in the Cretaceous the Tombigbee was not in existence at all. In every likelihood the Anculosae reached the three streams, Cahaba, Black Warrior and Tombigbee, from the Coosa River after the elevation of the continent and the linking of all these rivers with the Alabama.

CHARACTER OF ALABAMA STREAMS

The Coosa is said to have the most diversified molluscan life of any stream in the world. It has long been a classical collecting stream. Yet not until Mr. Smith undertook the labor was the collecting carried out in any systematic way. Concerning the reasons for the extensive animal population, Mr. Smith—so far as I can discover—has ventured to say nothing. But of the character of the Coosa and other Alabama streams, there occur many illuminating passages in his correspondence with Dr. Walker. Some of these are here printed in their chronological order.

From Wetumpka, he wrote toward the end of 1901:

"There is an island half a mile up the river, and we tried vainly to reach it for a long time, the water was too deep and swift. After awhile I managed to get a boat, and since then most of my collecting has been on the island. It is rocky and intersected by a number of small water channels, with numerous back-water pools. This island has turned out an astonishing number of species. Many of the forms are extremely rare and local. One pool is crowded with small species, some not over one-half inch, and it is about the only place in which I have found small ones at all."

Writing from Gadsden in October, 1904, Mr. Smith said:

"From Rome to Gadsden we found a constant succession of shoals, either along the shores or forming islands in the river. I think that the river shells are substantially the same down to the mouth of the Chattooga River. At first I thought there was a gradual change, but I found that a recurrence of the same conditions brought the same species. Below the Chattooga there are few shoals for ten or twelve miles; then a succession of rock and shingle shoals clear down to Gadsden; and on these we found a good many forms not seen above. I think, however, that this is only because the fauna gets richer; most of the species seen above persist as far as Gadsden."

In November of the same year he was at Riverside, writing:

"The Coosa below Gadsden is at first like the upper reaches. At the upper end of Minnesota Bend there are limestone rocks and shoals. Following this is a long stretch, eight or ten miles, in which the river is broad and lake-like with muddy bottom and low shores. I should think such reaches would be a pretty effectual bar to the migration of rock loving

Pleuroceridae, either up or down. Following this stretch come Leoto or Whistlenaut shoals, the first of the rock shoals which characterize the middle Coosa. These are really reefs of rocks extending quite across the river or leaving only a narrow channel. The river makes a strong current wherever it can find a passage. Two miles farther down and probably connected by rocks on the river bottom are the extensive Ten Island shoals. The Pleuroceridae show the greatest changes as we descend, that is, the changes are more apparent. The assemblage (upper Coosa forms) is continued as far as Minnesota Bend. Here on the limestone rocks there is a sudden and marked change. There is another marked change at the reef just above Leoto Shoals; and after that one or two new forms come in at every shoal."

In a letter of June 6, 1907, Mr. Smith gives a brief picture of collecting on the Weduska shoals:

"We could wade out half a mile in the rapids, which in that place are simply a succession of ledges with flat rocks or gravel between, the water swift in places, but never strong enough to be dangerous. I used to carry a large bag, and generally this and my pockets were filled in half an hour, though hardly one specimen in ten was saved."

Back in Wetumpka in February, 1908, Mr. Smith wrote:

"All this stretch (Cedar Island to Higgin's Ferry, Chilton County) is full of shoals except between Higgin's Ferry and Duncan's Riffle, where the water is still and deep. The distribution is exceedingly interesting. In very swift water we had to cling to rocks with one hand while fishing with the other for stones; once I got a dowsing."

Returned to University from Anita, he wrote of the Cahaba River:

"The Cahaba physically is very different from the Coosa. It is essentially a river of the Paleozoic limestone region, flowing through a gorge, and generally deep. The shoals, where they do occur, have deep water above and below. Stretches of deep water separate species of the Coosa, and apparently this is so of the Cahaba too."

Mr. Smith returned to the Middle Coosa in the summer of 1914. He says of Fort William shoals:

"Several reefs of rock cross the river diagonally, and on them we made our best hauls. It was exciting sometimes even for an old campaigner. There was one little pool under a fall which must have yielded over one hundred Gyrotomas. You would have laughed to see me sitting in the fall, holding on with one hand while I groped with the other, bringing up three or four every time; often they were washed out of my fingers, for the current was a caution. We worked until the last possible moment. When we left Fort William Shoals were entirely covered by the backwater of the power dam."

THE OPERCULA

The literature is singularly unhelpful regarding the opercula of the Pleuroceridae. After the first superficial examination, the earlier naturalists took it for granted, or they seem to have, that little or no variation existed in this character. Throughout the four hundred and more pages of Tyron's Monograph of the Strepomatidae (1873) are just two items in the text and two illustrations, one of them entirely unreferred to, which give any indication of a recognition of differences. Dr. W. D. Hartman (1871) mentioned the serrated operculum of *Anculosa foremani* Lea and the ribbon-like opercula of some specimens of *Leptoxis rubiginosa* Lea. Yet he generalizes about the operculum as if he were convinced that these two variants were but rare exceptions to a rule most firmly fixed. So keen an observer as Lewis apparently felt that the opercula were not worth the bother of examination though he was unorthodox toward the accepted facts of his day relating to species and their relationships. Not until Pilsbry, in describing *Goniobasis comalensis* (1906), pointed out a distinctive form of operculum did anyone hint that the organ might vary sufficiently to warrant intensive study.

From the beginning of his work in Alabama, Mr. Smith made a point of observing opercula. From his correspondence one gathers the information that he found them exceedingly helpful in separating puzzling forms of the family. In one instance, where the nodose *Goniobasis* (*Eurycaelon*) and nodose *Gyrotomae* appear together in the Coosa River, the operculum constituted a definite demarkation of generic character more conspicuous than a rudimentary Gyrotomic fissure. He had other experiences of the sort among species of *Goniobasis* in the Cahaba River. The two *Anculosae*, *formosa* and *foremani*, run very closely together in certain localities. The opercula permit immediate separation without uncertainty.

On December 6, 1905, Mr. Smith wrote to Dr. Walker: "*Goniobasis showalterii* Lea, as you know, has the operculum greatly prolonged. The species is common on some parts of Weduska, Peckerwood and Fort William shoals, and I noticed that when the snail has its foot out, the operculum curls over the body, lying on it very neatly. I have found the operculum of great service in separating species of *Goniobasis*, but it is necessary to use great care. No part of the mollusk is so subject to accidents and distortion as is the operculum. In fact I am practically sure some Pleuroceridae as well as *Campeloma* and *Tulotoma* may lose the operculum altogether and form another. I have found living and apparently healthy specimens without operculum, and I have found others with a tiny and almost transparent new-formed operculum in place of the normal large one."

The operculum sharply differentiates the species of the *picta* group from one another and also from all the other groups. This is true as well in regard to the line between *A. ligata* and other *Anculosae*. In the *compacta* group, the line is cleanly drawn as against other groups, but probably only the student of the genus would readily distinguish the variations of the opercula of the three species belonging to it. There is, on the other hand, a great deal of similarity among the opercula of the *taeniata*, *ampla* and *showalterii* groups, and this supports to some extent certain general similar-

ities in shell characters. In *A. flexuosa* H. H. Smith there are likenesses of shell which link the species both with the *picta* and the *taeniata* group. There is likewise a dimorphism of opercula.

In the *picta* group we have the largest opercula of the genus. They are all easily recognizable and separable apart from their shells, the spiral lines are usually well marked, there is a similarity of color and texture as there is a similarity in the fact that all have loosely-coiled whorls. The opercula of *picta* and *formosa* are alike in form, but the latter are large and the spiral lines are more clearly defined. From the Conasauga down to Cedar Bluff on the Coosa, the operculum of *dowiei* is more individual than it is farther south where it tends to mirror the operculum of *formosa*. As in the case of the shell, the operculum of *modesta* seems to be a degenerate form of *downiei*. The *foremani* operculum has the distinctive serrations first noticed by Hartman. It is inclined in many instances to be definitely triangular. Though in point of shell characters this species is closer to *formosa* than is *downiei*, the operculum yet points to a more distant relationship. Mr. Smith was at one time inclined to believe that his *clipeata* deserved erection as the type of a new genus upon the basis of the operculum, which is large, thick-margined, generally very dark and with the strong spiral lines near the center. It would seem that his opinion changed in this matter. The operculum of *clipeata* is carried at the very opening of the aperture, much as in the case of *Bythinia tentaculata* L.

The opercula of the *taeniata* group have tightly-coiled spiral lines, usually very indistinct. They are ovate to elliptical, ordinarily dark. In *taeniata* the opercula of young and half-grown specimens are usually elongate, but as the animal grows older it widens the organ. Those of *torrefacta* though generally rougher resemble the opercula of *taeniata* just as the shells are much alike. In *coosaensis*, the opercula are smaller, more regularly formed and less variable than in *taeniata*. The normal operculum of *griffithiana* is thick, dark, broader in proportion to altitude than in *taeniata*, the growth lines strong. The ribbon-like operculum which occurs in many specimens is a variant developing with the juveniles and there are no indications that it is brought about through accident or disease. The spiral lines and the nucleus are absent. Growth proceeds from the left margin, or that nearest the columella, along a straight line, turning outward slightly at the edges. As the ordinary operculum resembles a leaf, so in this kind of operculum the grain of a tree is suggested. Hartman (1871) was under the impression that such opercula occurred among individuals inhabiting still water. Mr. Smith found it in *griffithiana* in numbers on the Coosa shoals. In *aldrichi* we find opercula of the normal and the produced form common to *griffithiana*, though much smaller. In *choccoloccoensis*, the operculum is shaped like that of *taeniata*, but the spiral lines are more loosely coiled. The operculum of *brevispira* is narrow, elliptical in the young, developing the characteristic *taeniata* form not until well grown. It may be described as the antithesis of the operculum of *clipeata*, for it occupies only one-third to one-half of the aperture, and when withdrawn must go far within the shell.

In the *ampla* group, the opercula are not easily to be distinguished from:

those of the preceding group, and doubtless the affinities between the two groups is in general quite close. They have the closely-coiled inner whorls of the *taeniata* assemblage, are ovate to elongate, dark as a rule. In seeking an operculum of *ampla* to illustrate, none could be found among the river specimens which had any remaining traces of the spiral lines. The figure pictured is the operculum of a creek shell. Damaged and distorted opercula are the rule in this group. The *ampla* operculum is usually narrower in proportion to altitude than others of the group. In *mimica* the broad operculum illustrated is not wholly characteristic, elongate forms also appearing. The opercula of *plicata* are in general ovate, the growth lines frequent and strongly-marked. Those of *smithi* are closely related to the opercula of *plicata*.

No common characteristic is observable among the opercula of the *showalterii* group. *Showalterii* itself has a distinctive operculum, elliptical, dark, the margins of adult specimens thickened. The striking feature of the operculum of *sulcata* is the loosely-coiled spiral lines. Neither of these opercula does the operculum of *lirata* resemble, though in a longer series than has been at hand the connection might be made more clear. The operculum of *occultata* is like that of a small *sulcata*.

The opercula of the *compacta* group are small, thin, with tightly-coiled spiral lines when they appear at all. The organ to a large extent seems degenerate. The operculum of *compacta* which is illustrated has four whorls. This is probably an abnormality. The fan-like development of *melanoides* is characteristic also of the operculum of *vittata*.

The operculum of *ligata* is described in detail later on. There exists no close affinity to this form among the other Anculosae, nor is any relationship traceable to any kind of operculum so far discovered outside of the genus.

CLASSIFICATION

The Anculosae of the Alabama drainage divide into six groups, four of them well defined, two others which are not so distinctive and might prove upon more thorough study, particularly of the anatomy, to belong to one of the groups whose border lines are of satisfying clearness.

The *picta* group consists of six members, characterized by a similarity of shell structure and, to some extent, of opercula. Taking *picta* as the head of the group, not because it appears to be the most primitive form, but because it is the oldest in point of christening, *clipeata* and *formosa* are seen then to be the nearest relatives, with *foremani* more distantly connected and in shell characters allied to *formosa*. *Downiei* can be fancied upon this family tree as the direct descendant of *formosa*, and *modesta* as the poor relation of *downiei*.

For a second group, *taeniata* has been taken as the leading term. The small and not very firmly established local race *tarrefacta* is closely allied. Somewhat more distant is *coosaensis*, another local race, but which yet has acquired an unmistakable individuality and such prosperity as is indicated by large numbers. *Griffithiana* follows as a seemingly ancient offshoot. *Chocoloccoensis* would appear to be the descendant of *taeniata*, or of one of *taeniata's* antecedents, which invaded a tributary of the main

stream, becoming modified through isolation and the influences of creek conditions. *Brevispira* is still farther away from *taeniata*, presenting in part aspects common to *ampla* of another group and possessing a dimorphism peculiar to itself. *Aldrichi* I believe to be a derivative of *griffithiana* as also *flexuosa*, a puzzling form which supports the suspicion of hybridization more than any other species among the Alabama Anculosae.

The three members of the *compacta* group—*compacta*, *melanoides* and *vittata*—are small unsculptured mollusca, one living in Cahaba River, the second in the Black Warrior and the third in the Coosa. *Compacta* was recognized as a *Lithasia* by Tryon, but it is as truly an *Anculosa* as is *melanoides*, which it resembles. In shell characters the first two are alike, but as regards the opercula the affinities are closer between the second and third than between either of these and *compacta*.

Anthony's *ligata* constitutes a group to itself. It has no close relationships with any other living *Anculosa* and its operculum is unique.

The relationship of the members of the *ampla* group to one another is quite clear. *Mimica* is a creek form of *ampla*, confined to one stream so far as is known, which has become uniformly smaller, has intensified the parent sculpture and acquired a distinctive banding formula that involves more than 50 per cent of the collected shells. *Plicata* can be conceived as the living representative of emigrant *ampla* of long ago which went into the Black Warrior and the Tombigbee rivers. The small creek species *smithi* links with *plicata*. The whole group is compact, well characterized. Yet the gap between it and the *taeniata* group is vague. Conic forms of *ampla*, taken by themselves and lacking as they often do the flattened columella most strongly marked in juvenile and half-grown specimens, might easily be confused with *taeniata*. There is also a certain amount of resemblance in the opercula.

The *showalterii* group is less compact than the preceding one. Both *showalterii* and *sulcata* have smooth or nearly smooth forms, and seem then to belong to the *taeniata* group. Certain rather rare forms of *griffithiana* copy *lirata* and only because there exists a long gap in the river between the two races the species might justly be brought close together. The opercula are wanting in distinctiveness, resembling most those of the *taeniata* group. Yet the deeply sulcate character of the mass of these three species seems to warrant their separation into a group to themselves. They are besides common to one fairly short stretch of the Coosa River whereas the members of the *taeniata* clan are more widely scattered. *Occultata* is joined to this group on the ground of its *sulcata*-like operculum and the flaring peristome which is a well-marked feature of young *showalterii*. Mr. Smith also placed it here.

KNOWN DISTRIBUTION OF ALABAMA ANCULOSAE

PICTA GROUP

A. picta Conrad. Bars of Coosa River from below Wetumpka to Clairborne, Monroe County, on Alabama River.

A. formosa Lea. Coosa River, Minnesota Bend below Gadsden, Etowah County, to Wetumpka.

A. foremani Lea. Coosa River, Three Island Shoals, Talladega County, to Butting Ram Shoals, Coosa County.

A. clipeata H. H. Smith. Coosa River, below Riverside, St. Clair County, to Butting Ram Shoals.

A. downiei Lea. Conasauga River, Georgia, to about Riverside, on the Coosa.

A. modesta H. H. Smith. Coosa River, Cherokee and Etowah counties.

TAENIATA GROUP

A. taeniata Conrad. Coosa River, from northeastern corner St. Clair County, to Clairborne, Monroe County, Alabama River. Lower part of Cahaba River.

A. torrefacta H. H. Smith. Coosa River, Weduska Shoals.

A. coosaensis Lea. Coosa River, Fort William and Peckerwood shoals; Talladega County.

A. griffithiana Lea. Coosa River, The Bar, Chilton County, to Wetumpka.

A. aldrichi H. H. Smith. Coosa River, near mouth Yellowleaf Creek, Chilton County.

A. flexuosa H. H. Smith. Coosa River, Wetumpka.

A. chokoloccoensis H. H. Smith. Chokolocco Creek, Talladega County.

A. brevispira H. H. Smith. Coosa River, Three Island Shoals, Talladega County, to Higgin's Ferry, Chilton County.

AMPLA GROUP

A. ampla Anth. Cahaba River, upper reaches to mouth; Coosa River, Wetumpka; creeks of Calhoun, St. Clair, Talladega, Shelby, Chilton and Coosa counties, tributaries to the Coosa.

A. mimica H. H. Smith. Little Cahaba Creek, Bibb County.

A. plicata Conrad. Black Warrior and Tombigbee rivers.

A. smithi Goodrich. Valley Creek, Jefferson County.

SHOWALTERII GROUP

A. showalterii Lea. Coosa River, Fort William and Peckerwood shoals, Talladega County.

A. lirata H. H. Smith. Coosa River, Three Island and Fort William shoals, Talladega County.

A. sulcata H. H. Smith. Coosa River, Ten Island Shoals, St. Clair County to Peckerwood Shoals, Talladega County.

A. occultata H. H. Smith. Coosa River, The Bar, Chilton County, to Butting Ram Shoals, Coosa County.

COMPACTA GROUP

A. compacta Anth. Cahaba River and tributaries.

A. melanoides Conrad. Black Warrior River and possibly Alabama River.

A. vittata Lea. Coosa River, The Bar, Chilton County, to Wetumpka.

LIGATA GROUP

A. ligata Anth. Coosa River, Weduska Shoals, Shelby County, to Wetumpka.

Anculosa picta CONRAD

Figs. 6, 7

Anculosa picta Conrad, *Silliman's Journal*, Vol. ii, p. 342, pl. I, fig. 15, Jan., 1934.

Anculosa zebra Anth., *Proc. Acad. Nat. Sci., Phil.*, Feb., 1860, p. 69.

The species is described by Conrad from specimens he collected in the Alabama River at Clairborne, this material, according to Tryon, consisting of stunted or immature forms. Tryon probably had reference to a modification very common to the species in the Alabama River at Selma and less marked in the Coosa, occurring besides in at least one other member of this group. The normal *picta* is subglobose to conic, with areas almost flattened, having obscure nodules at the shoulders or in instances distinct nodules, the aperture large, ovate. In the case of the modification, the shell is decidedly narrow in relation to altitude, the whorl smooth and rounded, curiously compressed on the side close to the peristome, the aperture almost round.

The growth lines of *picta* are ordinarily fine, sometimes almost obliterated as if from the scouring by sand. Revolving striae are usually very faint and discontinuous, and often entirely absent. Folds, where they occur, are not very prominent. In one lot of Mr. Smith's own collecting from the Coosa at Wetumpka, 6 specimens had well-marked folds from suture to base, 3 had folds faint or nearly microscopic, 4 were without such markings; 6 had knobs or plicae at the shoulder, 7 were without such sculpture.

In color this species is usually a shining, light brown, varying to dark brown, sometimes greenish. The bands are fine, close-set lines of coloring matter, interrupted or continuous, varying in number from four or five to fifteen or sixteen. In several of the lots, the unbanded shells are equal in number to those with bands.

In half-grown specimens, the columella is strong, smoothly rounded, the deposit of callous at the top not particularly heavy. This character in old specimens shows a tendency to distortion; the columella becomes flattened on the outer edge and often is there eroded; the deposit of callous at the junction with the peristome is so large as to give an effect of buttressing peristome and columella. Of 27 shells in one lot from Wetumpka, the columella of all except one was white. A Cahaba River lot had 6 shells with white and 7 with reddish columella. White, purple and reddish columellae were noted in Alabama River shells. The peristome of *picta* is sharp-edged, firm, usually straight, sometimes curved near the suture.

The embryo shell is small, smooth, tightly coiled, the apex slightly raised. It consists of about one and one-half whorls. The adult *picta* may possibly acquire as many as six whorls.

The *zebra* forms of this species are unquestionably pathological. The coloring matter has been deposited in somewhat zigzag method longitudinally, four or five of these "blotches" occurring on the whorl. This irregularity in instances takes place in connection with the normal banding system. The abnormality has been noted in other species. Anthony's description and the remarks of Tryon lead to the assumption that *picta* was the shell before Anthony when he established the species *zebra*.

Measurements:

Altitude	Diameter	
19 mm.	11½ mm.	Coosa River, Wetumpka
18	11½	" " "
17½	12½	" " "
17	12½	" " "
18½	13	Cahaba River
18½	12	" "
17	12	" "
20½	13½	Alabama River
18½	12	" "
17½	11	" "
17½	11½	" " Selma
16½	10	" " "
15½	9½	" " "
13½	8¾	" " "
12	8	" " "

The operculum of *picta* is large, leaf-like, rather thin, reddish-brown, and consists of about three whorls. The left margin is thickened and usually straight, the apex acute, the right margin thin and frayed, the basal margin broadly rounded. The polar point is slightly sunken, the edges of the whorls within the operculum being sharply marked and raised though more so in some opercula than in others. The nucleus is well within the body of the operculum, slightly nearer the left than the right margin and situated about the lower third of the length. A "freak" operculum shows four well defined whorls. Growth lines are coarse.

Mr. Smith's Coosa River *picta* are labeled Wetumpka, but in a letter to Dr. Walker he has explained that the species was not taken in the true Wetumpka Shoals, but on gravel bars of the river below the town, a section geologically much younger. The other extreme of distribution, so far as known, is Clairborne.

Anculosa formosa Lea

Fig. 3

Anculosa formosa Lea, *Proc. Acad. Nat. Sci., Phila.*, 1860, p. 187; *Obs.* ix, p. 76, pl. 35, fig. 61.

Lea described specimens apparently of unusual rotundity and figured a juvenile individual. Tryon does not seem to have had access to a large

amount of material and was persuaded that Lea's *formosa* was synonymous with *A. ampla* Anth., a decision possibly justified under the circumstances. Mr. Smith was enabled to prove the specific identity of *formosa* from the shells in the Schowalter collection which did not come to the eyes of either Lea or Tryon. He himself collected a large series of these distinctive An-culosae. An adult from Fort William Shoals, Coosa River, is here described:

Shell: Conic, thick, Dresden brown, shining. It has ten or twelve low, broad, rather obscure folds from shoulder to base. At the shoulder are irregular nodules which in other shells often take the clear form of plicae. Microscopic lines of growth are fine; no revolving striae save the channels between the folds were observed. Suture impressed, irregular. Aperture ovate. A broad band appears at the top of the aperture and another at the base. Between these two bands are six or seven faint, interrupted fine lines of color such as occur in *A. picta* Con. Peristome sharp-edged, but firm; slightly curving near the suture. Columella porcelain white, very strong, curving regularly, rounded, flattened slightly on the outer edge, a heavy deposit of callous at the top, base unusually heavy. The shell is 19 mm. in altitude; diameter, 14¼ mm.; aperture, 8¾ mm. by 7. Collected by Herbert H. Smith, July, 1913.

The species first appears in the Coosa at Minnesota Bend, just below Gadsden. It has there many of the aspects of *A. downiei* Lea which occurs in the same shoals, being yellow or light brown, strongly folded and with distinct plicae. There is a gradual modification of these characters proceeding down the river. At Ten Island Shoals the shells tend to lose the plicae, to acquire a strongly shouldered appearance and to be slightly ligulate. The middle and lower river form begins to show at Three Island Shoals in Talladega County, though occasional mollusks above this locality have the middle river aspect. At Fort William Shoals plicated specimens are rather rare, smooth shells are more common than in the shoals above. The lots from Weduska Shoals, The Bar, Butting Ram Shoals and Wetumpka are smooth, without folds or clearly marked plicae.

Variations as to locality in the matter of banding are also noticeable. Minnesota Bend shells have fine lines within the aperture, often nearly obsolete, which follow the folds of the outer surface. At Ten Island Shoals a single shell was found which has three well marked bands of the usual form, one above the periphery, two below it. More and more shells of this character appear as the collections progress down the river. In one of the lots from Fort William Shoals, 44 have the fine, broken lines typical of *picta* with the addition of a heavy band at the base; 19 have the lines continuous together with the basal band; 20 have an arrangement of four equidistant, clearly defined bands. Five modifications of this latter arrangement were noted in a total of 28 specimens. In one lot from The Bar, nearly as many specimens had a few definite bands as had the many fine lines of color. The two forms were of equal number in material from Butting Ram Shoals.

The prevailing color of the columella of the up-river *formosa* is white. In a Fort William Shoals lot 85 shells had a white columella, 26 had the

columella purple, 4 were of red and 1 black. Below Peckerwood Shoals, which are an extension of those of Fort William, purple becomes the prevailing color of the columella, with the exception that the *formosa* taken by Mr. White at Wetumpka had the columella white.

In this species there occur specimens with a ground color of red, showing most richly in the columella. One shell from Fort William Shoals is black throughout, or a very dark purple. Material of the *flammata* coloration appears in lots from Hall's Island, Talladega County, down.

The embryo shell of *formosa* is smooth, tightly coiled, the apex slightly elevated. It consists of one and one half to one and three-quarters whorls. Probably an adult specimen, if uneroded, would show six whorls.

Two lots of shells in the Alabama collection, four specimens in all, are labeled as from the Cahaba and Alabama rivers. It is to be suspected that these are cases of mislabeling. Mr. Smith's collecting justifies the belief that Wetumpka is the southernmost point of distribution.

The operculum is thin, wing-like, dark-red. Left margin firm, nearly straight and slightly bent backward at the acute apex; right margin broadly curved, very much torn; basal margin rounded. Growth wrinkles very coarse. The nucleus is located in the lower third of the operculum about 1 mm. from the left margin. Whorls three. Spiral lines raised, not always well defined or regular. The area of attachment is elliptical, narrow relative to the size of the operculum. The operculum of *formosa* shows a close affinity to that of *picta*.

Measurements of Shells:

Altitude	Diameter	
17½ mm.	13 mm.	Below Minnesota Bend, Etowah County
19	13	Ten Island Shoals, St. Clair County
17½	13½	" " " " " "
16	12	" " " " " "
16½	12	Lonigan Shoals, " " "
18½	12¾	Clarence Shoals, " " "
18	13	Fomby Shoals, " " "
20	13½	Truss Shoals, " " "
18	14	Hall's Island, Talladega County
21	14½	Three Island Shoals, Talladega County
19	12	" " " " " "
24	14	Ft. William Shoals, " "
20	13	" " " " "
19½	13½	" " " " "
16	12	" " " " "
14	11½	" " " " "
19½	14	Peckerwood Shoals, " "
19	13	Weduska Shoals, Shelby County
19½	14	The Bar, Chilton County
18	12½	" " " " "
20	14	Butting Ram Shoals, Coosa County
19	13¼	" " " " "
15½	12	Wetumpka, Elmore County

Anculosa foremani Lea

Fig. 4, 5

Anculosa foremani Lea, *Proc. Amer. Phil. Soc.*, ii, p. 243, Dec. 1842.

In shell characters this species is closer to *A. picta* Con. than is *A. formosa* Lea. But while the operculum of *picta* and *formosa* are much alike, that of *foremani* is like the operculum of neither. The similarity of the shells of *formosa* and *foremani*, *picta* out of consideration, varies strangely with locality, the resemblances and differences seeming to play a game of see-saw as the collector travels down the Coosa River. At Three Island Shoals, for example, *foremani* is a smaller, smoother mollusk than *formosa*, without the basal band so oddly persistent in that species. At Fort William Shoals the two forms come so closely together that, lacking the opercula for guidance, a large series is required to make identification certain. At Weduska Shoals, the differences become more distinct again, *foremani* retaining folds, *formosa* having lost them, the fine lines of color of one being faint, those of the other strong. Thus with each locality there are variations permitting separation of the two species, yet not always because of the same characters. In general, *formosa* is a larger species, more shining, with slightly heavier columella and a greater tendency as it proceeds downstream to substitute a few bands of color for the many fine lines. If the hypothesis is correct that the animal, protected and less subject to environmental forces, is less inclined to change than the exposed shell of the mollusk then, with the opercula in mind, we may suppose that *foremani* sprang from a form distinct from the ancestral forms of *picta* and *formosa*. We must explain the marked resemblances of the shell as a case of convergent development.

The sculpture of *foremani* consists of fine growth lines, microscopic revolving striae being rather rare. About half of the specimens of any given lot have broad, flat folds, more or less distinct and about the same number have nodules at the shoulder which may be termed plicae.

The fine lines of color are usually interrupted and at places there are shells which, like *formosa*, acquire a band at the base in addition, though usually this character is not as strongly marked, when it exists, as in the other species. Bands first appear in material from Fort William Shoals, the arrangement being four bands with a fine line of color between two of them. Such specimens are comparatively rare and among *foremani* are noted only from the locality given, Peckerwood Shoals and Butting Ram Shoals. Shells having the pathological character of *flammata* and *zebra* are not uncommon to this species.

The color of the columella varies from white to red and purple. The collections from Three Islands Shoals have the columella white in four shells in six; at Butting Ram Shoals, virtually the southernmost point of distribution, purple columellae were to the white in about the same proportion.

The operculum is reddish brown with the edges transparent. It is nearly triangular in most instances and very small in proportion to the size of the

aperture. Growth lines coarse. The left margin is nearly straight, the right margin curved and serrated regularly, the base broadly rounded, serrated. The nucleus is sunken, the spiral lines loosely coiled, whorls three. The serrations begin at about one and one-half whorls, and usually can be observed even after the horny material of the operculum fills the interstices between them.

Measurements of shells:

<i>Altitude</i>	<i>Diameter</i>	
19½ mm.	13 mm.	Three Island Shoals, Talladega County
18	11½	“ “ “ “ “
21½	14½	Fort William Shoals, “ “
20½	13½	“ “ “ “ “
19	14	“ “ “ “ “
18	12	“ “ “ “ “
18	14	Peckerwood Shoals, “ “
20	13½	Weduska Shoals, Shelby County
18½	11½	“ “ “ “ “
18	13	The Bar, Chilton County
20½	13¾	Near mouth Yellowleaf Creek, Chilton County
19½	14	“ “ “ “ “ “
17	12½	“ “ “ “ “ “
20½	13	Butting Ram Shoals, Coosa County

The species is confined to the Coosa River, appearing first at Three Island Shoals and reaching the limit of its distribution at Wetumpka, Mr. Smith's collection of *foremani* at this locality consisting of just one specimen. Judging by the numbers collected, the shallows near the mouth of Yellowleaf Creek, Chilton County, are the most flourishing places in the river for this most interesting form.

Anculosa clipeata H. H. Smith, new species

Fig. 8

Shell: Conic, of moderate thickness, body whorl slightly flattened, the base rounded. Growth lines fine, tending to wear smooth below the periphery; crossed in places just below the suture by a few discontinuous, waving striae. Apex eroded. Suture impressed. Three or four low nodules appear on the shoulder, marking where growth has been made over the deposit of shell material at the top of columella. Aperture ovate, yellowish white. Peristome sharp-edged, firm, curving outward just below the suture, a little sinuous toward the base. Columella pearl-white, rounded, a little flattened on the outer edge near the center, heavy at the top. The ground color of the epidermis is raw sienna of the Ridgeway color standards, with twelve interrupted lines of dark coloring matter, these showing up very sharply within the aperture.

Operculum: Oval, thick, leathery, measuring 6 mm. by 3½ mm. Apex acute. Left margin not so curved as the right margin, this margin being thickened, smooth-edged. The basal margin is broadly rounded. The nucleus is very small, slightly sunken, located about 1½ mm. from the left margin and in the lowermost third of the operculum. Whorls three.

Measurements of shell: Altitude, 15½ mm.; diameter, 11¼ mm. Aperture—altitude, 6¼ mm.; diameter, 5 mm.

Type locality: Coosa River, Fort William Shoals, Talladega County, Alabama. Collected by Herbert H. Smith, June, 1914.

Type in the Museum of Zoology, University of Michigan; paratypes in that museum and the Alabama Museum of Natural History.

This species has two distinct geographical forms. From the first locality at which it has been found—between Riverside and Ogletree Island in St Clair County—to Peckerwood Shoals, Talladega County, the species has some of the general characteristics of the *picta* group, being bright in color, rounded at the base, rather smooth and usually having fine, interrupted lines in place of bands. At Weduska Shoals a decided change is observed. The shell here is medal bronze to olive green in color. The base is sub-angular. Growth lines are raised, often rough. The arrangement of bands, where bands occur, is four—interrupted or continuous. The shell suggests a small *A. taeniata* Con. While no specimen of this latter form appears to have been collected above Weduska Shoals, occasional specimens of the middle river form have been found from Weduska Shoals to Butting Ram Shoals, apparently the southernmost point of distribution.

The sculpture of *clipeata* varies slightly, some specimens having the folds which are more or less common in this group and others showing a tendency to develop obscure plicae. In a lot from Fort William Shoals, 29 individuals had folds upon the surface, 90 were without any and about one shell in fifteen had indications of plicae. Folds and plicae were both generally absent in collecting from Weduska Shoals downward. Of 117 shells of one lot from Fort William Shoals, 100 had the characteristic fine lines; 15 had bands, the arrangement being four or a modification of it; two were without lines or bands. A lot from The Bar, Chilton County, had sixteen shells with the four-band formula, the bands broken or continuous, with three modifications of this arrangement, represented by one specimen each. Three shells lacked any bands, and none had lines. From where *clipeata* is first found to Peckerwood Shoals, the collumella is white with only occasional shells wherein this character was red or salmon. In the lower river forms, the salmon or salmon-orange columella is common to about as many mollusks as the white columella.

The embryo shell consists of about one and one-half whorls, smooth, loosely coiled and virtually upon the same plane. The adult *clipeata*, if un-eroded, would probably be found to have five whorls.

The outstanding feature of this species is the extraordinarily large operculum. In specimens in which the opercula have not been removed they are seen to overlap the columella slightly, touching the edge of the outer lip and occupying practically the whole space of the aperture. Probably in life the operculum is not withdrawn more than one or two millimeters. Some unimportant variations have been observed. At Peckerwood Shoals, the operculum of the adult shell is thin and amber-brown as in the young. The basal margin seldom seems to suffer from abrasion as it does in opercula of many other species. The area of attachment, elliptical in shape, occupies about one-half of the operculum. Frequently the spiral lines seemed to be as strongly developed on the inner side as on the outer.

Measurements of shells:

<i>Altitude</i>	<i>Diameter</i>	
16 mm.	11½ mm.	Three Island Shoals, Talladega County
15½	11½	" " " " "
14½	10	" " " " "
20	12	Fort William Shoals, " "
17	11¾	" " " " "
16½	12	" " " " "
15½	11	" " " " "
16¼	11	Peckerwood Shoals, " "
14½	10	Weduska Shoals, Shelby County.
16¼	10¾	Near mouth Waxahatchee Creek, Shelby County
16½	11½	The Bar, Chilton County
15	10½	" " " " "
14	10	Butting Ram Shoals, Coosa County

This species, so far as the records show, is confined to the Coosa River, reaches its maximum development at Fort William Shoals—judging by size and the quantity of material collected—and disappears with the end of Butting Ram Shoals.

Anculosa downiei Lea

Figs. 1, 2

Anculosa downiei Lea, *Proc. Acad. Nat. Sci., Phila.*, 1868, p. 153.

The highest place in the Coosa drainage at which Mr. Smith collected this species was in the Conasauga River, east of Dalton where the stream forms the border between the two Georgia counties of Whitfield and Murray. The one shell collected there, though apparently adult, was only 11 1-2 mm. in height by 8 mm. in diameter. Near Tilton, in the same river and about fifteen miles farther down, the largest shell was 10 1-2 by 7 1-2 mm. At his next station, Resaca, Gordon County, Ga., Mr. Smith's largest *downiei* measured 12 x 9 1-2 mm.

In the Oostanaula River, the continuation of the Conasauga, the shells have reached an extreme of 14 1-2 x 10 mm. At Rome, Ga., where the Oostanaula and the Etowah rivers join to form the Coosa, the largest shell has the measurements 15 x 10 mm. But up the Etowah at Kingston, about thirty miles above Rome, the size has again dwindled, the largest *downiei* collected being 12 x 5 1-2 mm.

This is an excellent illustration of a rule often recited that the size of fresh water mollusks frequently bears a ratio to the size of the body of water inhabited. The reasons seem clear. The upper reaches of a river are in the stage of a creek, being subjected to greater relative variations than the stream farther down. The waters become low in the dry seasons, warm, often stagnant, charged with the gases of vegetable decay. The soluble foreign material brought into the creek by brooks becomes more highly concentrated than in the true river. The Anculosae, which ordinarily move about very little, are forced into an unnatural energy as a measure of self-preservation. There are alterations in the quantity of food supplies, probably alterations in the quality of this food, certainly decided changes in the chemical constituents of the water. Circumstances dictate a smaller animal and therefore a smaller protective shell.

At Black Bluff on the Coosa River, a short distance below Rome, Mr. Smith's largest specimen of *downiei* measures 17×10 1-2 mm., at Cedar Bluff in Cherokee County, Alabama, the size has increased to 18 1-2 \times 14 1-2 mm. This last is the largest lot collected by Mr. Smith and it seems to be indicated that here the species is most flourishing. In Terrapin Creek, the same county, conditions somewhat identical with those in Georgia again obtain. The average size of the adult shells is 14×9 1-2 mm., the maximum, 16×11 mm. Changes below this point are not great, yet are noticeable. At Fitz's Ferry, the largest *downiei* measures 16 1-2 \times 11 1-2 mm., at Maple Grove, 14×10 ; near Slackland, Etowah County, 15 1-2 \times 9 1-2; Lonigan Shoals, 14×11 ; Fomby Shoals, 15×11 ; Leoto Shoals, 16×11 ; Riverside, St. Clair County, 15×10 1-2. After Cedar Bluff, it would appear, the species tends to run out numerically, and this is accompanied by physical alterations.

The shells of any one colony of *downiei* show little of the extreme variability which marks the Pleuroceridae in general, maintaining about the same proportions of altitude to diameter from young to adult.

In typical specimens, the surface of the body whorl is covered with folds from suture to base. Below the periphery these ordinarily proceed regularly to the lip and are only occasionally wavy or wrinkled. Near the suture the folds are very much waved where they "pass over" the plicae. In the case of the up-river shells, the folds are narrow, sharply cut, but as one examines the shells proceeding downstream one notices that the folds become broad, smooth upon their surface, so nearly upon a plane that in poor light the shell to the eye seems smooth. At Coosa, Georgia, specimens appear which are very nearly smooth near the base and in the Cedar Bluff lots are several individuals of this character. Of thirty shells taken at Leoto Shoals, seven only have the typical folds; in the instance of twenty the folds are obsolete or nearly so below the periphery and three are entirely without folds. It is as if a characteristic wholly absent or rare in up-river forms had become the normal habit on Leoto Shoals. In almost every lot there are a few shells whose folds are broken into beads where the plicae are crossed. The "obscure, transverse revolving striae" of Lea's description are usually not continuous, being absent or faint upon the tops of the folds. Lea lays as much emphasis upon his shells being plicate as upon their being folded. But the plicae are not a constant character. They differ in size and in number. They are not always present. Study suggests that the plicae are caused by the massing of shell material at the top of the columellae during the rest periods and that individuals are governed by no fixed natural law as to the amount of the accumulation. When new growth begins, the secretion is in smaller quantity, and thus an effect is given of miniature hills and valleys, and in as much as the "valleys" are often filled with dark coloring matter the plicae in such cases stand out conspicuously.

The color bands are in the texture of the shell as well as in the epidermis, being defined most clearly within the aperture. These bands consist of interrupted deposits of pigment, customarily laid within the folds though often "spilling over" into the creases between the folds. Sometimes the

color material is so irregularly secreted that deposits of it coalesce and the aperture is given a mottled effect. In only one shell of the collection, taken at Cedar Bluff, has there been so much secretion of pigment that the aperture is uniformly dark—indicating that what is more or less common among certain species of *Goniobasis* and *Pleurocera* is rare in *A. downiei*. Differences in color between shells from near the headwaters and those from mid-river or lower are slight. The unbanded shells are ordinarily a bright shining yellow, those thinly banded olive brown and the ones with heavy bands dark brown. In the Cedar Bluff collection shells for the first time appear that carry a great deal of pigment in the body material, being pinkish by transmitted light. Several more so distinguished were in the lots from Center Landing, the same county. At Fitz's Ferry, shells appear whose "body" color is deep red. Others were found to the point where *downiei* disappeared from the river. This coloration is not a case of bands coalescing, for bands may be distinguished against the background of red. The color includes the columella, usually a porcelain white, and the operculum, ordinarily maroon.

The embryo shell seems to be only one whorl in size, usually upon the same plane as in *Planorbis*, but not always. One young shell taken at Fitz's Ferry has two folds at the periphery of such size as to suggest the carina of young *A. praerosa* Say.

The operculum is thin, light red to maroon. Left margin thickened, slightly curved, the right margin ragged and broadly curved, the basal margin rounded. Growth lines coarse, widely spaced, spreading like an opening fan. The polar point is typically close to the left margin, though not on the edge. The spiral lines are well defined, loosely coiled, the whorls three. The smooth *Leoto downiei* have large opercula, the left margin straighter than usual, the whorls opening broadly. These opercula, together with shell characters, emphasize the relationship of the species with *formosa*. In general, the operculum of *downiei* is lighter of color than that of *formosa*, thinner, the spiral lines more cleanly cut. Also it is lighter than the operculum of *picta*, wider in proportion to length and it lacks the straight left margin, a pronounced character in *picta*. The spiral lines of *downiei* are clear to the naked eye. A magnifying glass is necessary to make out those of *picta*.

Anculosa modesta H. H. Smith, new species

Fig. 9

Shell: Conic, about twice as high as it is wide, having broad, flat, somewhat waving folds from suture to base of body whorl. Two or three low nodules suggest plicae nearly obsolete. Lines of growth delicate, regularly spaced. No revolving lines can be made out with a glass of moderate power. Color brown, shining. Two narrow bands becoming obsolete before the peristome is reached appear on the body whorl, one at the periphery, the other just above. No bands show in the ovate, bluish-white aperture. Apex eroded, only one whorl being entire. Suture not strongly impressed, a little waving near the peristome. Columella white, delicate, smooth, rounded, with only small deposits of callous top and base. Peristome thin, nearly straight, sharp-edged, a little broken.

Operculum: Very thin, reddish, 5 mm. in altitude, 3 mm. in diameter. Lines of growth fine, interrupted by occasional heavier lines which give the operculum the appearance of an opening fan when viewed by transmitted light. Left margin slightly curved, right margin broadly curved, thin and torn. Apex acute. Polar point, crater like, somewhat large for so small an operculum; it is located on the left margin about 1 mm. above the base. Spiral lines loosely coiled. About one and one-half whorls within the operculum can be traced. Area of attachment small, narrow, elongate.

Measurements of type: Altitude, 11 mm.; diameter, $7\frac{1}{2}$ mm. Aperture—altitude, 6 mm.; diameter, $3\frac{1}{2}$ mm.

Type locality: Coosa River, Riddle's Bend, Cherokee County, Alabama. Collected by Herbert H. Smith, October, 1904.

Type in the Museum of Zoology, University of Michigan. Paratypes in the Alabama Museum of Natural History.

This species is confined apparently to the Coosa River in Cherokee and Etowah counties, Alabama, above the middle river shoals. Mr. Smith's shells come from only three localities, rather close together. *Modesta*, to all seeming, is a small local race whose affinities are closest to *A. downiei* Lea. It differs from that species in being smaller, having weaker folds, less pronounced plicae, a greater tendency to vary. The bands are not so numerous. The operculum of *modesta* is much thinner and shows a more decided variability. The impression is given that in the case of this species the operculum has lost much of its usefulness as a protective organ.

Of 34 specimens from Riddle's Bend 1 has quite strong folds, 27 are moderately folded suture to base, in 4 the folds can be made out only with a glass and in the case of 2 shells there are no folds. No revolving striae were seen. The plicae consist mostly of flat nodules, irregular, seldom continuous in any one specimen.

The color varies from a shining yellow to light brown. The banding arrangement is four thin, continuous bands. Only one modification, other than that in the type, was noted, a single banded specimen lacking the basal band. Many shells have bands in the epidermis which do not show in the aperture. The number of specimens lacking bands exceed those with them.

The columella is usually porcelain white, sometimes cream-colored, uniformly regular and rounded. The variation in the peristome is exceedingly slight, this character being usually straight, sometimes a little curved near the suture.

The operculum is of the *picta-formosa-downiei* type, but is evidently degenerating and varies accordingly in size, form and sculpture. Two opercula were observed to have curious little pits upon the anterior side as if diseased. This has not been remarked in the case of any other species.

Measurements:

<i>Altitude</i>	<i>Diameter</i>	
11½ mm.	7 mm.	Riddle's Bend, Cherokee County
11¼	7¼	" " " "
10¾	7	" " " "
9	6¾	" " " "
12	8	Below Minnesota Bend, Cherokee County
10	7	" " " " "
12	8	Fitz's Ferry, Etowah County
11¼	7½	" " " "
10½	7½	" " " "

Anculosa taeniata (Conrad)

Fig. 10

Anculotus taeniatus Conrad, *New Fresh Water Shells of U. S.*, p. 63, 1834.

This species has the longest range of any of the Anculosae of the Alabama system. Conrad described it from Clairborne, which is much nearer to the Gulf of Mexico than it is to the mouth of the Coosa River. Mr. Smith collected it as high on the Coosa as the northeastern point of St. Clair County and on all the big shoals below as far as Wetumpka. Material in the Schowalter collection is credited to the Cahaba River. It has been taken at Selma on the Alabama below the mouth of the Cahaba. Doubtless it could be found in favorable locations between this place and the type locality at Clairborne, and possibly beyond.

The variation in *taeniata*, while considerable, is not as confusing as that of several others of the species under consideration. There appear to be no more than a few clearly traceable offshoots. In form the species is heavy, subangular, usually shouldered or humped, often longitudinally produced. Lines of growth are very fine and close together. These are crossed, though not in the case of all shells, by revolving lines which are usually discontinuous and often undulate. Viewed under a glass this sculpture, when well marked, gives the surface of the shell the appearance of peach down. Shells with folds mostly confined to the shoulder appear in nearly all the lots, these being more common in material from the lower part of the Coosa than from the upper. Of 81 *taeniata* from Ten Island Shoals, St. Clair County, 64 were smooth, 17 had folds at the shoulder. Out of 74 from The Bar, Chilton County, the smooth shells numbered 56, those with folds 18. Yet there is actually no striking change in sculpture from the St. Clair County stations to Wetumpka.

The columella of *taeniata* is usually fairly stout, smooth, rounded, regularly developed and lacking the "buttressed" callous present in the equally large *A. formosa* Lea and *foremani* Lea. In old specimens of *taeniata* the face of the columella is sometimes ground down as if against the rocks, so as to give it the flattened appearance characteristic of some of the other species of Alabama Anculosae. Changes in the color of the columella from north to south were observed. Of 81 shells from Ten Island Shoals, 58 had the white columella, 5 were pink, 18 were streaked or spotted with purple or brown pigment. The columellae of the Truss Shoals shells were purple without exception. At the Three Island Shoals, the white columella became rare and at Ft. William Shoals one lot of 70 shells had only one specimen with a white columella. The columellae of Weduska Shoals material were purple or reddish while those of the shells from The Bar were all purple. The few shells from the Cahaba in the Schowalter collection had the white columella slightly touched with color. Fading in these specimens was marked.

The peristome of this species is ordinarily straight, sometimes slightly curved close to the suture; strong, sharp-edged.

The upper river shells are yellowish to olive-brown, the bands being well defined. Material from the lower part of the Coosa are much darker, less

shining, the bands more obscure. A mottled effect as in *flammata* and *zebra* mutations is rather rare, as is also the occasions when the coloring matter of the bands has spread throughout the shell.

Fifteen arrangements of bands were noted in this study—the arrangement of four equidistant bands prevailing. Nine arrangements were modifications of this formula, these being exceedingly uncommon and so indicating that they represent merely individual variation or aberration. Few shells without bands and few with the bands broken into squares or oblongs occur in the upper parts of this species' range. Below Lock 4, broken bands become predominant. In nearly every lot one to several shells occur which have bands upon the epidermis that do not show in the aperture.

The nuclear shell of *taeniata* is smooth, loosely-coiled, having about one and one-half whorls. Of seven juveniles from Ten Island Shoals, the columellae of six were white or pink and one was purple. All these shells were four-banded, the peristome flaring; no angulation occurred at the periphery.

The operculum is elongate, reddish-brown, with growth lines fine to coarse, closely set together. The left margin is firm, very slightly rounded. Apex rounded. The right margin is thin, often broken and uneven, curved. The basal margin is broadly rounded, frequently worn or ragged. In ten opercula examined, the polar point of five was upon or close to the left margin. In the other half, it was nearly in the center of the basal margin. This shifting of position was due to wearing. The nucleus is very small, indented, crater-like. Such spiral development as can be made out in most of the opercula is closely confined to a very small space near the base, and in only one specimen examined was it possible to trace the full three whorls common to the operculum of species of this genus. The area of attachment is elongate, oval. In a small form of *taeniata* which Mr. Smith separated from collections at Ten Island, Three Island and Butting Ram shoals, the chief differentiation is an elongated, narrow operculum with a straight left margin.

Measurements of shells:

<i>Altitude</i>	<i>Diameter</i>	
17½ mm.	11 mm.	Clarence Shoals, St. Clair County
16	11	Lonigan " " " "
20½	14½	Ten Island Shoals, St. Clair County
18	12½	" " " " " "
15½	11½	" " " " " "
17	12	Lock 2, St. Clair County
16½	12	Truss Shoals, St. Clair County
16	10½	Three Island Shoals, Talladega County
20	13½	Ft. William Shoals, " "
20	13	Peckerwood Shoals, " "
19	13	Weduska Shoals, Shelby County
17½	12	" " " " " "
22	15	The Bar, Chilton County
21½	14½	" " " " " "
20	14½	" " " " " "
16½	11½	" " " " " "
16½	12	Wetumpka, Elmore County

Anculosa torrefacta H. H. Smith, new species

Fig. 11

Shell: Smaller than and not so heavy as the adult of *A. taeniata* Conrad, the species to which it is most closely related. It is subglobose, subangulated, slightly indented at the base. Lines of growth fine, close together, crossed by revolving striae, usually wavy and not always continuous. Just below the suture to within eight or ten millimetres of the peristome are low, broad nodules which are made to appear larger than they are by reason of spots of dark pigment between them, these nodules probably being the nearly obsolete remains of plicae. The type has no folds. The body color of the shell is red-brown, rather dull, looking as if burned. It is broken by four wide, continuous bands of purple. Apex eroded, the body whorl alone remaining. Suture irregular. Peristome sharp-edged, slightly sinuous, a little curved close to the suture. Columella smooth, regular, rounded, the callous not very heavy for a shell of this size; it is colored with purple, this being lighter at the base of the columella. Aperture ovate, reddish, marked with the four purple bands, one of which is lighter in tone than the others.

Operculum: Dark, reddish brown, thick; altitude 8 mm., diameter 4 mm.; the whole leaf-like. The left margin is nearly straight, the apex acute, the right margin firm, irregular; basal margin rounded. The polar point is small and at the base of the left margin. Area of attachment elongate, rounded at base, apex acute; bordered by a ridge of black callous.

Measurements of type: Altitude, 16 mm.; diameter, 12 mm. Aperture—altitude, 12 mm.; diameter, 7 mm.

Type locality: Coosa River, Weduska Shoals, Shelby County, Alabama. Herbert H. Smith, collector, August, 1913.

Type in the Museum of Zoology, University of Michigan; paratypes in that museum and in the Alabama Museum of Natural History.

* This species is apparently confined to the Weduska Shoals. It represents an offshoot of *A. taeniata* and resembles to a degree the smooth forms of *A. griffithiana* Lea. Not all of the shells have the microscopic sculpture of the type, though it is common to most. Shells were found in the Smith collection the early whorls of which were decidedly plicate and one specimen bore two waving, narrow folds at the shoulder and dim, very flat folds on the base. A second specimen had widely spaced, nearly obsolete revolving lines like the channels between the ribs of sulcate Anculosae. Forms much constricted of body whorl were not uncommon.

On old shells, the columella is nearly always eroded at the umbilicus. Material with the columella white is rare; in banded shells this character is commonly purple, in unbanded specimens reddish. The curved peristome is present in all the ligulate shells, common though not pronounced in others. Specimens with straight lip are about one in four or five.

Four equidistant bands are the prevailing banding arrangement, these being usually broken into square or oblong markings. Shells with continuous bands as in the type are about one in six.

Torrefacta has a humped squat look and when numbers are laid out on a table they remind one of pictures of Indians sitting at council with blankets over their shoulders.

The operculum varies somewhat, the lines of growth being sometimes interrupted by coarse lines representing the rest periods, the apex varying from acute to rounded, the left margin being as often curved slightly as straight. The right margin, particularly in young shells, is often torn, the

the basal margin usually so. The nucleus is small, pit like. The number of whorls is probably three. Such spiral lines as can be made out under the glass become lost in the material of the operculum after about one and one-quarter whorls.

Measurements of shells:

<i>Altitude</i>	<i>Diameter</i>	<i>Altitude</i>	<i>Diameter</i>
19½ mm.	13½ mm.	17 mm.	12½ mm.
18½	12½	16½	11½
18	13	15½	11¼
17½	12	15	11

All are from Weduska Shoals.

Anculosa coosaensis Lea

Fig. 13

Anculosa coosaensis Lea, *Proc. Nat. Acad. Sci., Phila.*, March, 1861, p. 54.

This species, in Tryon's opinion, was the half-grown form of *A. taeniata* Conrad. Specimens of *coosaensis* in the Alabama collection show all the marks of maturity in the matter of shell deposit. The animal abandons its spire and confines its life to the body whorl, as in the mature of other forms. The shell experiences proportionally the same erosion. Tryon's decision, it may be, came about from the fact that certain specimens of *taeniata* taken by Dr. Schowalter in the Alabama River at Selma are so dwarfed as superficially to resemble Lea's species. A larger series of the true *coosaensis* than Tryon had before him would, in all likelihood, have prevented this mistake.

The species is apparently one of the most narrowly confined of the *Anculosae*. The explorations of Mr. Smith brought it to light only on the Fort William and the Peckerwood shoals of the Coosa River, the second group of shoals being not much more than an extension of the first. Because of this perhaps the variation in form is not great. Ordinarily the body whorl is flattened, but it is sometimes slightly constricted. Specimens occur which are subangulated, though typically the periphery is rounded. Numbers of the young are subglobose rather than conic.

Sculpture consists of fine to rough growth lines, crossed by striae which are sometimes but not always continuous, waving to straight. At times these revolving lines are more nearly to be described as raised than incised. A few shells were found with folds, also a few with sharp carinae as in the young of *A. praerosa* Say. The plicae when they appear are never more than flat, broad nodules with spots of dark coloring matter between them which brings them into prominence.

Color varies from yellow to dark brown, a few shells being reddish, a few green. Young shells are more apt to be greenish than older ones. The banding formula is usually four equidistant lines of color, continuous or broken. Of the eight arrangements of banding noted, seven were simple modifications of the prevailing system. Ninety-five shells in a Fort William Shoals lot were banded in epidermis and aperture, 6 in the epider-

mis only, I was without bands and I was streaked with color irregularly after the pattern of the shells known as *flammata*.

The columella of *coosaensis* is smooth, regularly developed, the larger callous at the top not particularly strong. As in the case of other species of this group, the outer edge of the columella is flattened near the umbilicus, being at right angles to the body whorl. This character is not always present or when present well marked. In color, the columella is purple or reddish, white being uncommon. In one lot, 87 had the columella purple, 16 with it slightly colored red or purple, 1 with this inner lip white. The peristome is straight or slightly curved near the suture.

The embryo shell seems to consist of about two small, smooth whorls, tightly coiled, sometimes elevated, sometimes on the same plane. Five or six whorls for the fully grown shell are indicated.

The operculum is elliptical or ovate, moderately heavy, light to dark red. Lines of growth are fine to coarse. In some opercula these lines are crossed at right angles by waving striae. Rest scars are not prominent or easily to be differentiated from growth lines. Apex usually rounded, sometimes acute. Curves of the margins unequal. The polar point is slightly raised, and normally is upon or near the left margin near the base. The whorls are three. The spiral development can seldom be made out; it is closely confined to the area near the polar point.

Measurements of shells:

<i>Altitude</i>	<i>Diameter</i>				
17½ mm.	9½ mm.	Coosa River,	Schowalter	collection	
17	10	"	"	"	"
16	10	"	"	Mohr	"
15½	10½	Ft. William	Shoals,	Talladega	County
15¼	9¾	"	"	"	"
14½	10	"	"	"	"
14	9	"	"	"	"
13½	10	"	"	"	"
13½	9	"	"	"	"
13	8½	"	"	"	"
11	8	"	"	"	"
11½	8	Peckerwood	"	"	"

Anculosa griffithiana Lea

Fig. 15

Anculosa griffithiana Lea, *Proc. Amer. Phil. Soc.*, II, p. 83, July, 1841.

Anculosa rubiginosa Lea (?), *Proc. Amer. Phil. Soc.*, II, p. 83, July, 1841.

Following the example of Tryon, collectors and authors have usually given precedence to the name *rubiginosa*, a species described by Lea at the same time and upon the same page as *griffithiana*. The former species was, however, put down as a shell of "Warrior River", whereas the locality of the species under discussion here was given as the Coosa River. Only one character—"columella, thick, dark purple"—appears to point to the Coosa mollusk, while the rest of Dr. Lea's description of *rubiginosa* can apply to a smooth and fairly common form of *A. plicata* Conrad which does inhabit

the Black Warrior. Furthermore, occasional specimens of *plicata* have the "columella thick, dark purple". As against an argument that *rubiginosa* was not actually a Coosa shell it might be recited that Lea had the carelessness of his contemporaries in regard to type localities. But unless the one shell from which Lea described *rubiginosa* can be found and positively identified as his type, the uncertainty will remain. It seems best to employ the name *griffithiana*, and that this was Mr. Smith's belief is indicated by some of his labels.

The species has a narrow range. It occurs in great numbers at Wetumpka and it is from this place that most of the shells in the collections have come. Eight miles north, it is less flourishing—to judge from Mr. Smith's collections there. At Noble's Ferry in the same county, only one specimen of the species was taken by Mr. Smith. No locality is given for *griffithiana* above the northern line of Chilton County which by air line cannot exceed forty-five miles from Wetumpka. One lot of *griffithiana* from the Schowalter collection bears a Cahaba River label. These shells appear to be identical with Wetumpka material, and as Mr. Smith himself did not find the species in the Cahaba this may be considered an error on the part of Dr. Schowalter.

The shell as a rule is stoutly folded from suture to base, the folds being most pronounced in the Wetumpka shells. Smooth specimens or nearly smooth appear in all the lots, the greatest number coming from The Bar, Chilton County. In one lot from Wetumpka about one individual in eight is without folds. In another lot, one shell in four is without folds, one in eight has folds nearly obsolete. On the upper whorls of the shell are faint indications or remains of plicae. The fine growth lines are usually well defined, though upon some of the older specimens and on top of the folds of many others these lines have worn away. Microscopic revolving lines can be made out on most of the material. They show most plainly on shells devoid of folds.

Seven arrangements of the bands were noted in this study, the most common being four rather heavy, continuous, equidistant strata of coloring matter. Among Wetumpka shells, about twice as many unbanded specimens occur as banded. About one shell in twenty-eight has bands upon the epidermis which do not show in the aperture; about one in thirty-five has bands broken into squares as in the case of other species of this group. Among folded shells from The Bar which Mr. Smith separated from smooth forms, more banded than unbanded shells appear, the ratio of the one to the other being three to one.

The columella of *griffithiana* is rounded or angulated. It is usually stained with purple, red or pink coloring material. Shells with a white columella are rare. A characteristic of the species is that the columella covers the umbilical niche rather poorly. In some specimens a slight, eroded groove or hollow is left and in few specimens is the base covered completely and smoothly. The color of the shell ranges from yellow to dark brown, red shells are not uncommon and occasionally slightly mottled shells appear.

The peristome is very slightly curved near the suture, is sharp-edged and in heavily-folded shells it tends to be sulcate.

The nuclear whorls are tightly coiled, smooth and not upon the same plane, the embryo shell appearing to be one and one-fourth to one and one-half whorls in size. In one young and uneroded specimen the nuclear whorls are bright red, smooth, elevated; the second whorl dark, green, slightly carinate, shining and smooth between the carinae; the third whorl angulated at the base, folded, having four interrupted bands. In another juvenile the second whorl has a slight beading at the top close to the suture, a spot of color occurring between nodes.

The operculum is dark red by transmitted light, about twice as long as wide. Lines of growth are pronounced, the margins thickened and usually smooth, the apex pointed though sometimes rounded. The polar point is at the edge of the left margin below the center. The operculum is usually "indented" at the polar point where the animal has rubbed the operculum against the columella. In instances, the basal margin has been worn away until the nucleus rests upon the base. The spiral lines in most of the opercula examined are very nearly obsolete. Three whorls are indicated, the first two very tightly coiled. Tryon illustrated a specimen of *griffithiana* with tongue-shaped operculum, but makes no mention of it in the text. Numbers of shells with opercula of this nature are in the Alabama collection. This form is described elsewhere.

A label in a tray of *Wetumpka griffithiana* reads: "On rocks in swift water less than 4 feet deep when the river is low."

Measurements of shells:

<i>Altitude</i>	<i>Diameter</i>	
20½ mm	11½ mm.	Wetumpka
18½	11	"
17	12	"
16	12	"
15½	10½	"
15	10	"
13	9	"
15	10	Eight miles above Wetumpka
13½	10	" " " "
11½	8½	Noble's Ferry, Elmore County
12	9½	Butting Ram Shoals, Coosa County
12	9	" " " " "
11½	8½	" " " " "
14	10	" " " " "
13	9½	" " " " "

Anculosa aldrichi H. H. Smith, new species

Fig. 16

Shell: Subglobose, smooth, shining, subangulate, the base somewhat flattened and indented. Color of epidermis light brown, crossed by four dark, discontinuous bands each about 1 mm. wide. Within the aperture these bands appear against a bluish-white background of shell material. Apex eroded, the body whorl alone remaining entire. Lines of growth fine, regularly spaced, interrupted by three rest-period scars which are rather narrow, two of them being raised above the surface of

the shell. The growth lines are crossed by very delicate, microscopic revolving striae, waving, broken, absent on some parts of the shell. Suture a little irregular. Aperture ovate. Columella moderately stout, rounded except on the outer edge at the center where it is flattened. Peristome sharp-edged, but firm, a little curved close to the suture.

Operculum: Dark, rather thick, lines of growth very fine, rest scars not heavy. Size 5 mm. by 3½ mm. Apex rounded. Curves of left and right margins nearly equal. The base of the operculum of the type is lighter colored and thinner than the rest of the operculum, indicating that it has been renewed after injury or wear. The polar point is small, very slightly raised above the plane of the operculum. It is on the left margin near the base. One and one-half whorls of the closely-coiled spiral development are traceable. The area of attachment is elliptical, the edges thickened with dark callous.

Measurements: Altitude, 13½ mm.; diameter, 10 mm. Aperture—altitude, 6½ mm.; diameter, 5 mm.

Type locality: Coosa River, near mouth of Yellowleaf Creek, Chilton County, Alabama. T. H. Aldrich, collector.

The type is in the Museum of Zoology, University of Michigan; paratypes in that museum and the Alabama Museum of Natural History.

This is a localized race, being apparently confined to one shoal of the Coosa River. It has the general appearance of *A. taeniata* Conrad, but it is uniformly smaller, less shouldered, flatter of base. The affinities seem to be closer to *A. griffithiana* Lea, which it resembles in form, in both the normal and the produced opercula, and in the tendency to develop the folds characteristic of the *griffithiana* most common to collections. There are specimens which are hard to distinguish from *A. coosaensis* Lea and some of the young are very like the juveniles of *A. ligata* Anth. *Aldrichi* is a good illustration both of the variability of these Coosa races and the marked habit of any given form of Pleuroceridae in any one locality to resemble all other forms there.

The microscopic sculpture varies in strength and it sometimes occurs that the longitudinal lines are less prominent than the revolving lines. Specimens with folds are not uncommon, but the variation from flat and scarcely perceptible elevations to rib-like folds, and their irregularity in many instances probably argues that the character is not fixed or directly inheritable. Material with plicae is comparatively rare, and where it occurs the plications consist merely of low, flattened nodules made a little striking to the eye by spots of dark coloring matter between them.

The color of *aldrichi* varies from yellow to dark brown, olive-green specimens being not uncommon. The larger number of individuals is banded, and often these bands coalesce so that the epidermis has a "zebra" effect. The prevailing banding arrangement is four continuous or broken lines of color, variations consisting of modifications of this formula. In one lot, 111 shells had four bands, mostly discontinuous and frequently with the two inner bands joined or nearly so; 13 had one or more bands suppressed; 74 had bands in the epidermis that did not appear in the aperture; 8 were without any bands.

The embryo shell is very small, smooth, tightly coiled, only slightly elevated. The uneroded adult would probably have five whorls.

The operculum of the type resembles most of the opercula examined,

there being variations in the curve of the margins and the position of the polar point, the form of the apex and the extent of the wear and tear experienced. Perhaps a dozen *aldrichi* were found to have the produced operculum, noted in *griffithiana*. The normal operculum of the latter species is larger than that of the species under discussion, as is also the operculum of *taeniata*. There is, however, a clear resemblance in the opercula of the three species, and *coosaensis* may be included.

Measurements of paratypes:

<i>Altitude</i>	<i>Diameter</i>	<i>Altitude</i>	<i>Diameter</i>
15½ mm.	10¾ mm	13 mm.	9½ mm.
14¾	11	13	9
14	10	11	7½
13½	10¼	10½	8½
13	10		

***Anculosa flexuosa* H. H. Smith, new species**

Fig. 17, 18

Shell: Subglobose, rather heavy, surface broken with stout folds from suture to base and having a half-dozen low, broad nodules at the shoulder which give a flattened effect to parts of the body whorl. Apex flattened, partly eroded. Growth lines fine, worn away in places upon the tops of the folds. Suture impressed, irregular. Aperture broadly ovate, bluish-white, the channels between the surface folds showing through. Peristome a little curved below the suture, quite thin, slightly crenulate. Columella of the type specimen deep purple, rounded, flattened on the surface from the center nearly to the base. Color of shell, buckthorn brown. Within the aperture appear a few spots of color, all that the type has of color bands or lines.

Operculum: Very thin, reddish, translucent, small for so large an *Anculosa*. Apex acute. Left margin firm, nearly straight, curving abruptly to the apex. Right margin thin, torn, broadly curved. Basal margin worn and broken. Growth lines fine. The polar point is located at about where the left and basal margins meet. Nearly two whorls may be made out within the operculum with the glass. The area of attachment is narrow, elliptical, the deposit of dark callous on the edges being small.

Measurements: Altitude, 17 mm.; diameter, 13½ mm. Aperture—altitude, 10 mm.; diameter, 7¾ mm.

Type locality: Coosa River, Wetumpka, Elmore County, Alabama. Collected by Herbert H. Smith. October, 1903.

Type in the Museum of Zoology, University of Michigan; paratypes in that museum and the Alabama Museum of Natural History.

This species, so far as known, is confined to the vicinity of Wetumpka unless a somewhat puzzling shell more nearly conic, taken by Mr. Smith at Duncan's Riffle, Chilton County, can be assigned to it. Specimens taken by Schowalter, Call and T. H. Aldrich have been brought together in the Alabama collection, indicating that while *flexuosa* is not exactly a common mollusk it cannot be pronounced rare. Possibly it has been fairly widely distributed as *A. formosa* or *griffithiana* by Dr. Schowalter, as individuals have been found in some of Dr. Schowalter's boxes or trays which bear these labels.

Most of the material, like the type, is heavily folded. But a few spec-

imens appear which are wholly or nearly smooth. The nodules are not constant, and when they are present they vary in strength. Judging from the shells examined, color bands or lines are tending in this species to become obsolete. Of 11 specimens in one lot, 7 were without bands or lines, 3 had fine lines broken or continuous, 1 had an arrangement of four very dark continuous bands. The type specimen lacks the heavy callous at the top of the columella, present in some of the material which evidently is older. The columella is ordinarily strong, broad, rounded, tending to become slightly flattened on the outer surface and on the edges near the center. Of the 11 specimens of the one lot mentioned above, the columella was white in 1, purple in 2 and reddish or salmon in the case of 8. The outer lip is sinuous more often than not.

Two forms of operculum were observed, one which is of the *griffithiana* type and the other suggesting relationship with the *picta* group.

Flexuosa is much more robust than *griffithiana* and the development of fine color lines is foreign to that species. Considering size, color lines, opercula and general shell texture and sculpture one might be inclined to think the form a hybrid of *griffithiana* and *picta*. Yet the absence of evidences of hybridization elsewhere in the genus *Anculosa* discourages this idea.

Measurements:

<i>Altitude</i>	<i>Diameter</i>	<i>Altitude</i>	<i>Diameter</i>
19½ mm.	14½ mm.	17¼ mm.	13 mm.
19	14	14	11½
18	13½	14	11

All from Wetumpka.

Anculosa chocoloccoensis H. H. Smith, new species

Fig. 14

Shells: Obtusely ovate, not heavy, lines of growth rather coarse; spiral striae over parts of the shell, undulate, obscure, not continuous; rest scars prominent. Apex eroded. Suture impressed, a little irregular. Color buckthorn brown; shining; epidermis showing four interrupted bands, the basal band very faint; bands appearing in aperture as lines of dark dots or oblong markings. Columella reddish, strong, rather heavy in the center, regularly curved, the outer edge flattened and nearly at right angles to the body whorl; at the base projecting slightly over the epidermis. Aperture ovate, peristome very thin.

Operculum: Thin, reddish, 7¼ mm. in altitude, 3¾ mm. in diameter. The left margin is nearly straight; right margin curved, firm; basal margin broadly rounded; apex acute. Lines of growth fine. Nucleus indented, located on left margin close to the base. Whorls three, closely coiled. The area of attachment to the foot is narrow, elliptical.

Measurements: Altitude, 13¼ mm.; diameter, 11¼ mm. Aperture—altitude, 6½ mm.; diameter, 5½ mm.

Type locality: Chocolocco Creek at Jackson Shoals, Talladega County, Alabama. Collected by Herbert H. Smith, September, 1905.

Type in Museum of Zoology, University of Michigan; paratypes in the Alabama Museum of Natural History.

This species was collected by Mr. Smith at three localities, Jackson Shoals, Eureka and two miles above the Coosa River, all the stations being upon Choccolocco Creek and within Talladega County. There is only slight variation in the material, though the shells taken at Eureka are uniformly more slender than the Jackson Shoals specimens. In shell characters the adult mollusk is closer to *A. taeniata* Con. than to any other species, but the two carinae on the whorls of the juveniles might seem to indicate a relationship with *A. ampla* Anth.

Six specimens of the type lot are smooth, shining, with only faint revolving striae; 2 have well-marked revolving striae and are somewhat duller; one has a fold 2 mm. below the suture, crossing low plicae and giving a banded effect. A shell from Eureka has fine, erect lines from suture to base, continuous and undulating.

The banding arrangement consists of four lines, usually interrupted, these showing more often in the epidermis than in the shell material of the aperture. A single shell only has five bands.

The columella is normally rounded, rather large; in one old specimen it is heavy and buttressed at the top as in Anculosae of the *picta* group. The color of the columella varies from white to purple.

The embryo shell is small, tightly coiled, the apex elevated. It consists of about two whorls. The juvenile shell does not enlarge rapidly. It has two well-defined carinae at the periphery, characteristic of the young of *A. praerosa* Say, *ligata* Anth. and creek forms of *ampla* Anth. All the juveniles have a weak columella. The four bands are made up of widely spaced dots. A perfect adult would probably have five whorls.

The operculum of this species is rather large in proportion to the size of the shell as compared with opercula of other members of the *taeniata* group. In paratypes, the left margin was found to be more curved than in the operculum of the type. It seemed to be the tendency of most of the animals to wear away the operculum against the columella at the thickened material close to the nucleus. In only the one specimen could the spiral lines be clearly traced.

Measurements:

<i>Altitude</i>	<i>Diameter</i>		<i>Altitude</i>	<i>Diameter</i>	
16½ mm.	10¼ mm.	Jackson Shoals	13¾ mm.	8½ mm.	Eureka
13½	10	" "	12	8	"
13	9½	" "	10¾	8	"

Anculosa brevispira H. H. Smith, new species

Fig. 12

Shell: Subglobose, suggestive of *A. ampla* Anth. Longitudinal growth lines rather fine, regularly spaced, crossed over part of the shell by discontinuous revolving lines. Apex slightly eroded, flattened, the whorls developing with remarkable rapidity, this expansion beginning immediately after the embryo whorls. Suture impressed. Body whorl broadly shouldered, bearing four or five low nodules with spots of dark coloring matter between them. Peristome thin, flaring, nearly straight. Columella moderately heavy, flattened nearly its whole length so as to give the inner edge a ridged

effect; color white, touched with red-brown on the outer edge close to the epidermis. Aperture broadly ovate, reddish, having four interrupted, equidistant bands about 1 mm. in width. Color of shell buckthorn brown.

Operculum: Dark red, somewhat thin, in shape like a minute willow leaf; more narrow in proportion to length than the operculum of *A. taeniata* Conrad. Growth lines are well marked, but not particularly heavy. Left margin nearly straight, right margin curved, firm; basal margin broadly rounded, worn. Apex slightly rounded. The polar point is on the left margin close to the base. No trace of the spiral lines can be discovered under the glass. The area of attachment occupies slightly more than half the posterior surface, being elliptical, edged with dark callous.

Measurements: Altitude, $13\frac{1}{2}$ mm.; diameter, $10\frac{1}{2}$ mm. Aperture—altitude, $7\frac{1}{2}$ mm.; diameter, $5\frac{1}{2}$ mm.

Type locality: Fort William Shoals, Coosa River, Talladega County, Alabama. Collected by Herbert H. Smith, June, 1914.

Type in the Museum of Zoology, University of Michigan; paratypes in that museum and the Alabama Museum of Natural History.

This species varies greatly in form, most specimens having the characteristically expanded aperture, but many being as conic as *griffithiana* Lea or *taeniata* Conrad. The young do not closely resemble the adults, the mature characters developing with about the third whorl. The peristome of the juvenile shell is not flaring; it curves at the suture over the early deposit of columellar callous. The upper part of the whorl is more shouldered than in most of the old shells. The affinities of *brevispira* are somewhat obscure, but the impression given during the study of the species is that it is near to *taeniata*.

Numbers of the specimens are folded or slightly ribbed. Occasional specimens bear nodules at the top of the body whorl which may indicate descent from a plicate state. In one lot, 9 individuals have folds from suture to base which vary in strength; 19 have folds at the shoulder only; 59 are entirely smooth.

The color of the epidermis ranges from snuff brown to sepia and a few specimens have the dark mottled appearance of some *A. showalterii* Lea. The bands are usually four in number, continuous or broken. Three variations of the banding arrangement from the normal formula were observed, and each lot collected by Mr. Smith contains shells without bands.

The columella, flattened and a little angular rather than curved, seems to be one of the most definite characters of this race. The lower outer edge is not raised so distinctly above the "abutting" epidermis as in the case of *ampla*. The color of the columella is usually purple. In some it is white and in many specimens it is splotted with purple or red, the ground color being white or pink.

The embryo shell is minute, one and one-half whorls in size, the apex a little raised. The second whorl when completed is very large as compared with the nuclear section. An adult probably has four whorls.

One doubtful specimen of *brevispira* was taken at Three Island Shoals. The species appears to be exceedingly common on parts of Fort William Shoals. It was not found apparently from there down the river until The Bar and Duncan's Riffle in Chilton County were reached, though doubtless it does exist at favorable stations between these shoals. Lower river speci-

mens, rather rare, vary somewhat from typical forms, but are quite recognizable.

The operculum of *brevispira* is very small in proportion to the aperture. As seen in the shell it lies close to the columella, the apex fitting into the corner between the columella and peristome with a little room to spare. At the base, however, is a wide gap and nearly one-third of the aperture between the right margin of the operculum and the peristome is left unprotected.

Measurements:

<i>Altitude</i>	<i>Diameter</i>			
18 mm.	13 mm.	Fort	William	Shoals
17½	13½	"	"	"
16½	12¾	"	"	"
15½	11	"	"	"
15½	10¼	"	"	"
14	10	"	"	"
13½	11	"	"	"
13½	9½	"	"	"

Anculosa ampla Anthony

Fig. 23

Anculosa ampla Anth., *Annals N. Y. Lyc. Nat. Hist.*, VI, p. 158, pl. v, fig. 22, 23, Oct. 1855.

Anculosa elegans Anth., *Proc. Acad. Nat. Sci., Phila.*, Feb. 1860, p. 69.

In point of distribution this species is one of the most interesting and certainly the most puzzling of the Anculosae of the Alabama drainage. It is the characteristic member of the genus in the Cahaba River. In the Coosa it has been found sparingly at Wetumpka, close to the mouth of that river, and there only. But north of Wetumpka the species has been collected in five western and three eastern tributaries of the Coosa.

Not another Anculosa of the drainage has so strange a distribution. If this were due to environmental requirements on the part of the species, one might expect to find a similarity in the habitats of *ampla*. There is anything except similarity. In the Cahaba drainage the species occupies not merely the parts which are river-like in character, but also the upper reaches where the conditions are those of a creek, the Little Cahaba River which is more creek than river, and a mineral spring five miles from Centerville which is on the Cahaba. The difference between the Coosa tributaries and the Coosa proper at Wetumpka is that between small streams with lively but not very heavy current and a large river with a strong and, for many months in the year, a deep current. Other Anculosae of the Alabama system are distributed with known or apparent continuity. For example, *A. downiei* Lea lives in the Coosa drainage from the Conasauga to just beyond the middle Coosa Shoals, *A. taeniata* Conrad from the middle Coosa to Clairborne on the Alabama.

The explanation for the unusual distributional record of *ampla* which

seems most reasonable at this time is that the species is a relic of a race dating far back in geological time and in the comparatively recent and quite noticeable evolutionary alteration of the Coosa mollusca it has disappeared from that stream except at Wetumpka, holding its own only in the tributaries. The ancient lineage of *ampla* is possibly indicated in the shell itself, some juvenile forms of it having characteristics strikingly resembling *A. praerosa* Say of the Tennessee system.

The usual form of *ampla* is subglobose, the aperture ovately rounded, the body whorl shouldered at the suture and there often bearing folds and plicae. Yet in nearly all lots of Mr. Smith's collection many specimens appear which are conic, the aperture narrowly ovate or even elliptical, the surface wholly free of folds and plicae. The pronounced sculpture is more common to the shells of the Cahaba than to the material from the Coosa creeks. Where folds and plicae both occur the region near the suture is usually broken by nodules or tubercles, resembling in this regard *A. plicata* Conrad of the Black Warrior. In the creek forms these characters vary with localities—being a marked feature, for instance, of the Canoe Creek specimens and entirely absent from the Waxahatchee, Buxahatchee and Warson collections. The growth lines of *ampla* are rather strong, the revolving lines usually obscure or often absent.

The species is yellow, dark brown or olive green. The creek forms are easily distinguished from those of the rivers by being brighter, the epidermis having escaped the erosion from sand and the common accidents of heavy currents. About fifteen different arrangements of bands were observed in this study, but most of them were merely modifications of the prevailing formula of four equidistant, interrupted or continuous bands. The creek forms show no marked difference in this character from those of the rivers, though unbanded specimens appear to be rarer in the creeks than in the other localities. In one lot of 224 specimens from Lily Shoals of the Cahaba, 33 were without bands.

The inner edge of the columella of *ampla* is ridged rather than rounded as in other groups of Anculosae. This is plainer in young and half-grown specimens than in the adult. It is not usually flattened on the outer edge, though one lot of creek shells shows this characteristic in virtually all the specimens. The lower third of the columella is produced or flattened as if smoothed with a palate knife. In color the columella is white, red or purple, this last color being the most common. Occasional lots, as those from the Coosa at Wetumpka, have the columella white. The peristome is sharp-edged, firm, usually straight as if the animal held itself tightly to flat stones.

The embryo shell is small, smooth, elevated, rounded and apparently consists of two whorls. Most of the juveniles collected by Mr. Smith have the usual Anculosa form, but specimens from Wetumpka are very much flattened of apex and have the aperture flaring like *Neritina*. Juveniles taken in Waxahatchee Creek and in the Cahaba River at Centerville bear two carinae at the periphery as in the young of *A. praerosa* Say.

The operculum of *ampla* is dark red to brown, somewhat broader in proportion to length than in the case of *A. taeniata* Conrad. The apex is

rounded, though occasional opercula of the creek forms have the apex acute. The left margin is usually curved, but sometimes straight or nearly so; the right margin is always broadly curved, usually thin and torn; the basal margin rounded when entire. The polar point is on the left margin close to the base, the spiral lines closely coiled, the edges of the whorls within the operculum virtually disappearing after the first one and three-quarters whorls.

Measurements of the shells:

<i>Altitude</i>	<i>Diameter</i>	
20 mm.	13½ mm.	Cahaba River, Lily Shoals, Bibb County
17½	13½	“ “ “ “ “ “
16	11½	“ “ “ “ “ “
15½	12	“ “ “ “ “ “
15½	10	“ “ “ “ “ “
15½	11	“ “ Pratt's Ferry, “ “
14½	10½	“ “ “ “ “ “
11½	9½	Little Cahaba River
16	11½	Coosa River, Wetumpka
15½	12	“ “ “
15½	10½	“ “ “
13½	9½	Canoe Creek, St. Clair County
15	10½	Ohatchee Creek, Calhoun County
14¾	10	“ “ “ “
14	9¾	“ “ “ “
15	10	Kelly's Creek, St. Clair County
13	9	Yellowleaf Creek, Shelby County
14½	10½	Waxahatchee Creek, Shelby-Chilton Counties
13	10	“ “ “ “ “

***Anculosa mimica* H. H. Smith, new species**

Fig. 24

Shell: Rather heavy, rough, in form like the subglobose forms of *A. ampla* Anth. Growth lines coarse, revolving lines apparently absent. There are four heavy folds and one light fold at the shoulder upon which are narrow nodules or tubercles suggestive of the sculpture of *Paludomus corinata* Reeve. The nodules are strongest near the peristome. Color of epidermis citrine, broken by three well-marked bands, these appearing in the aperture as six very dark, continuous bands. Columella strong, ridge-like at the center, flattened on the outer surface from the middle to the base, outer edge projecting slightly over the body whorl. The columella is nearly pure white and has two small blotches of purple on the inner edge. Peristome flaring as in *ampla*, thin but firm; thickened about 1 mm. within the aperture. Aperture broadly ovate.

Operculum: Similar to that of *A. ampla*. Nucleus pitted, located upon the left margin near the base. Whorls three. The operculum illustrated is slightly deformed at the left margin close to the nucleus.

Measurements: Altitude, 12½ mm.; diameter, 9½ mm. Aperture—altitude, 6½ mm.; diameter, 5½ mm.

Type locality: Little Cahaba Creek, three miles east of Piper, Bibb County, Alabama. Herbert H. Smith, collector, June, 1916.

Type in the Museum of Zoology, University of Michigan; paratypes in that museum and the Alabama Museum of Natural History.

This is a small local race, superficially resembling *A. plicata* Conrad, but more closely related to *A. ampla*. In the type lot, 21 of the shells have the folds as in the type, 10 have strong, oblique plicae crossing three to five folds and ending just below the shoulder, 3 are without folds or plicae. Two or three specimens have small folds continuing from suture to base. There is very slight difference in the form of the shells, virtually all having a flattened apex very little eroded, the flaring peristome and the flat columella.

More shells than any others had the arrangement of six bands of the type. Several modifications, however, were noted; eight specimens of the type lot, for example, having the formula of four bands which prevails in *ampla*. One shell in four of the type lot was melanic.

Little variation occurs in the columella. The color is usually purple. The peristome is straight, a little sulcate in young specimens where the folds reach the outer lip. No shell with perfect apex appears in this collection, but from specimens only slightly eroded the embryo seems to have been about one and one-half whorls in size, smooth and in nearly the same plane. The characteristic sculpture apparently develops immediately with the first growth after the nuclear whorls.

Measurements:

<i>Altitude</i>	<i>Diameter</i>			
14½ mm.	11 mm.	Little Cahaba Creek		
13½	10	"	"	"
13	10	"	"	"
9	8¼	"	"	"

Anculosa plicata (CONRAD)

Fig. 25

- Anculotus plicatus* Conrad, *New Fresh Water Shells of U. S.*, p. 61, 1834.
Anculosa bella Lea, *Proc. Amer. Phil. Soc.*, II, p. 83, July, 1841.
Anculosa tuberculata Lea, *Proc. Amer. Phil. Soc.*, p. 83, July, 1841.
Anculosa rubiginosa Lea (?), *Proc. Amer. Phil. Soc.*, p. 83, July, 1841.
Anculosa tintinnabulum Lea (in part), *Proc. Amer. Phil. Soc.*, IV, p. 167, 1845.
Anculotus smaragdinus Reeve, *Monog. Anculotus*, t. 3, f. 23, April, 1860.

Conrad described his species as inhabiting "tributaries of the Tennessee River in Alabama." The description of *plicatus* fits the characteristic *Anculosa* of the Black Warrior River and not at all any mollusk of the Tennessee drainage. That Conrad collected in the Black Warrior is evidenced by his frequent references to the river in his "New Fresh Water Shells," and indeed several of his types came from that stream. If his mistake was not that of confusing notes or labels, he might very well have been under the impression at the time of collecting *plicatus* that his stream belonged to the Tennessee system, for tributaries of the Tennessee and the Black Warrior very nearly interlock.

The question of Lea's *rubiginosa* is discussed elsewhere in this paper. The recognized *tintinnabulum* Lea occurs in East Tennessee, the author

remarking superficial resemblances to *plicata* which later he would probably have considered unimportant.

The peculiar plicae for which Conrad named his species does not occur in all shells. Nor do all the shells have tubercles or beads or sculpture of that nature. The folds upon which the nodules are formed vary in number from one at the suture to several which continue to the base. On one lot from the Forks of the Black Warrior, 19 had each one fold, 5 had two or more, 18 were smooth. Of 94 from Tuscaloosa, 8 only were smooth. Material from shoals near Lock 15 consisted of 66 shells with from one to four folds, 5 with folds to the base, 19 that were smooth. The tubercles and plicae of the Tombigbee River shells were rather obscure. Fine growth lines parallel with the peristome are common to all the shells, varying slightly in strength. Faint revolving lines crossing the growth lines are to be found with a strong glass.

Eight banding arrangements were noted in *plicata* from the Forks of the Black Warrior, the number of banded individuals being only slightly in excess of those without such ornamentation. The most common arrangement was four thin equidistant lines of coloring matter, the two next most common having respectively a line at top and base and a line at suture, periphery and base. In the Jefferson County shells, the arrangement of three bands was the prevailing form and this was so also in the instances of *plicata* from Tuscaloosa and Lock 15. Frequently bands appear on the epidermis while absent in the shell material of the aperture.

The columella of *plicata* is smooth, rounded and usually the upper half is splashed with brown. It has never the gross, buttressed effect which occurs in some of the larger Anculosae of the Coosa River. The aperture is bluish-white as a rule, though sometimes pink or pure white. The peristome is sharp-edged, firm, very slightly curved. Conrad described his shell as "greenish or blackish." Uncleaned shells are covered with a black deposit of mineral matter. Green shells do occur, but brown is the most frequent color.

Even among the juvenile shells individuals with uneroded spires are extremely rare. The nuclear whorls of a specimen from near Lock 15 are smooth, elevated, without sculpture. No line between these whorls and those which follow is indicated. An uneroded adult specimen of *plicata* would probably have seven or eight whorls. Of 32 juvenile shells from the Forks of the Black Warrior, seven are as strongly carinate as the young of *praerosa* Say and serve to make plainer the relationship of *plicata* with *ampla*. The other juveniles are rounded or subangulated at the periphery.

The operculum is dark red, of moderate thickness, sometimes wider just below the rounded apex than at the base. Left margin curved, right margin slightly more so, inclined to tear. Growth lines light to coarse, occasionally fanlike as in opercula among *Goniobasis*. A few opercula have a wavy sculpture near the outer edge parallel with the right margin. The whorls are three, the first two being more sharply defined than in *ampla*. They are closely coiled.

Measurements of shells:

<i>Altitude</i>	<i>Diameter</i>	
18½ mm.	11 mm.	No label
15½	10½	Black Warrior River, Schowalter collection
17	11	Forks Black Warrior, Walker County
15½	12½	" " " " "
14	10	" " " " "
14	10	Black Warrior River, Jefferson County
13	9½	" " " " "
19	13	" " " Tuscaloosa
16½	11	" " " "
15½	9	" " " "
15	10	" " " near Lock 15
13	9	" " " " " 15
12	9	" " " " " 15
15	10	Little Warrior River
16	11	Tombigbee River
15	10	" "

Anculosa smithi Goodrich, new species

Fig. 26

Shell: Subglobose, smooth, shining, the diameter nearly equal to the altitude. Color of epidermis citrine at top and green-yellow at base. A narrow, dark band below the suture, a heavier band at the periphery, which divides into two bands, these becoming obsolete behind the peristome. The sutural band is the only one showing within the aperture. Apex eroded, only the body whorl and part of the next to the last whorl remaining. Lines of growth fine, somewhat irregular as compared with the same character in other species, these being crossed by much finer, discontinuous revolving lines—a somewhat silky appearance being given to the shell under the glass. Suture impressed, regular, a little waving just behind the outer lip. Below the suture is a rather faint line which forms a somewhat angulated shoulder upon the body whorl. Peristome sharp-edged, nearly straight, the shell thickening about 1 mm. just within the lip. Columella rounded, flattened slightly at the base, bluish-white, splashed with brown over the upper half. Aperture ovate, bluish-white.

Operculum: Thin, reddish, translucent, rather small. Growth rays fine. The left margin is curved, thickened; the right margin more curved, thin, broken. The nucleus is close to the basal margin. The spiral lines show three whorls. The operculum of *smithi* is much more like *plicata* than *ampla*, being distinguishable by its smaller size, thinness and finer sculpture.

Measurements: Altitude, 12 mm.; diameter, 8½ mm. Aperture—altitude, 6½ mm.; diameter, 3 mm.

Type locality: Valley Creek, Toadvine, Jefferson County, Alabama. Drainage of the Black Warrior. Collected by Herbert H. Smith, June 27, 1913.

The type is in the Museum of Zoology, University of Michigan; paratypes in that museum and the Alabama Museum of Natural History.

Of 93 shells closely examined, 14 had a single well-marked raised line, more or less irregular, immediately below the suture; in 24 this line was broken, discontinuous or only faintly indicated. The line did not appear on the other shells at all. This would seem to be a character connecting *smithi* with *plicata* of the main stream. About one shell in three is without

bands. Seven different arrangements of the bands were observed, the commonest consisting of a single thin band at the top of the aperture, with two bands at the base. Many of the specimens had bands in the epidermis without showing any in the aperture. In one specimen only were the bands coalesced so as to involve the whole shell. In this case the aperture was purple-colored throughout. The columellae of nearly all the shells were tinged with brown or red from top to center and the columella of one individual was tinged with purple nearly to the base.

No shell with uneroded spire was found in this lot from Valley Creek. Such parts of apices as remain indicate the nuclear whorls are smooth and loosely coiled, the whorls immediately following being without carinae. The largest number of whorls counted was four.

There is a strong resemblance between this shell and the creek and small river forms of *A. praerosa* Say of the Tennessee drainage. Also it is close to *A. plicata* Conrad. A smooth specimen of *plicata* from the Forks of the Black Warrior River, when compared with *smithi*, was flatter of whorls, angulated at the periphery rather than rounded, the columella proportionally not so heavy. A specimen of *praerosa* from Flint Creek, Alabama, a Tennessee River tributary, was slightly more conic, broad of base instead of regularly rounded, the lip having the characteristic curve of *praerosa* instead of the straightness of *smithi*. All three specimens when placed together, while easily distinguishable, yet showed a striking general resemblance. The inclination is to assume that the species under discussion represents a connecting link between the Tennessee Anculosae and those of the Black Warrior. But there is need first of an anatomical understanding of the three species and perhaps of the geological history of the western Alabama stream.

Measurements of paratypes:

<i>Altitude</i>	<i>Diameter</i>	<i>Altitude</i>	<i>Diameter</i>
12 mm.	8 mm.	11 mm.	8 mm.
11½	8½	11	7½
11½	8	10	7½

All are from the type locality.

Anculosa showalterii Lea

Fig. 19

Anculosa showalterii Lea, *Proc. Acad. Nat. Sci., Phila.*, XII, p. 93, March, 1860.

Anculotus sulcosus Anth., *Reeve Monog. Anculotus*, t. 6, f. 44, April, 1861.

This species appears to be confined to the Fort William and Peckerwood shoals of the Coosa River. Judging from the material collected by Dr. Schowalter and Mr. Smith, it is not nearly as numerous in individuals as many other members of the genus.

The *showalterii* which Lea described were "much ribbed . . . with seven transverse ribs . . . outer lip much expanded and very much crenulate." Mr. Smith found and identified smooth forms of the species, corresponding to the smooth forms of the usually heavily sculptured *A. griffithiana* Lea.

The size of the ribs of any individual sulcate shell may differ, and in one lot the number of ribs per individual varied from six to fifteen; in the same lot three juvenile shells had each six ribs. In partly grown specimens the ribs are undercut, i. e., the base of the rib is smaller than the outer surface. As the animal matures base and edge of the rib are on the same plane. Where the ribs fall below six in number there is usually a decrease in their size or strength, and in such instances the sculpture is best described as folds. In material from Fort William Shoals were mollusks with folds at the top of the whorl, becoming obsolete before the periphery is reached; specimens with folds at the suture and upon the base, the space between being smooth; shells with just the suggestion of folds which were confined to the top of the whorl. Fine growth lines crossed by straight or waving revolving lines appear on virtually all the specimens. They are shown most strikingly on the smooth forms, giving the epidermis the silky appearance characteristic of *A. ligata* Anth.

Ordinarily the body color of *showalterii* is very dark brown, but shells occur which are straw color, some somewhat mottled and a few in which the ribs have a lighter color than the interspaces. The bands tend to follow the ribs, but the coloring matter is sometimes absent and in other instances it is spread through the shell material irregularly. In one lot from the Schowalter collection, there are seven specimens without bands to eight having bands. The usual arrangement is four, rather heavy, equidistant bands.

The columella of old shells is heavy, rounded. Shells with a white columella occur, but in most shells it is stained with brown or purple. The crenulate outer lip of which Lea speaks is found ordinarily only in the younger shells, the furrows within the aperture seldom exceeding three mm. in length. As the animal grows older it fills these channels. The peristome has a slight curve at the suture in numbers of the specimens, but usually it is straight and in certain examples almost appressed, as if the habitat were very swift water and the animal clung tightly to the face of the rocks. The color of the aperture is white, reddish, dark red and sometimes almost black.

The embryo consists of about one and one-quarter whorls, quite loosely coiled, in the same plane and widening suddenly at the aperture. As near as can be made out from this material, a perfect, uneroded, adult would not exceed four whorls.

The operculum is of moderate thickness, dark brown or red, nearly twice as long as it is wide. Lines of growth are strong, but not coarse. The left margin is thickened, as is also the right margin in the opercula of old shells; in the young it is thin and usually torn. The left margin is nearly straight, the right curved, the apex not very pointed, the basal margin broadly rounded. Normally the polar point is close to the base of the left margin, but in old and worn specimens this position has shifted toward the center of the basal margin. On none of the material examined could the spiral lines be traced.

The shells of adult animals differ greatly in size. Sulcate forms do not gain the size of some that are only partially sulcate or are nearly or wholly smooth.

Measurement of shells:

<i>Altitude</i>	<i>Diameter</i>				
13½ mm.	11 mm.	Coosa River,	Schowalter	collection	
10½	8¾	"	"	"	"
16	11	Fort William Shoals,	Talladega	County	
15½	11	"	"	"	"
14	11	"	"	"	"
10	8½	"	"	"	"
17	12	Peckerwood	"	"	"
16½	12	"	"	"	"
15	11	"	"	"	"

Anculosa lirata H. H. Smith, new species

Fig. 22

Shell: Small, subglobose, in form much like a juvenile specimen of *A. griffithiana* Lea. Body whorl subangular, slightly indented over the umbilicus. The type has nine folds or ribs from suture to base, each of about the same size. The two uppermost folds are somewhat wavy, though no other indication of plicae exists. The longitudinal lines of growth are delicate, but distinct, being crossed by revolving lines; the sculpture having a silky appearance under the glass; this is particularly noticeable in the spaces between the folds. Color dark brown, somewhat mottled. Aperture: ovate, having four continuous, equidistant bands. The columella is small, smooth, rounded, purple at the top, white from just above the center to the base. Apex: eroded, only a part of the penultimate whorl remaining in addition to the body whorl. Suture not deeply impressed. Lip slightly crenulate, having only a suggestion of the furrows present in many individuals of *A. showalterii* Lea. The lip is not flaring.

Operculum: Thin, dark or rusty brown, about one-half as wide as it is high. Apex acute. Left margin curved, slightly thickened; right margin curved, thin, a little torn. Basal margin injured, but probably broadly rounded in a perfect state. The polar point is near the left margin. The spiral lines cannot be traced. The operculum differs from the opercula of *A. showalterii* Lea and *A. sulcata* Smith in being more nearly oval, more delicate.

Measurements: Altitude, 11½ mm.; diameter, 7½ mm. Aperture—altitude, 7 mm.; diameter, 3½ mm.

Type locality: Coosa River, Fort William Shoals, Talladega County, Alabama. Collected by Herbert H. Smith, June, 1913.

Type in the Museum of Zoology, University of Michigan; paratypes in the Alabama Museum of Natural History.

The type lot of *lirata* consists of three shells only. The species seems to represent a variation of *showalterii* Lea, smaller, more conic, more delicate of sculpture. It differs also in the operculum. The shell suggests a dwarfed *sulcata* Smith, but has a fewer number of folds and lacks the shouldered effect of the body whorl of that species. Connecting forms with *sulcata* appear in material from Three Island Shoals, above the type locality. From Wetumpka material in the Calkins collection, Mr. Smith has separated a shell very much like the type specimen of *lirata* and among *Anculosae*

collected by Call at the same place are about a half-dozen more shells of the same form. The locality seems to argue that these Wetumpka shells are depauperate forms of *griffithiana* Lea, and doubtless they are when one considers the apparently restricted habitat of the *showalterii* group. The question illustrates the variability of the Coosa River Pleuroceridae and the tendency of each species to develop forms resembling other species in the same locality.

In sculpture, all of the material is very much alike. The Three Island Shoals specimens differ in having larger folds or ribs than the Fort William Shoals specimens, these being also more widely spaced. One of the shells from Fort William Shoals is lighter in color than the type, one darker. One is without bands in the aperture, the other has bands which are interrupted, following the sides of the folds. The banding arrangement in the Three Island Shoals shells are after this pattern rather than that of the type.

Measurements:

<i>Altitude</i>	<i>Diameter</i>				
11 mm.	8 mm.	Fort William Shoals,	Talladega County		
10	7¼	"	"	"	"
13	9	Three Island	"	"	"
12	8½	"	"	"	"
11	8	"	"	"	"

Anculosa sulcata H. H. Smith, new species

Fig. 20

Shell: Rather heavy, subglobose, nearly as wide as it is high, slightly angled at the periphery and indented a little in the base, resembling *A. griffithiana* Lea in this regard. The type has fifteen strong, narrow ribs of varying size from suture to base. The first two ribs of the body whorl are at right angles to the whorl preceding, giving a decided shouldered effect to the shell. The large body whorl is covered with fine growth lines and these are crossed at places by revolving lines more or less undulate. Color light brown, shining. Three continuous bands show within the aperture, the uppermost being heavier than the other two. Apex eroded, only two whorls remaining. Suture irregularly impressed, almost channeled where the first rib of the body whorl rises above it. Peristome slightly curved, crenulate. Columella porcelain white, smooth, rounded, not so heavy as in several species of equal size. Aperture ovate, yellowish-white, translucent. The aperture is smooth to within one or two mm. of the peristome, thereafter furrowed.

Operculum: Dark, thin, in size 8½ mm. by 4½ mm. Apex rounded. The left margin is firm, the right margin fragile. Lines of growth fine. Polar point is close to the base of the left margin. Whorls three, the spiral lines loosely coiled. The area of attachment is long and narrow.

Measurements: Altitude, 19¼ mm.; diameter, 14½ mm. Aperture—altitude, 14¼ mm.; diameter, 7½ mm.

Type locality: Coosa River, Ten Island Shoals, St. Clair County, Alabama. Collected by Herbert H. Smith, October, 1914.

Type in the Museum of Zoology, University of Michigan; paratypes in that museum and the Alabama Museum of Natural History.

The species is apparently confined to the stretch of the Coosa River

between the shoals a little below Greensport, St. Clair County, and Peckerwood Shoals, near the southern end of Talladega County. Shells from Ten Islands Shoals, Lock 2, Hall's Island and "near the mouth of Upper Clear Creek" are very much alike. The Three Island Shoals material contains shells connecting *sulcata* with *livata* and through that species with *showalterii*. This relationship is made plainer by the specimens from Fort William Shoals. The one shell taken at Peckerwood Shoals, while having folds, resembles the smooth forms of *showalterii* very much.

In the typical specimens, the ribs vary in size and distance apart. Individuals occur the ribs of which are so flattened that in rubbing the finger over the surface of the shell one scarcely feels the sculpture. A juvenile *sulcata* taken by Mr. Smith has only eight narrow, thin ribs, widely spaced. Another specimen has three strong folds at the shoulder and no more. However, such variation is rare. *Sulcata* is characteristically strongly ribbed. The microscopic sculpture is apparently present upon all shells. In the case of the partly smooth forms, this sculpture has a "cross-hatching" effect beautiful under the glass.

Ten different banding arrangements were observed, the usual arrangement being four continuous equidistant bands. Of 81 shells in one lot from Ten Island Shoals, 16 were without bands, 2 had bands upon the epidermis but not in the aperture, 61 had well-defined bands in the aperture and of these last 45 had the arrangement of four bands. In the transition lot from Three Island Shoals, the bands were broken, irregular, following the sides of the ribs and the channels between, the tops of the ribs having only the usual coloring matter of the epidermis. In the Fort Williams Shoals shells, the thin bands are continuous and appear in pairs. The folds of the dark Peckerwood Shoals shell have small, irregularly shaped deposits of coloring matter which show in the aperture as broken bands.

The columella of most typical *sulcata* is white to bluish-white, occasionally lead-colored above the center, sometimes purple throughout. In the transition forms the purple columella is common, the white comparatively rare. It would appear as if the juvenile shells of the typical forms had columellae more or less touched with purple, this being overlaid in the adult shell by deposits of pure white enamel. The color of *sulcata* ranges from the yellowish-brown of material from the upper river localities, through the mottled shells of Three Island and Fort William shoals to the mahogany-brown shell of Peckerwood Shoals.

The peristome of all the *sulcata* is very slightly curved, usually crenulate and rarely smooth-edged.

The nuclear whorls of *sulcata* are small for the genus, rather tightly coiled, smooth, elevated. The ribs begin to develop with the second whorl. In the case of a juvenile shell from Fort William Shoals, a carina appears at the top of the second whorl, this quickly taking on the appearance of a typical fold or rib. So far as can be judged from the greatly eroded specimens, the species does not acquire more than five whorls.

In only two opercula could the spiral lines be traced. This feature seems to consist of two and a quarter widely coiled whorls within the operculum.

In one case the lines were raised, rough, thickened. In the other the spirals were deeply incised and were much more plainly marked than the first example.

Measurements of paratypes:

<i>Altitude</i>	<i>Diameter</i>	
22½ mm	14½ mm.	Ten Island Shoals, St. Clair County
19½	14½	" " " " " "
19	13	" " " " " "
19½	13½	Hall's Island, Shelby County
17½	13½	" " " "
17	11½	" " " "
19½	13½	Lock 2, St. Clair County
19½	13	" 2, " " "
16½	11½	" 2, " " "
16½	12	Three Island Shoals, Talladega County
15	12	" " " " "
15½	12	Fort William " " "
18	13	Peckerwood " " "
15	11½	Coosa River, Schowalter collection

Anculosa occultata H. H. Smith, new species

Fig. 21

Shell: Subglobose, the most Neritina-like of all the Anculosae. Thin. Growth lines very delicate, regular, close together. A few revolving striae appear on parts of the shell, are very obscure and do not continue around the whorl. Apex eroded, body whorl very large, broadly rounded at the shoulder, almost flattened, lacks folds or plicae. Suture not very deeply marked. Peristome thin, but firm, straight, flaring so that the aperture is practically round. Columella regularly curved, broadly flattened on top, the inner edge almost sharp; bluish-white with spot of purple at the top, its junction with the peristome lacking the deposit of callous which fills this area in several other species of the genus. Color of shell brown, with four very dark continuous bands.

Operculum: Thin, red, elongate, apex and basal margin rounded. Growth rays very fine. A few obscure waving lines appear close to and parallel with the right margin. The polar point is placed on the left margin near the base. The spiral lines cannot be made out in entirety, but appear to be widely coiled, as in the operculum of *A. sulcata*.

Measurements of type: Altitude, 11 mm.; diameter, 8¾ mm. Aperture—altitude, 6½ mm.; diameter, 6¼ mm.

Type locality: Coosa River, Duncan's Riffle, Chilton County, Alabama. Herbert H. Smith, collector.

Type in the Museum of Zoology, University of Michigan; paratypes in this museum and the Alabama Museum of Natural History.

The localities in which this species has been collected are Duncan's Riffle, Higgin's Ferry, The Bar, Butting Ram Shoals and "near the mouth of Yellowleaf Creek," all in the Coosa River and within the reaches touching Chilton and Coosa counties.

Most of the shells, including the young, have the Neritina-like form, a few only being found in this collection which are conic as in the case of the juvenile of *brevispira* Smith, which in a way this species resembles.

The sculpture is confined to the fine growth lines and occasional indications of revolving striae. Color varies from yellow to dark brown. In many of the shells the bands are so dark and broad that the ground color of the epidermis shows only as narrow lines. The bands are continuous or interrupted, the formula of four equidistant bands prevailing. Of 125 specimens in one lot from the Higgin's Ferry locality, 111 had the four bands; 2 had five bands; 7 had modified arrangements of the four-banded formula; 5 were without bands. No variation was observed as between localities.

The flattening of the columella was more pronounced in the material from the type lot than in most of the other shells. This, however, is a fairly constant characteristic and is so marked in some specimens as to give them an excavated appearance, this being occasionally heightened by the erosion of the body whorl over the umbilical region. The color of the columella is usually purple, though white is not uncommon. The peristome sometimes has a slight curve close to the suture.

The embryo *occultata* is very small, the apex raised or flattened, loosely coiled, smooth, consisting of one and one-half whorls. In many of the juveniles the peristome is raised at the top above the plane of the apex and the bulk of the shell matter is so crowded into the upper half that the lower half of the shell is made up mostly of a thin columella and a flaring outer lip. This last character is suggestive of *Neoplanorbis smithi* Walker.

Measurements:

Altitude	Diameter	
13 mm.	10 mm.	Higgin's Ferry, Chilton County
12½	9	" " " "
12	9½	" " " "
10½	8	" " " "
11	8¾	The Bar, Chilton County
11½	7½	Butting Ram Shoals, Coosa County

Anculosa compacta (Anthony)

Fig. 27.

Melania compacta Anth., *Annals N. Y. Lyceum Nat. Hist.*, Vol. VI, p. 123, pl. iii, fig. 22, April, 1854.

Lithasia nuclea Lea, *Proc. Acad. Nat. Sci., Phila.*, XII, p. 188, 1860.

A note by Mr. Smith among his labels reads: "This is the *M. compacta* Anth., *Lithasia nuclea* Lea, *Lithasia compacta* of Tryon and later authors. Certainly not a *Lithasia*, and that genus has not been found in the Alabama drainage, though several species are incorrectly referred to it. I think that *compacta* is an *Anculosa*, allied to *A. vittata* Lea. A variety or closely allied species lives in the Warrior."

The judgment of Mr. Smith appears sound. Lea in his description of *nuclea* notes the similarity to *Anculosa*. It is strange that Tryon should have recognized *compacta* as a *Lithasia* while placing the allied *melanoides* Conrad of the Black Warrior among the *Anculosæ*.

Though Lea's *nuclea* is credited to the Coosa River there is good reason for believing that the species is confined to the Cahaba River and its tributaries. Lea received his material from Dr. Schowalter, and all the *compacta* which have been found in the Schowalter collection are assigned to the Cahaba.

The sculpture of *compacta* consists simply of fine growth lines, often worn nearly smooth. No revolving lines can be made out with a glass of ordinary power. Color varies from yellow to dark brown. Green shells, especially among the juveniles are fairly common. Bands, where they appear, are three in number, equidistant, varying slightly in width and depth of coloration. Only one banded specimen was found which differed from this formula, the variation consisting merely of the absence of the basal band. The two shells collected by Mr. Smith in the Cahaba at Henry Ellen were without bands. Of one lot of four specimens from Lily Shoals, one only was without bands. In the second lot from this locality, 85 had bands, 26 were without them.

The columella of *compacta* is small, smooth, rounded, angulated at the center rather than rounded. A callous just below the turn is sometimes sufficiently heavy so as to suggest a "tooth". In color the columella is usually white, often marked with purple or red. The Calkins lot has 4 specimens with white columellae; 3 the columellae of which are entirely purple; 5 with the columella part white, part a faded purple. In the larger Lily Shoals lot, white is the predominant color.

The form of the species varies slightly. The periphery is frequently subangulated, far more often rounded. A few have the constriction of the body whorl so characteristic of *A. ligata*. In one lot, several specimens have the narrowed aperture and produced peristome of the species known as *Goniobasis louisvillensis* Lea, which is probably a *Lithasia*. Shells with the apex entire are wholly absent from this collection, but from specimens only partly eroded six whorls for a fully grown *compacta* are indicated.

A form of the species from Buck Creek, a tributary of the Cahaba in Shelby County, is light yellow, flat of whorls, almost pyramidal and without bands. This creek form is exceedingly puzzling because of its resemblance to *Goniobasis germana* Anth. and close study is required to separate the two. This is another illustration of the meager barrier which separates some of the genera of the Pleuroceridae.

The operculum is small, thin, ovate, red. Growth lines and rest scars are rather heavy. Apex rounded, the right and left margins about equally curved. The right margin is thin, the left margin firm. The polar point is very small and near the base of the left margin. The whorls within the body of the operculum are closely coiled, and in the specimen illustrated the total number of whorls is four—an irregularity comparable with an instance occurring in *picta*. Compared with the operculum of *melanoides*, that of this species is darker, heavier, more ovate, the growth lines heavier, the polar point more distinct. Judged by the opercula, the relationship between *vittata* and *melanoides* is closer than the connection between either of these species and *compacta*.

Measurements of shells:

Altitude	Diameter				
16¼ mm.	9¼ mm.	Cahaba River,	Aldrich	collection	
14	8½	"	"	"	"
13	8	"	"	"	"
12	7¾	"	"	"	"
14½	8¾	"	"	Calkins	collection
14	8	"	"	"	"
11	7½	"	"	Henry	Ellen, Jefferson County
12½	7¾	"	"	Lily	Shoals, Bibb
12	8	"	"	"	"
11¼	8½	"	"	"	"

Anculosa melanoides (Conrad)

Fig. 28

Anculotus melanoides Conrad, *New Fresh Water Shells of U. S.*, p. 64, 1834.
Anculosa turgida Hald., Supplement to No. 1, *Monog. Limniades*, Oct. 1840.

Conrad's description of *melanoides*, like most of the other early descriptions of the Pleuroceridae, is indefinite and incomplete. The diagnosis might fit many other species of the family. The locality given, "inhabits rivers in North Alabama," also lacks definiteness. The foregoing comments apply as well to Haldeman's *turgida*. In the absence of type specimens and a clear description, reliance is placed upon Tryon's identifications and his illustration in recognizing the smaller of the two Black Warrior Anculosae as the true *melanoides*, and upon Tryon again for putting *turgida* down as a synonym.

The uniformity in the size and proportions of this species would seem to indicate that it is one of the older members of the Pleuroceridae, having passed through the era of variability and plasticity and become suited to a varying environment. That it is perhaps a vanishing race might be assumed from the apparently narrow range and the smallness of its numbers. Its competitor, *plicata*, is seemingly far more common and in numbers of individuals exceeds it as in the Ohio River *A. praerosa* exceeds the small *A. costata* and possibly *A. trilineata*.

The sculpture of *melanoides* is confined to fine growth lines which in most specimens, not in all, are crossed by faint, discontinuous revolving lines. There are no nodules, tubercules or striae. Upon the adult specimens, the only ones at hand, there occur no carinae. The rest scars are dark and delicate.

The body color varies from yellow to brown, with occasional specimens of a greenish tinge. Yellow bandless forms are so smooth that they shine as if varnished. The number of banded specimens is to unbanded individuals as three to four. Only two banding arrangements were remarked—(1) band at suture and at base; (2) band at suture, periphery and base. The ratio of form 2 to form 1 is five to one.

The columella forms an angle at its center rather than a curve, being

virtually straight from center to base, and at the base slightly reflected. A minute projection or curve at the center of the columella suggests an incipient "tooth," and it is this character possibly which caused Haldeman to liken *turgida* to the Atlantic drainage *A. dissimilis* Say. In color the columella is white, pinkish or reddish; in one specimen it is purple throughout. The peristome is very slightly curved and is bordered with black.

The whorls are flat, the body whorl being subangular. No uneroded shells appear in the Smith collection, but one or two individuals which retain parts of the upper whorls give indication that the spire of *melanoides* is smooth or, in instances, delicately touched with incomplete revolving lines. The maximum number of whorls is probably six.

The operculum is very thin, translucent and yellow-brown in color. The growth lines are regular, somewhat wavy in places and, by transmitted light, these are seen to be crossed by exceedingly fine curving lines from the basal margin to the left margin below the apex. The margins are ragged, even the thickened left margin being torn in some specimens. The polar point normally rests upon the left margin. The spiral development could not be traced.

Mr. Smith appears to have had doubts as to *melanoides* being a true Anculosa. It is one of the border species such as link different genera of this family together, and it might be a matter of personal choice as to where the naturalist shall place it. The nearest relative is *Melania compacta* Anth., of this group, which Tryon placed under *Lithasia* and which Mr. Smith, in his notes and labels, pronounces no *Lithasia* at all. The operculum links up *melanoides* with *vittata* more closely than with *compacta*. Until clearly defined anatomical distinctions are discovered, the proper grouping of these shells will remain in question and any argument which could be raised over shell characters of border species alone would represent futile expenditure of breath.

Measurements:

<i>Altitude</i>	<i>Diameter</i>	
13 mm.	7½ mm.	Warrior River, Alabama
11	7	" " "
10½	6½	" " "
10	7	" " "
10	6	" " "
9½	5½	Tuscaloosa, Alabama
9	5	" "
8	5	" "

Anculosa vittata Lea

Fig. 29

Anculosa vittata Lea, *Proc. Acad. Nat. Sci., Phila.*, xii, p. 188, 1860.

This species was described by Dr. Lea as from the Coosa River at Wetumpka. Mr. Smith does not seem to have found it there. As there are no specimens in the Schowalter collection it is highly probable that the occurrence of *vittata* in this locality is extremely rare and that the few shells of Dr. Schowalter's finding passed out of his hands. Thirty or forty miles north, however, where the Coosa borders Chilton County Mr. Smith found the species in quantity, his three localities for *vittata* being The Bar, Higgin's Ferry and Duncan's Riffle. A note with the lot from The Bar reads "swift water."

Considering the variability of most of the Anculosae of the Coosa, the characters of *vittata* are remarkably constant. The sculpture consists of very fine, hair-like lines of growth and occasional revolving lines which are noticeable only near the suture. These latter lines on the upper whorls of a few specimens are strong enough to suggest carinae. The rest scars, in keeping with the sculpture mentioned, are unusually delicate.

The color varies from yellow to rusty brown, the shells being dull rather than shining. The prevailing arrangement of the well-marked bands is a band hugging the suture, a band at the base and two bands, rather close together, at the periphery. Nine other arrangements were noted in this study, but they are all modifications of the prevailing formula.

The columella is very flat, broad, the outer edge raised above the body whorl. This edge is crescent-shaped as viewed from the side. The inner margin is slightly angled at the center rather than curved, and it here has the mere suggestion of a tooth as in *A. melanooides* Conrad, this character being more pronounced in material from The Bar than elsewhere. The columella is white to bluish-gray, in some specimens purple. The peristome is sharp-edged, firm, usually straight or having only a slight curve close to the suture.

It would appear that *vittata* is not as much exposed to erosion as most of the Anculosae, for entire specimens occur in this material much more than in others. The nuclear whorls are tightly to loosely coiled, smooth, elevated. The development of the shell is so regular that it is impossible to discover the dividing line between the embryo whorls and those which follow. So far as Mr. Smith's collection shows, the adult has not to exceed four and one-quarter whorls.

The operculum is very small, oval, thin, transparent, yellow to brown. The left margin is firm and curved only slightly less than the thin and torn right margin. The basal margin is worn and irregular as if from rubbing against the columella. The polar point is scarcely more than an indentation at the base of the left margin. The spiral development does not show up even under a fairly strong glass. Growth lines are light. In most opercula of this genus, the area of attachment occupies as a rule not more than one-half of the operculum. In the case of *vittata* it appears to involve

virtually the whole of the operculum. This suggests that in this species the operculum is becoming decadent—an assumption supported perhaps by its smallness and thinness.

Shell measurements:

<i>Altitude</i>	<i>Diameter</i>	
7½ mm.	6 mm.	The Bar, Chilton County
7¼	5½	“ “ “ “
6½	5	“ “ “ “
8	6	Higgin's Ferry, Chilton County
7¾	6½	“ “ “ “
7	5	“ “ “ “
6½	4½	“ “ “ “
7	5	Duncan's Riffle, “ “
6	4½	“ “ “ “

Anculosa ligata Anthony

Fig. 30

Anculosa ligata Anth., *Proc. Acad. Nat. Sci., Phila.*, Feb. 1860, p. 67.

This species is apparently confined to the last seventy-five or one hundred miles of the Coosa River. Shells from the following localities are in the collection brought together by Mr. Smith:

Weduska Shoals and near the mouth of Waxahatchee Creek, Shelby County; near the mouth of Yellowleaf Creek, Cedar Island, Higgin's Ferry and The Bar, Chilton County; Butting Ram Shoals, Coosa County; Wetumpka, Elmore County. In the Schowalter collection, Mr. Smith found *ligata* in material from Buck Creek, Shelby County, which is in the Cahaba drainage. Mr. Smith's label indicates that he doubts the occurrence of the species in this stream. The specimens had probably been misplaced.

Judging from the numbers of shells taken at the different stations, the species flourishes most prosperously on the Weduska Shoals and in the shallows of The Bar. Only two specimens were taken at Wetumpka.

The constriction of the body whorl which suggested to Anthony the name *ligata* is present on all the shells examined. It is sometimes not pronounced, as in the case of the shells from near the mouth of Waxahatchee Creek; sometimes almost channeled, as in shells from Weduska Shoals. No folds or ribs are present and the only features in the nature of plicae or tubercles are irregular nodes near the suture, present only rarely. Striae parallel with the peristome are crossed by fine lines, usually continuous, which are often wavy. Under the glass, the epidermis has the appearance of woven linen. The revolving lines are best shown by half-grown individuals and are stronger near the suture than upon the base of the shell.

Seven different banding arrangements were observed, the usual one being a heavy band at the suture, at periphery and upon the base. The ratio of banded specimens to unbanded is about five to one. Though ordinarily the bands upon the epidermis are broken into squares, within the aperture these bands are usually continuous. In only two specimens does the coloring matter of the bands coalesce so as to darken the aperture.

The columella is light for *Anculosa*. It is slightly angulated at the center as in *A. compacta* Anth. It is sometimes porcelain white or bluish white, more often stained pink or red. It was noticed in material from Butting Ram Shoals that the shells with a white columella were old. The lip is curved as in *A. praerosa* Say. This curved lip in the case of some specimens gives the suggestion of the fissure of *Gyrotoma*. The peristome is thin, firm, and in the instance of some old shells it is slightly thickened with callous. The aperture is white, blue-white, reddish, and in some shells yellowish. The color of *ligata* from near the mouth of Waxahatchee Creek is chestnut brown; the Weduska Shoals shells, olive to dark brown; those from The Bar, light to rusty brown. Anthony's shells were dark green. This is a rare color among Mr. Smith's specimens.

The nuclear whorls of *ligata* are raised, smooth, apparently consisting of one and one-half whorls—the line between the embryo shell and the following whorl being hard to make out. The suture is almost channelled on the first two whorls of *ligata*. The typical "cross-hatch" sculpture begins to show upon the third whorl. The periphery of most of the juvenile shells is flattened. The extreme number of whorls of this species is probably five or six.

The operculum is almost oval, dark brown, rather thick, leathery. Edges of both left and right margins are thickened. Lines of growth are coarse, those on the basal margin extending into four to seven stout, thorn-like serrations, curving to the left. The polar point is deeply sunken and is located on the left margin close to the base. The spiral development is obscure, but in one specimen examined the two whorls within the operculum could be traced.

The salient features of *ligata* are the constricted body whorl, the textile-like microscopic sculpture and the hooked processes of the basal margin of the operculum.

Measurements:

<i>Altitude</i>	<i>Diameter</i>	
13½ mm.	8½ mm.	Coosa River, Schowalter collection
12½	8½	" " " "
12	8½	" " " "
14½	10½	Weduska Shoals, Shelby County
14	9	" " " "
13½	9½	" " " "
16½	10	Butting Ram Shoals, Coosa County
15	10	" " " " "
16	11	The Bar, Chilton County
15	10½	" " " "
13	9	" " " "
13	9½	Wetumpka, Elmore County
11	8½	" " " "

SPURIOUS SPECIES

Anculosa pumilus Conrad, *New Fresh Water Shells of U. S.*, p. 62, 1834.

This is a *Somatogyrus*.

Anculosa flammata Lea, *Proc. Amer. Phil. Soc.*, II, p. 243, December, 1843.

Description was from a single specimen and was based principally upon a pathological condition in which the coloring matter of bands or lines is deposited longitudinally. Frequently a shell of this kind has bands or lines as well. Several species in the Alabama collection have occasional *flammata* specimens. They are most common in the *picta* group and it is to this group that Lea's species appears to belong, though just to which one it cannot here be said.

Anculosa incisa Lea, *Proc. Amer. Phil. Soc.*, II, p. 243, 1843.

This is *Gyrotoma incisa* Lea.

Anculosa solida Lea, *Proc. Amer. Phil. Soc.*, II, p. 243, 1843.

According to Tryon this equals *Lithasia brevis* Lea, described at the same time.

Anculosa squalida Lea, *Proc. Amer. Phil. Soc.*, IV, p. 167, 1845.

Nothing among Mr. Smith's collections corresponds to the Lea description and Tryon's figure with exactness, and Mr. Smith himself does not appear to recognize it. The type locality is Tuscaloosa, which is on the Black Warrior. The only *Anculosa* of the size of *squalida* which is known from that stream is *plicata*, described by Conrad in 1834. Lea's figure and Tryon's are of quite different shells and, seemingly, different genera.

Anculosa contorta Lea, *Proc. Acad. Nat. Sci., Phila.*, XII, p. 187, 1860.

No material which can be ascribed to this species appears in the Alabama collection. It was described from one specimen, taken by Dr. Schowalter. It is in all likelihood a deformed individual.

Anculosa planulata Lea, *Wheatley Cat. Shells*, p. 28, Alabama; description not published.

Tryon seems to think this equals *A. ampla* Anth.

A mollusk named by Anthony *Melatoma sphaericum* (Reeve Monog., sp. 8, 1861) and recognized by Tryon as a *Schizostoma* (*Gyrotoma*) is evidently an *Anculosa*, probably belonging to a described species of the *picta* group.

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PLATE I

ANCULOSA

Figure 1. *A. aldrichi* H. H. Smith. Type. Coosa River, near mouth of Yellow-leaf Creek, Chilton County. (Cat. No. 10139.)

Figure 2. *A. aldrichi* H. H. Smith. Paratype. (Cat. No. 10138.)

Figure 3. *A. ampla* Anth. Lily Shoals, Cahaba River. (Cat. No. 10140.)

Figure 4. *A. ampla* Anth. Coosa River, Wetumpka. (Cat. No. 10142.)

Figure 5. *A. ampla* Anth. Lily Shoals, Cahaba River, Ala. (Cat. No. 10140.)

Figure 6. *A. brevispira* H. H. Smith. Type. Coosa River, Ft. William Shoals, Talladega County. (Cat. No. 10144.)

Figure 7. *A. choccoloccoensis* H. H. Smith. Type. Choccolocco Creek, Talladega County. (Cat. No. 10145.)

Figures 8 and 9. *A. clipeata* H. H. Smith. Type. Coosa River, Ft. William Shoals, Talladega County. (Cat. No. 10146.)

Figure 10. *A. clipeata* H. H. Smith. Paratype. (Cat. No. 10147.)

Figures 11 and 12. *A. compacta* Anth. Lily Shoals, Cahaba River. (Cat. No. 10149.)

Figures 13 and 14. *A. coosaensis* Lea. Coosa River, Ft. William Shoals, Talladega County. (Cat. No. 10150.)

Figure 15. *A. downiei* Lea. Coosa River, near Cedar Bluff, Cherokee County. (Cat. No. 10152.)

Figure 16. *A. downiei* Lea. Coosa River, near Cedar Bluff, Cherokee County. (Cat. No. 10152.)

Figure 17. *A. flexuosa* H. H. Smith. Type. Coosa River, Wetumpka. (Cat. No. 10154.)

Figure 18. *A. foremani* Lea. Coosa River, Ft. William Shoals, Talladega County. (Cat. No. 10157.)

Figure 19. *A. foremani* Lea. Coosa River, The Bar, Chilton County. (Cat. No. 10158.)

Figure 20. *A. formosa* Lea. Coosa River, Ft. William Shoals, Talladega County. (Cat. No. 10159.)

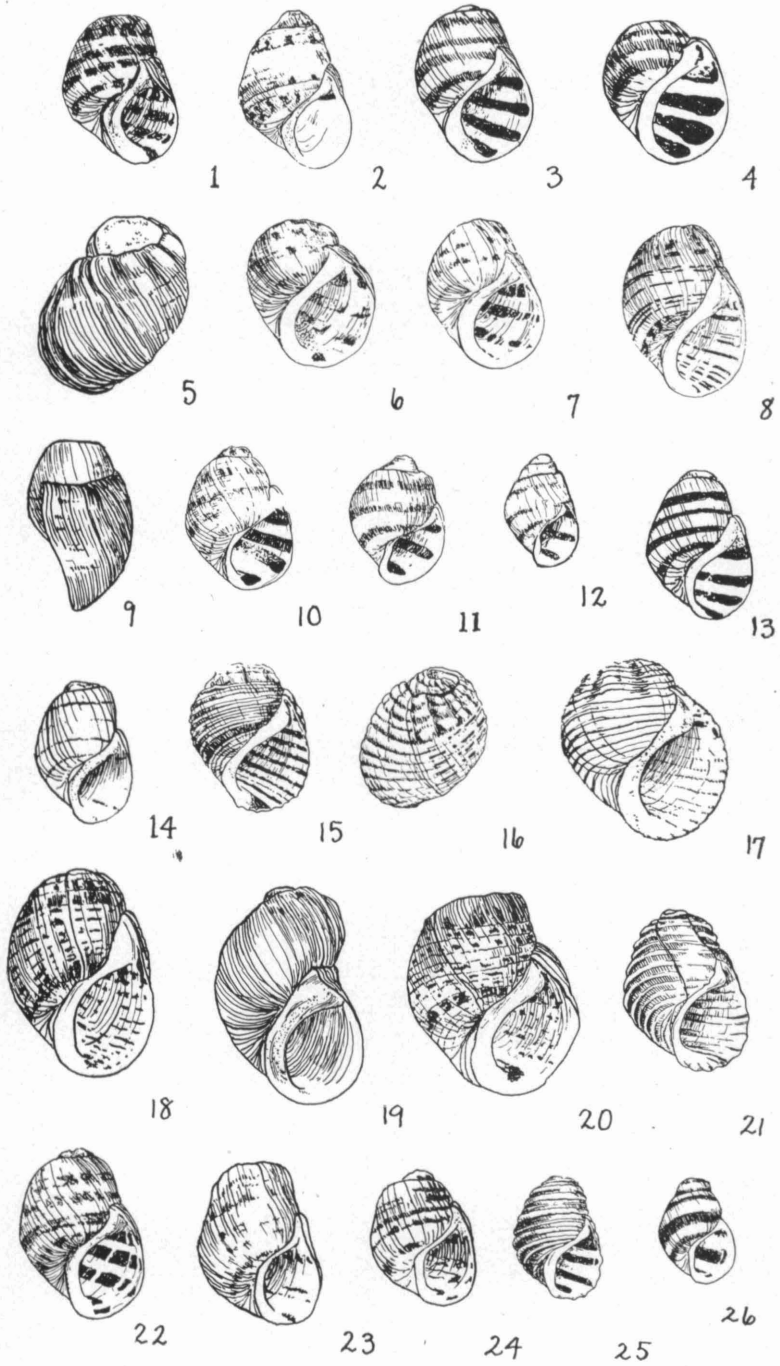
Figure 21. *A. griffithiana* Lea. Coosa River, Wetumpka. (Cat. No. 10165.)

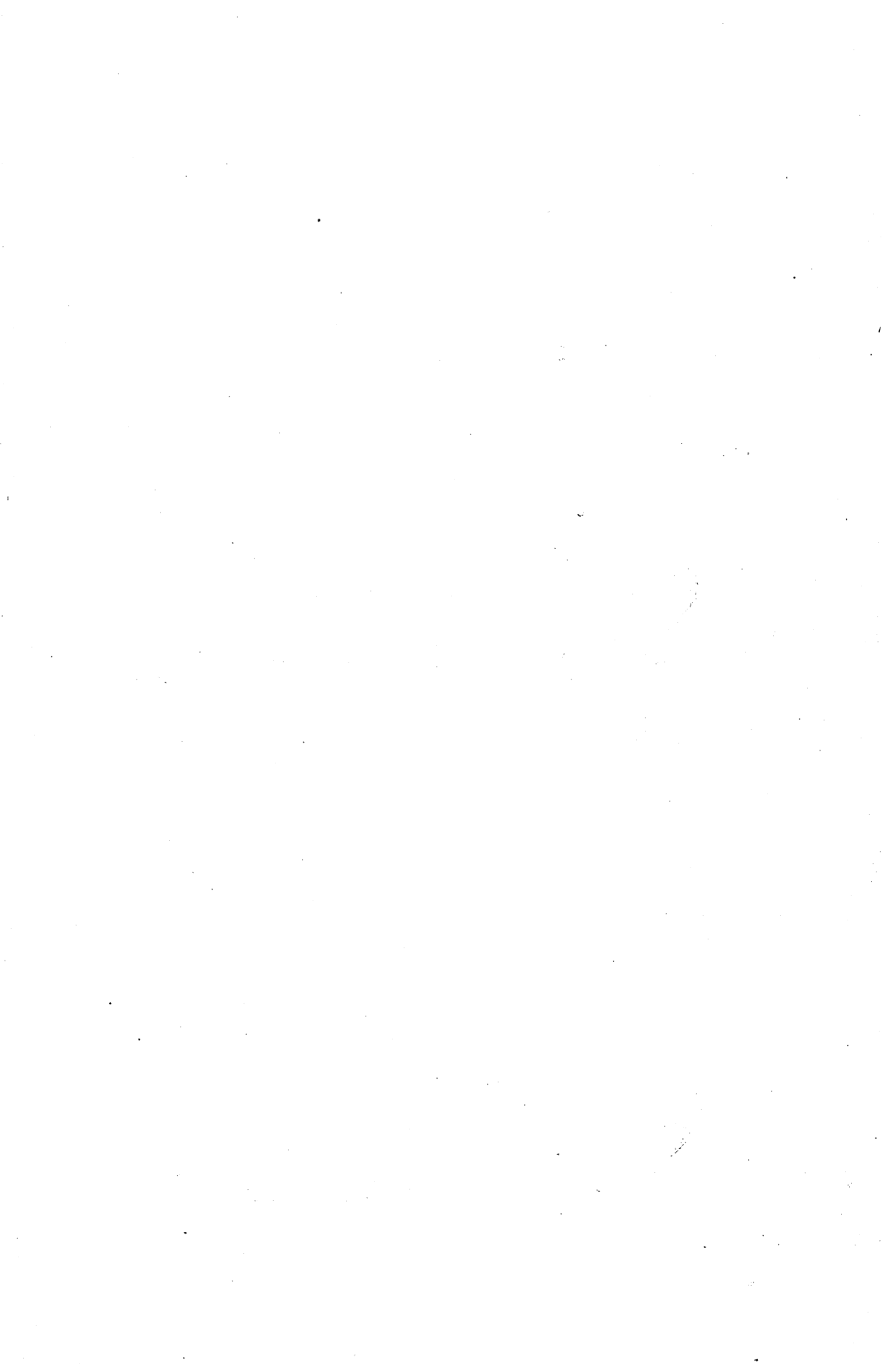
Figure 22. *A. griffithiana* Lea. Coosa River, The Bar, Chilton County. (Cat. No. 10166.)

Figures 23 and 24. *A. ligata* Anth. Coosa River, The Bar, Chilton County. (Cat. No. 10167.)

Figure 25. *A. lirata* H. H. Smith. Type. Coosa River, Ft. William Shoals, Talladega County. (Cat. No. 10168.)

Figure 26. *A. melanoides* Conrad. Black Warrior River. (Cat. No. 10169.)







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PLATE II

ANCULOSA

Figures 27 and 28. *A. mimica* H. H. Smith. Type. Little Cahaba River, Bibb County. (Cat. No. 10170.)

Figures 29 and 30. *A. modesta* H. H. Smith. Type. Coosa River, Riddle's Bend, Cherokee County. (Cat. No. 10172.)

Figures 31, 32, and 33. *A. occultata* H. H. Smith. Type. Coosa River, Duncan's Rifle, Chilton County. (Cat. No. 10173.)

Figure 34. *A. picta* Conrad. Alabama River, Selma. (Cat. No. 10175.)

Figure 35. *A. picta* Conrad. Coosa River, Wetumpka. (Cat. No. 10176.)

Figure 36. *A. plicata* Conrad. Forks of Black Warrior River, Walker County. (Cat. No. 10179.)

Figure 37. *A. plicata* Conrad. Near Lock 15, Black Warrior River. (Cat. No. 10177.)

Figure 38. *A. plicata* Conrad. Black Warrior River, Tuscaloosa. (Cat. No. 10178.)

Figures 39 and 40. *A. showalterii* Lea. Coosa River, Ala. From the Schowalter Collection. (Cat. No. 10180.)

Figures 41 and 42. *A. showalterii* Lea. Coosa River, Peckerwood Shoals, Talladega County. (Cat. No. 10181.)

Figures 43 and 44. *A. smithi* Goodrich. Type. Valley Creek, Toadvine, Jefferson County. (Cat. No. 10183.)

Figure 45. *A. sulcata* H. H. Smith. Type. Coosa River, Ten Island Shoals, St. Clair County. (Cat. No. 10184.)

Figures 46 and 47. *A. taeniata* Conrad. Coosa River, Ten Island Shoals, St. Clair County. (Cat. No. 10188.)

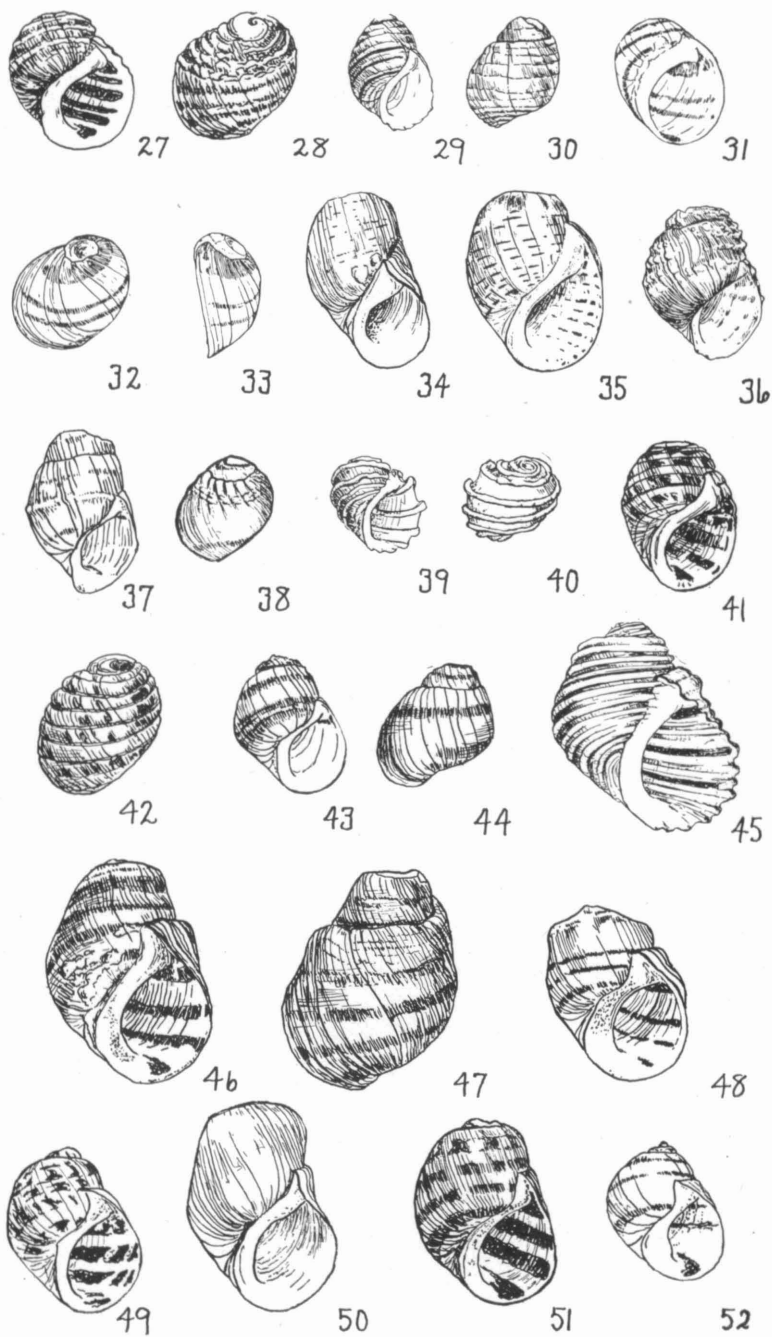
Figure 48. *A. taeniata* Conrad. Coosa River, Ft. William Shoals, Talladega County. (Cat. No. 10187.)

Figure 49. *A. taeniata* Conrad. Coosa River, The Bar, Chilton County. (Cat. No. 10186.)

Figure 50. *A. torrefacta* H. H. Smith. Type. Coosa River, Weduska Shoals, Shelby County. (Cat. No. 10189.)

Figure 51. *A. torrefacta* H. H. Smith. Paratype. Coosa River, Weduska Shoals, Shelby County. (Cat. No. 10190.)

Figure 52. *A. vittata* Lea. Coosa River, The Bar, Chilton County. (Cat. No. 10191.)





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PLATE III

OPERCULA

- Figs. 1, 2 *Anculosa downiei* Lea.
Fig. 3 " *formosa* Lea
Figs. 4, 5 " *foremani* Lea.
Figs. 6, 7 " *picta* Conrad.
Fig. 8 " *clipeata* H. H. Smith.
Fig. 9 " *modesta* H. H. Smith.
Fig. 10 " *taeniata* Conrad.
Fig. 11 " *torrefacta* H. H. Smith.
Fig. 12 " *brevispira* H. H. Smith.
Fig. 13 " *coosaensis* Lea.
Fig. 14 " *chocoloccoenis* H. H. Smith.
Fig. 15 " *griffithiana* Lea.
Fig. 16 " *aldrichi* H. H. Smith.
Figs. 17, 18 " *flexuosa* H. H. Smith.
Fig. 19 " *showalterii* Lea.
Fig. 20 " *sulcata* H. H. Smith.
Fig. 21 " *occultata* H. H. Smith.
Fig. 22 " *lirata* H. H. Smith.
Fig. 23 " *ampla* Anthony.
Fig. 24 " *mimica* H. H. Smith.
Fig. 25 " *plicata* Conrad.
Fig. 26 " *smithi* Goodrich.
Fig. 27 " *compacta* Anthony.
Fig. 28 " *melanoides* Conrad.
Fig. 29 " *vittata* Lea.
Fig. 30 " *ligata* Anthony.

