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Freshwater and Terrestrial Mollusks

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rine mollusks is of
pad groups: (1) fresh-
species); (2) fresh-
water snails (class Gastropoda, subclass Prosobranchia, order Mesogastropoda, 3 families, 3 species; subclass Pulmonata, order Basommatophora, 1 family, 2 species); and (3) land snails (subclass Pulmonata, order Stylommatophora, 2 families, 6 species).

Study of this fauna begins conveniently with Dawley's (1965) checklist of fresh-water mollusks of North Carolina and Hubricht's (1970) checklist of terrestrial snails of the state. There is a checklist of estuarine species (Wolfe and Wolfe 1970), but none of these was ascertained by this Committee to be in jeopardy. Marine mollusks are considered elsewhere in this volume. Dawley's list is taxonomically somewhat uncritical, thus partially redundant, and includes 100 or so taxa. Recent additions to our knowledge of the North Carolina fauna, however, probably ensure that her original total was nearly correct. Hubricht's list is more current and precise. His total of about 150 taxa is probably a good approximation of the number of land snail forms that will eventually be revealed in the state. In these numerical terms, the non-marine mollusk fauna of North Carolina can be considered rather well known, but this is hardly true in biological terms. For example, although we have listed nine entities as *Endangered*, we have eight as of *Undetermined* status. Thus, not nearly enough is known about this fauna for the purposes of this Symposium or for other purposes. Nevertheless, using the figures given above, we can state unequivocally that about a tenth of the fresh-water and terrestrial mollusks of North Carolina is in one degree or another of jeopardy. This estimate is unlikely to change for the better in the foreseeable future, despite the fact that changes in individual species' classifications are inevitable as a consequence of improved information.

Roughly 10% of the fauna in danger — this is a sad indictment of our activities. The situation is particularly bad for one of the groups, the fresh-water mussels. Their larvae (the glochidia) must pass a brief period as parasites on a vertebrate host, usually a fish, immediately after discharge from the female. Only a limited number of hosts is physiologically appropriate to a given species of mussel. Disruption of the ichthyofauna can therefore lead to profound changes, usually extirpations, in the mussel fauna. In addition, most mussels are unusually sensitive to the varieties of adversity that affect other fresh-water mollusks. In view of this multiple vulnerability to environmental disturbance, it is not surprising that 17 species and/or populations of mussels are of concern to this Committee. The correct number of mussel species in North Carolina is uncertain, but these 17 are likely a majority.

Other types of disturbance include point-source pollutants like municipal, industrial, and agrarian effluents, and non-point-source effects, such as sheet erosion and biocides. These phenomena are becoming

increasingly well known in the Carolinas (see Hendrickson et al. 1976). Less familiar problems include poor road maintenance, especially of rural roads, and forestry practices. Many of these adversities promote stream sedimentation, while others create toxic effects. All have a deleterious impact on fresh-water mollusks of all kinds, as well as on other aquatic organisms.

Land snails, too, can be affected by many of these factors, especially toxicity. The chief threat to terrestrial species considered in this report, however, is habitat disruption, including deforestation and road cuts. No matter how well intended, in the name of opening additional lands to public recreation, the present and potential activities of state and federal park services threaten, possibly endanger, and may even have already destroyed some of the snails considered below. The increasing abuses of public lands through logging, strip mining, and similar activities represent an added danger, though specific threats of this kind to North Carolina species are not known to us at this time.

Solutions to these problems require both legal and scientific approaches. Local, state, and federal environmental regulations must be updated and strengthened, and reflect increased sensitivity to scientific findings. In the meantime, the existing body of environmental law, which is considerable, must be assiduously enforced. At present this is not being done in very many places. There is some measure of irresponsibility in legislative bodies and the private sector, but just as important are public apathy and ignorance of the facts. These provide a fertile substrate for more conspicuous evils. Because apathy is often at least partially dispelled by knowledge, a Symposium such as this has special timeliness and value, both among scientists (no strangers to ignorance) and non-scientists alike.

In the context of rare, threatened, and endangered biota, a statewide program of public education is needed in North Carolina, and such efforts could pioneer in the nation as a whole. Hunters, fishermen, game wardens, park rangers, public officials, and other non-specialists should be able to distinguish and help protect jeopardized species. Although there are exceptions, most of the mollusks and other organisms of concern to this Symposium are rather easily identified. Therefore, such readily available and understandable literature on the subject as simple field guides is practicable as well as imperative.

We feel that, although the immediately foregoing remarks are justified, such remedies would be initially weakened by a "shotgun" approach. Attention must first be focused on the more crucial target areas of concern. These areas may be defined geographically, or ecologically, or both. The Committee has identified several such areas:

(1) Only a few North Carolina land snails are believed to be in jeopardy. With the exception of *Triodopsis soelneri*, the Waccamaw Helix of the Waccamaw basin and environs, these are montane species dwelling in the western counties. Some are threatened by road construction, park activities, and the like. Their populations must be "roped off" or otherwise segregated from human contact through a program akin to the traditional "bird sanctuary" approach.

(2) The Tar River of the Pamlico basin supports an undescribed species of *Canthyria*, the Tar River Spiny Mussel, and a rich fauna of other fresh-water mussel species. Every effort must be bent to preserve this river from sedimentation, chemical effluents, sewage, and other pollutants, and

channel modifications. Fortunately, there appears to be no impoundment declared for the Tar. although limited "clearing and snagging" projects were completed in 1938, 1942, and 1946 (USACE 1975). Any attempt to renew such activities must be discouraged because of their effect on fish habitats and, as discussed above, the well being of the mussel fauna.

Editor's Note: Since this chapter was completed Rowland M. Shelley has provided the following comments: "Three major impoundments have been proposed for the Tar system, two of which, Spring Hope and Grey Rock, are on the Tar River itself. The other, White Oak, is on Fishing Creek, a major tributary. Moreover, Spring Hope is in that part of the Tar River where *Canthyria* occurs. There may be additional, smaller impoundments planned for this system as well. Also, in the past several years a municipal water supply weir was built across the Tar River in an area of Nash County where *Canthyria* occurs, creating a large lake. The structure could have significant impact on this species, and on *Elliptio lanceolata*."

(3) The Waccamaw basin in southeastern North Carolina and northeastern South Carolina supports more unique non-marine mollusks than any other locale in the state. The mussel fauna is especially notable (see Fuller et al. 1976). Lake Waccamaw itself, at the head of the basin in Columbus County, contains several endemic species and/or populations. The Waccamaw River below the lake is almost as interesting, but in Horry County, South Carolina, it becomes synonymous with the Intracoastal Waterway, and below the confluence this river is almost a molluscan desert (Fuller and Imlay 1976). Lake Waccamaw appears to have suffered little or no damage as a result of a narrow ring of human habitation on its banks, but intensive land development beyond that ring is afoot. If poorly managed, this development would be attended by the usual problems of sediment from construction and road building, organic enrichment from sewage, and others. This could drastically affect the Lake in a few months or years. From the molluscan point of view, protection of Lake Waccamaw is the single most important goal of conservation in the state. The Lake offers North Carolinians a unique opportunity to combine mollusk studies, experimental biology, public education, and ecological research, with judicious human habitation and recreation. Probably the most significant immediate step is stabilization of the shoreline, most of whose original vegetation, especially the tree cover, has long since disappeared. Ever a special case, the Waccamaw basin poses the interesting necessity of vigorous cooperation with neighboring South Carolina if it is to be preserved above the Intracoastal Waterway.

Achievement of conservation of these three "target areas" is the business of the general public, their political representatives, and state agencies, as much as it is a concern of biologists. In the meantime, however, scientists must endeavor to advance our knowledge of at least the 28 mollusks that are of concern in this report. Several kinds of information are of paramount importance. *Helisoma magnificum*, the Cape Fear Ramshorn, and *Taphius eucosmius*, the Greenfield Ramshorn, have been listed here as *Threatened* and presumed *Extinct*, respectively. Perhaps both are gone, but this must be verified or denied through careful search. Similarly, the correct ecological and geographic ranges of all other species must be ascertained. Only then are final decisions on their status warranted, and only then can thorough research into their respective biologies be conducted. For all species of concern, numerous kinds of

knowledge are essential: more and less favored habitats, reproductive season and capability, juvenile and adult mortality, predators, foodstuffs, resistance to physical and chemical factors, and so forth. The list seems endless, but a start must immediately be made. Once again, fresh-water mussels, the group most in jeopardy, offer special problems. Knowledge of the identity of every glochidial host for each mussel species is absolutely necessary, and this calls for the most thoughtful cooperation between ichthyologists and malacologists in a common research enterprise. Essential to all these endeavors is statewide support, be it in the form of financial aid or the neighborly sharing of information by the individual citizen.

One of the potential (and probable) weaknesses of this document is the matter of species deservedly of concern that have been inadvertently or otherwise omitted. Whereas we feel justified in the belief that coverage of the land snails has been thorough, we are not nearly so confident of our treatment of the aquatic fauna. A case in point is the snail family Hydrobiidae. New forms are still being discovered and described almost every year. Many of these species are restricted to springs and other ecologically vulnerable habitats (see *Federal Register* 1976, 41: 17742-17747). It is likely that much of our American hydrobiid fauna was eliminated before we even had the chance to discover it, and this has probably happened in North Carolina. In any case, there are surely more undiscovered and undescribed hydrobiid species in the state than the *Endangered* Waccamaw Snail, discussed below. The fresh-water mussels of the Carolinas are certainly better known than the Hydrobiidae, but include animals that are very inadequately understood. For instance, *Lasmigona subviridis* (Conrad), the Green Floater, should perhaps have been treated among the accounts below. This species ranges widely in the Atlantic drainage of the Carolinas and Virginia, but is infrequently encountered. On the other hand, it is often locally abundant, and has a high degree of tolerance of sedimentation. Therefore, we chose to exclude it from our listings, which may have been a mistake.

The value of our molluscan faunas has never been very widely appreciated. Relevant knowledge concerning the impact on an ecosystem caused by the elimination of one or more species is in its infancy. Already, however, the topic is a large one. Much more is understood about some organisms than about others, and the former obviously better exemplify ecosystematic interrelationships. Of the three broad groups (land snails, aquatic snails, and fresh-water mussels) of concern, mussels best illustrate the present "state of the art". But, both aquatic and terrestrial snails have at least equally important roles in the food web, as nourishment for such invertebrates as leeches, beetles, and other snails, and vertebrates like birds and fishes. These relationships are particularly well documented in the case of fishes and aquatic snails (Baker 1916), and Harman (1974) considered them at length, with emphasis on the disturbed environment. Elimination of a species has an unhealthy effect on the variety, complexity, and ecological resilience of its food web. Thus, the loss of so much as a single kind of snail has adverse consequences, however subtle and removed, for the associated ecosystem and is to be avoided. Extinction means, also, that the potential, immediate, and practical advantages of the fallen are forever lost to man. Such advantages may range from research and actual healing in human medicine, through the advancement of more abstract

knowledge that, seemingly impractical at first, is the foundation of the sort of progress that truly benefits the human species.

Fresh-water mussels share these rather erudite values, but offer a number of practical advantages as well. Certain of these are unique among animal attributes in at least some respects. Together they strongly support the claim that mussels are the most important non-insect group of aquatic macroinvertebrates. First, they are extremely biomassive under optimal circumstances. This point quantitatively underscores the significance of the following qualitative points. Second, as filter-feeders, mussels ingest and commonly digest large quantities of micro-organisms and more or less inert organic material. Figuratively stated, they are natural "vacuum cleaners". Third, mussels accumulate numerous chemical species at concentrations that are readily measurable, whereas background levels are commonly not. Such chemicals include potassium and its compounds, which are common ingredients of wood-products industrial discharges. Paper and pulp mills abound in the Carolinas, and evidence is gradually gathering that this element is toxic to a variety of aquatic animals (M. J. Imlay, pers. comm.). More specifically, potassium at levels as low as 4 ppm can be lethal to fresh-water mussels (Imlay 1973). These remarks emphasize yet another potential if subtle killer of Carolinian wildlife, and demonstrate how valuable mussels can be as monitors of water quality, through bioassay or their absence. Fourth, many mussel species, as shown in the individual accounts which follow, are sensitive monitors of physical habitat disturbances. Fifth is the essential symbiotic relationship between mussels and fishes, already outlined. The important point here is that this relationship may have advantages for host as well as parasite. Wilson (1916) expressed the belief that glochidiosis conferred upon the host(s) an immunity to infection by caligoid copepods known as Anchor Worms, an especially destructive and occasionally epidemic group of fish parasites. Wilson's point was disputed in a geographically and biotically parochial study by Tedla and Fernando (1969), but should he be proven correct, a crucial value of mussels to fish would be established.

These points, plus mussel symbioses with other groups of organisms and their roles in the food web, were additionally discussed by Fuller (1974c). Possibly the most important of such relationships today involves mussels and an introduced bivalve competitor from southeastern Asia, the so-called "Chinese Clam," *Corbicula manilensis* (Philippi). This form is rather closely related to our native fingernail, pea, and pill clams of the family Sphaeriidae (Burch 1972, 1975a). After 30 years as a scourge of the macrobenthos in the Pacific and Gulf drainages, as well as in the Mississippi basin, *C. manilensis* was detected in the Atlantic drainage several years ago. Except in Lake Waccamaw (Fuller and Imlay 1976), this exotic remains undiscovered in North Carolina, but it currently ranges from the Altamaha River basin of Georgia north into the Delaware basin in Pennsylvania and New Jersey[1]. Gardner et al. (1976) reviewed the relevant facts and references and told a grim tale of the adverse impact of the Chinese Clam on the naiad fauna of the Altamaha basin. Many of these fresh-water mussels, as the Gardner group correctly reckoned, are endemic to this basin and *Endangered* on a nationwide and global basis. This point of view had been corroborated by Heard (1975), who related, also, his suspicion that *Corbicula* has been the chief factor in the reduction and/or extinction of certain mussels in the eastern Gulf drainage. It seems that no one knows why this pollutant is so devastating to Nearctic

[1] See page 194.

fresh-water mussels. Is *Corbicula* a superior competitor for benthic space on waterway floors? Does it compete selectively for planktonic food? Do the larvae, allegedly solely planktonic, out-compete mussel glochidia for fish hosts? Do adult *Corbicula* devour unionid larvae and/or newly post-larval juvenile mussels? How is this exotic distributed from river basin to river basin? Why has it no apparent effect on aquatic snails? These questions remain unanswered. This must change, for the Chinese Clam suddenly looms as the most effective danger to native unionids in the Atlantic drainage. Fuller and Imlay (1976) suggested that it is most successful where man has already influenced waterways, but the full answer to its depredations remains obscure. Prior to the excellent account by Gardner et al. (1976), the best record of the *Corbicula* story was Sinclair's (1971). Many articles on this species appear in *The Nautilus* (published by the Delaware Museum of Natural History, Greenville), and the interested reader should be aware, also, of the *Corbicula Newsletter* (published by the Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee).

As indicated by the last question posed above, *Corbicula manilensis* does not appear to jeopardize indigenous fresh-water gastropods. However, such snails, and especially rock-dwelling animals like the Pleuroceridae, are threatened by another exotic, the introduced Eurasian snail, *Bythinia tentaculata* (Linnaeus), the Faucet Snail (Emerson and Jacobson 1976). Harman (1974) reviewed this matter, and it appears that *B. tentaculata* is able to out-compete pleurocerid snails only in habitats already disturbed by man. This viewpoint is in harmony with recent evidence (Fuller and Imlay 1976) that *Corbicula manilensis* competes rather poorly with fresh-water mussels in soft-bottom Atlantic drainage streams, such as those on the Coastal Plain of North Carolina, that have not already been disturbed by man. Thus, it appears that exotic organisms probably compete less successfully with native benthos in more natural aquatic habitats. In the Atlantic drainage of the United States, *Bythinia* apparently occurs no farther south than the Potomac River basin in Maryland and Virginia (Krueger 1975), and, as noted above, *Corbicula* ranges widely in this drainage, but is not known to have been recorded widely in North Carolina. The Tarheel State is fortunate that neither of these "immigrants" yet has a firm foothold in the state, but residents are warned that either could pose a very serious threat to native organisms. The appearance and spread of these mollusks is something that could be reported by untrained observers with results of the greatest value. Recognition of the Chinese Clam was considered above. The Faucet Snail may be identified with the aid of works by Emerson and Jacobson (1976), Harman and Berg (1971), and Robertson and Blakeslee (1948).

In order to facilitate communication among users of this volume, including scientists unfamiliar with mollusks, we have provided common names for the 28 species of concern. The goal has been to have the names brief, appropriate, vivid, and consistent with the small body of relevant tradition. A few examples are worth mentioning. Members of the fresh-water mussel genus *Anodonta* are notable for their ability to survive sedimentation because of their lightly built, buoyant shells. Accordingly, they have long been known as "Floaters" in the Mississippi basin and the Gulf drainage, where mussels are more familiar to the general public, through their nearly century-old commercial harvest, than they are in the Atlantic drainage. We have applied the name Floater, suitably qualified for each species, to all

Anodonta, as well as to all *Alasmidonta*, a morphologically, ecologically, and phylogenetically allied genus. Similarly, members of *Lampsilis* and related mussel genera are called "Muckets" in the Interior basin, and the same course is adopted here. On the other hand, the goal of brevity, at least, has not always been achieved, as in "Tar River Spiny Mussel," but, though cumbersome, this name is certainly appropriate.

These names are offered for the convenience of users of this report, and it is not imagined that our creations will stand forever. They may, however, serve as an added stimulus for a movement toward standardization of Nearctic non-marine molluscan names, which is badly needed. Our indiscriminate use of the European "Helix" for almost all land snails is one example of a weakness in our present approach and should eventually be revised in favor of a greater variety of vernacular names.

There are no standard eclectic references to the taxonomy and other aspects of the biology of non-marine mollusks of North Carolina. There are some excellent sources of more limited scope, mentioned below, but none of these is entirely up to date, as will be clear from the individual species accounts. Pilsbry's (1939, 1940, 1946, 1948) monograph on the land snails of North America north of Mexico is *the* reference of its kind and as valuable in North Carolina as elsewhere. Also of great value for the state are Hubricht's (1970) checklist, Burch's (1962) field guide, and the latter's (1969) biogeography of Appalachian land snails. The standard introduction to fresh-water mussels of the Atlantic drainage, including North Carolina, is Johnson's (1970) treatment. Burch's (1973, 1975b) manuals are superior in certain respects, and the present account by this Group Committee adds novel information to knowledge of mussels in the state. Standard references on the fresh-water snails that are of concern here are the works of Baker (1945), Bartsch (1908), Clench and Turner (1955), Goodrich (1942), Thompson (1968), and Tryon (1873). In general, though, the aquatic gastropods of North Carolina are poorly known.

These books and papers deal primarily with species and are of little avail to the uninitiate, who must first identify an unknown organism through the higher taxonomic ranks before hoping to ascertain a specific determination. For students of North Carolina non-marine Mollusca, this problem is resolved by recourse to one or more of several works of broad systematic scope, including Clarke (1973), Clench (1959), Emerson and Jacobson (1976), Harman and Berg (1971), Heard (1968), Pennak (1953), and Walker (1918). Those interested in the further study of North Carolina mollusks may be aided by the following works: Baker (1911), Basch (1963), Burch (1972, 1975a), Clench and Fuller (1965), Fuller (1974c), Harman (1974), Herrington (1962), Pilsbry (1934), Te (1975), van der Schalie (1965), and Walter (1956).

There can be no doubt that appreciation of our mollusks of concern would have been facilitated by illustrations more numerous than those provided. Nevertheless, in the interests of space and cost, visual aids have been restricted to novelties of form and concept that have not already and adequately been figured elsewhere. References to other published illustrations are given in the species accounts as needed. It must be conceded that restriction of illustrations has been, in effect and in part, a trade-off in favor of more plentiful bibliographic references. In a work of this type, a learning experience for all concerned, these are here interpreted as of greater value to the student than would be additional pictures.

The photographs that adorn certain of the accounts are the work of Daniel J. Bereza, a member of the Committee, and Jerry Harasewych. D. J. Bereza and James D. Williams aided me critically in the selection of many of the vernacular names herein employed. Further, I have profited by written submissions from other members of the Committee. William J. Clench provided most of the information concerning *Spirodon dilatatum*, the Kanawha River Snail, in North Carolina and elsewhere. Leslie R. Hubricht, G. Alan Solem, and especially F. Wayne Grimm, provided or indicated most of the information about land snails. Locality data for numerous species in the state were supplied by Harriet H. Riggs and Rowland M. Shelley. George A. Te sent copious notes regarding the ecological and taxonomic status of the fresh-water snail genus *Physa* in North Carolina, but (thankfully!) no members of this genus, whose resistance to environmental disturbance is notorious, were accorded any jeopardy status by the Committee. Previously unpublished data that were contributed by others are acknowledged here or in the species accounts and should henceforth be cited accordingly (e.g., "Grimm in Fuller (1977)"). In addition, numerous, courageous oral reports by Committee members influenced our deliberations. Finally, decisions about inclusion and status of the 28 species of concern were the responsibility of only those Committee members who were actually able to attend the Symposium. However, as Chairman, and in the light of subsequent information, I have been so bold as to adjust, only slightly and in a few cases, the status of a given species as determined by Committeemen present at the Symposium. In making such decisions and in acquiring new data of various kinds, I have been aided by several persons not actually on this Committee, including Mary G. Curry, Dwight W. Taylor, Ruth D. Turner, Malcolm F. Vidrine, and Kirk E. Wright.

I have taken the execution of this account solely upon myself. Fortunately, the initial manuscript profited from critical readings by selected Committee participants -- Bereza, Grimm, Imlay, Shelley, and Williams. Clearly, any credit that accrues to this narrative must be widely shared, while discredit falls to me alone. Support for various aspects of this report was provided by National Science Foundation Grant GB-40064, the Pew Foundation, the Department of Limnology at the Academy of Natural Sciences of Philadelphia, the Fish and Wildlife Service of the U. S. Department of the Interior, and dozens of persons who gave more of their "spare" time than they could readily afford.

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Species List

Species	Status
Gastropoda	
Mesogastropoda	
Viviparidae	
Lioplax subcarinata, Waccamaw Scavenger 155	Endangered
Hydrobiidae	
Amnicola sp., Waccamaw Snail 156	Endangered
Pleuroceridae	
Spirodon dilatatum, Kanawha Riversnail 185	Undetermined
Basommatophora	
Planorbidae	
Helisoma magnificum, Cape Fear Ramshorn 171	Threatened
Taphius eucosmius eucosmius, Greenfield Ramshorn 170	Extinct?
Stylommatophora	
Endodontidae	
Anguispira paucicostata, Mt. Mitchell Snail 186	Undetermined
Polygyridae	
Mesodon archeri, Cherokee Helix 186	Undetermined
Mesodon clarki nantahala, Noonday Helix 173	Threatened
Mesodon jonesianus, Newfound Gap Helix 156	Endangered
Mesodon orestes, Avenger Helix 186	Undetermined
Triodopsis soelneri, Waccamaw Helix 174	Threatened
Bivalvia	
Heterodonta	
Unionidae	
Alasmidonta triangulata, Triangle Floater 187	Undetermined
Alasmidonta varicosa, Brook Floater 179	Special Concern
Anodonta couperiana, Barrel Floater 180	Special Concern
Anodonta implicata, Alewife Floater 188	Undetermined
"Canthyria" sp., Tar River Spiny Mussel 158	Endangered
Carunculina pulla, Savannah Shoremussel 159	Endangered
Elliptio "lanceolata", Yellow Lance 181	Special Concern
Elliptio marsupiobesa, Cape Fear Spike 161	Endangered
Elliptio sp., Waccamaw Lance 175	Threatened
Elliptio sp., File Spike 189	Undetermined
Elliptio waccamawensis, Waccamaw Spike 162	Endangered
Fusconaia masoni, Atlantic Pigtoe 177	Threatened
"Lampsilis" ochracea, Tidewater Mucket 182	Special Concern
"Lampsilis" radiata complex, Lake Waccamaw population, Waccamaw Mucket 164	Endangered
Ligumia nasuta, Eastern Pondmussel 190	Undetermined

Prolasmidonta heterodon, Ancient Floater	168	Endangered
Villosa constricta, Notched Rainbow	184	Special Concern

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SPECIES ACCOUNTS

GASTROPODA; MESOGASTROPODA; VIVIPARIDAE
(Livebearer Snails)

Lioplax subcarinata (Say) WACCAMAW SCAVENGER

Description: A small snail, length about 13 mm (1/2 in.), with an operculum, carinate whorls, and usually straw colored shell. These characters will serve for identification because it is the only Carolinian *Lioplax*, and closely resembles no other snail in the Carolinas, and the only known population south of Virginia is restricted to Lake Waccamaw. An excellent illustrated review of this species' morphology and range was presented by Clench and Turner (1955), and it was additionally figured in Emerson and Jacobson (1976).

Distribution: Range -- discontiguous; basins of Potomac, Susquehanna, and Delaware rivers in Maryland, Pennsylvania, and Virginia; one population in North Carolina.
North Carolina -- Lake Waccamaw, Columbus Co.

Habitat and Mode of Life: The Waccamaw Scavenger characteristically burrows in sand and mud waterway floors, but appears readily susceptible to much fine sedimentation. In the latter respect it is oddly different from members of the closely related genus *Campeloma*, which thrive in fine muds. Some species of this genus are figured in Clarke (1973), Harman and Berg (1971), and others elsewhere. Like *Campeloma*, on the other hand, *L. subcarinata* is thought to devour small invertebrate animals and organic debris. In Lake Waccamaw it is moderately common in sand beneath shallow waters.

Reproduction: Judged by the Lake Waccamaw population, this snail can breed very successfully under congenial circumstances.

Status: *Endangered.* See Remarks below, and the account of *Elliptio waccamawensis*.

Remarks: The vernacular name introduced here refers to this species' alleged feeding mode and to Lake Waccamaw. To thus identify this population with its mother waterway is thought justified because, bereft of opportunity for interbreeding with its kind elsewhere, it is surely an isolate and an incipient species. An alternative common name, Keeled Mystery Snail, was introduced by Emerson and Jacobson (1976).

References: Clarke (1973), Clench and Turner (1955), Emerson and Jacobson (1976), Harman and Berg (1971); see list following introduction.

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GASTROPODA; MESOGASTROPODA; HYDROBIIDAE
(Faucet and Watercress Snails and relatives)

Amnicola sp. WACCAMAW SNAIL

Description: A formal description of this species, new to science, is being prepared by Dr. Fred Thompson, a member of the Committee on Freshwater and Terrestrial Mollusks. Any description will have to await publication of this paper, but it can be noted here that this is a small form apparently restricted to Lake Waccamaw.

Distribution: Range -- an apparent North Carolina endemic; Lake Waccamaw, Columbus Co.

Habitat and Mode of Life: This snail is common in submerged vascular vegetation (F. G. Thompson, pers. comm.).

Status: *Endangered.* See the account of *Elliptio waccamawensis* (Status) later in this chapter.

Remarks: As intimated in the Introduction, the Waccamaw Snail is an excellent example of a species that could be extinguished before there is adequate opportunity to make it fully known to science and the public. It is likely that additional undescribed hydrobiids, some endemic and in great danger, are still undiscovered in North Carolina.

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GASTROPODA; STYLOMMATOPHORA; POLYGYRIDAE
(Polygyras, Helices, and relatives)

Mesodon jonesianus (Archer) NEWFOUND GAP HELIX

Description: Measuring about 13 mm (1/2 in.) in breadth, this snail so closely resembles two small congeners, *M. subpalliatus* (Pilsbry) and *M. wetherbyi* (Bland), that further descriptive remarks are pointless. Burch (1962) has made the distinctions among these three animals quite clear, but Pilsbry's (1940:758, Fig. 455) illustrations are incorrectly labeled: the smallest snail in his Figure 455a of *M. wetherbyi* is *Mesodon jonesianus*, and only the two larger snails in Figure 455c are *Mesodon jonesianus* (F. W. Grimm, pers. comm.).

Distribution: Range -- a few localities in the Newfound Gap region of North Carolina and Tennessee (Sevier Co.).
North Carolina -- western; Haywood and Swain cos. (Hubricht 1970, 1973).

Habitat and Mode of Life: This species is restricted to moist forests of birch, beech, maple, and hemlock. Nothing else about its natural history has been published (but see below).

Status: *Endangered.* This species was listed as "rare" (DNER 1973) and "endangered" (Hubricht 1972). Because of its narrow range, great rarity, and specialized habitat, we consider it *Endangered.* The Newfound Gap region is included in the Great Smoky Mountains National Park, but, ironically, road building and clearing, and other activities designed to increase the recreational value of the Park, are a grave potential threat. We do not know of present direct threats to specific populations, and further research might indicate that the status of this form should be lowered. This would be highly desirable. On the other hand, other than the mixed blessing of inclusion in a National Park, no measures protective of this snail are in effect. We recommend a National Research Area for a radius of several miles around Newfound Gap. A potent avenue toward more immediate, legal protection of *M. jonesianus* is currently being explored; the U. S. Fish and Wildlife Service has proposed it as a nationally *Endangered* species, saying "This species lives in the humus zone very near to a parking area at Newfound Gap, North Carolina. Trampling of the forest litter can easily destroy this species. There are only an estimated 300 living individuals which are found only in birch, beech, maple, and hemlock forest in the Great Smoky Mountains National Park in Swain County, North Carolina." (*Federal Register* 1976, 41:17742-17747). If this proposal is approved, the Newfound Gap Helix will be protected by the provisions of Public Law 93-205.

Readers will have noted two difficulties inherent in the foregoing remarks. First, certain details in the Fish and Wildlife Service account of *M. jonesianus,* quoted above, are at variance with information gathered by this Committee and expressed above also. Clearly, each statement is based on partially superior data, and complements and strengthens the other. This does not affect the need to interpret the Newfound Gap Helix as *Endangered,* but emphasizes the need to continue researches concerning all species, especially those jeopardized by our activities. Second, neither this report, any ensuing legislation by North Carolina, nor any federal act, can be expected to ensure the safety of any organism without the continued and vigilant committment of every citizen. The need to promote public awareness in this context is discussed in the Introduction to this chapter.

Remarks: The vernacular name introduced here, Newfound Gap Helix, refers to the lone region to which this species is believed to be restricted. An alternative name, Jones' Middle-toothed Land Snail, was used by the Fish and Wildlife Service in the *Federal Register* listing cited above.

References: Burch (1962), DNER (1973), Hubricht (1970, 1972), Pilsbry (1940); see list following introduction.
Hubricht, L. R. 1973. The land snails of Tennessee. Sterkiana 49:11-17.

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BIVALVIA; HETERODONTA; UNIONIDAE
(Fresh-water Mussels)

"Canthyria" sp. TAR RIVER SPINY MUSSEL

Description: As the only spinose mussel in North Carolina, this species can be confused with no other in the state. Also, it is apparently endemic to the Tar River. A formal taxonomic description is being prepared by Dr. D. H. Stansbery, Ohio State University; this will provide illustrations and additional identifying characters when published. Meanwhile, the student can depend upon the figure published in Shelley (1972).

Distribution: Range -- North Carolina endemic; Tar River.

Habitat and Mode of Life: The Tar River Spiny Mussel has been collected on sand and mud bottoms in shallow water, but its presence in muskrat middens (M. J. Imlay, pers. comm.) suggests that it also occurs in deeper water. Having been encountered on few occasions, it is presumed to be extremely rare, and little is known of its natural history, including the identity of any glochidial host or other aspects of its reproduction.

Status: *Endangered.* This species is extremely rare and endemic to a single river, an interpretation which supports the earlier (DNER 1973) state decision. The federal Office of Endangered Species, U. S. Fish and Wildlife Service, is contemplating *Endangered* registry for the species. No protective measures are currently in force, and none seems to be officially contemplated, but it is clear that the full length of the Tar River must be protected from adverse impacts if its Spiny Mussel is to be preserved. Research into distribution of this species is required in order that flourishing populations, if any exist, be located and protective measures be intensified in such areas. Also, the glochidial hosts, if any, must be identified. These measures are important in terms of pride in the natural wonders of North Carolina, and the esthetic and unique nature of this species. A more tangible reason for protection of the Tar River Spiny Mussel is its potential research value. Spiny mussels of unique species occur in the James River system of Virginia and the Altamaha of Georgia, as well as the Pamlico, which includes the Tar River. It seems probable that millenia ago there dwelt in the Atlantic drainage a genetically related "race" of spinose fresh-water mussels which is survived today by three modern species. Knowledge of the details of the presumed discontiguous natural extinction of this group would inform us greatly concerning the survival of fresh-water mussels, individually and as a group, and the advantage they can offer an ecosystem. The same is true in the case of *Prolasmidonta heterodon*, discussed later.

Remarks: It is unfortunate that in a report such as this, intended for a general readership, a full scientific name and description are not available for a given species. However, these are forthcoming for this mussel, and for the moment users can accurately be content with the vernacular name, Tar River Spiny Mussel, which is, obviously, derived from

the river to which the species is apparently restricted.

References: DNER (1973); see list following introduction.
Shelley, R. M. 1972. In defense of naiades. Wildlife in N. C. 36:4-8, 26-27.

Carunculina pulla (Conrad) SAVANNAH SHOREMUSSEL

Description: A tiny species, whose shell rarely exceeds 26 mm (1 in.) in length. At maturity it is consistently the smallest freshwater mussel in the entire Atlantic drainage. The surface of the shell is commonly corrugated by prominent growth rings and the periostracum is coarse. There is conspicuous sexual dimorphism of shell and of the animal within. More specifically, the female is unique in the North Carolina fauna because of its caruncle. These characters, individually and in combination, ensure correct identification of this animal. It has been figured by Bates (1966), Emerson and Jacobson (1976), and Johnson (1970).

Distribution: Range -- Altamaha River system, Georgia, north into Cape Fear and Neuse river systems, North Carolina (Johnson 1970).
North Carolina -- only population known to have been thriving within last decade occurs or occurred in University Lake, near Chapel Hill, Orange Co. (J. P. E. Morrison, pers. comm.).

Habitat and Mode of Life: The Savannah Shoremussel favors shallow, still, or sluggish water at stream margins. No glochidial host is known for this species, but Wilson (1916) and Mermilliod (1973) recorded sunfishes and a bass (Osteichthys; Centrarchidae) as hosts of *C. parva* (Barnes) of the Mississippi basin and Gulf drainage. The host(s) of the Savannah Shoremussel may perhaps best be sought initially among centrarchid fishes. Nothing further is known, or realistically inferred, about important aspects of its natural history. Recent perennial observations on Bates' (1966) population of *C. pulla* indicate that, even in the presence of congenial habitat and glochidial hosts, this species has a low reproductive rate.

Status: *Endangered*. The great rarity of *Carunculina pulla* is sufficient justification for this assignment. Of the few published records, most are from North Carolina, but the only population known to thrive at present is that in the Savannah River described by Bates (1966) as *C. patrickae*. These, and the Orange County specimens, are the only living examples known to have been recorded for many years. There is an obvious decline in recorded occurrence of this species. It was not entered on former Carolinian lists of jeopardized organisms (DNER 1973, Nature Conservancy 1975), so the present listing is an important step toward conservation of this animal. No protective measures are in force, and preservation of the habitats of the Orange County, North Carolina, and Savannah River populations is crucial if it is to survive. Identification of at least the dominant natural host(s) of the glochidia is essential research for conservatory management of the species.

Remarks: Species of *Carunculina* "may be extremely abundant in a few inches' depth, following the water's rise and fall, seeking its margin (Clench and Turner 1956, Grantham 1969, Isely 1925, Murray and Leonard 1962, Utterback 1915-1916)." (Fuller 1974c). This activity appears to be characteristic of *C. pulla*. The vernacular name coined here reflects its usual habitat, as well as its customary occurrence in streams traversing Coastal Plain savannas, plus the fact that its healthiest known population occupies a portion of the river system of the same name. There exists another vernacular epithet, "Bankclimber," that is appropriate to species of the genus. It was originally associated with *Plectomerus dombeyanus* (Valenciennes), a common species in the Gulf and lower Mississippi basin drainages that belongs to another subfamily (Ambleminae) and bears no morphological resemblance to any *Carunculina*, and with *Lampsilis fallaciosa* 'Smith' Simpson, a widespread Mississippi basin mussel of debatable taxonomic validity or rank. The latter is more generally called the Slough Sandshell and, though of the same subfamily as *Carunculina* (Lampsilinae), looks very different from members of that genus (see Coker 1915). Accordingly, the expression "Shoremussel" is offered as an alternative. There are others. Murray and Leonard (1962) originated or adopted the name Lilliput Mussel for *C. parva*, another Mississippi basin species which, like most representatives of the genus, is typically of diminutive size. Presumably the reference is to Lilliput, the land of tiny people in Swift's *Gulliver's Travels*. Emerson and Jacobson (1976) coined Dusky Caruncle Mussel for *C. pulla* itself (as *Toxolasma pullum*). In this case the references are to the Latin adjective *pullus*, for "dark," as the color of its periostracum, and to the caruncle. We have chosen the name given here because it is more natural, more understandable, more euphonius, and less cumbersome than the extant alternatives, and because, in reference to "Lilliput," not all *Carunculina* are tiny. It is an ironic reflection on "the state of the art" that so much verbiage can be expended on the vernacular name of a species about which we know so little!

The members of the genus *Carunculina* pose an intimidating taxonomic challenge. Views on the numbers and names of true species in the genus range in time and character from Call's (1896) to the recent opinions of Johnson (1970, 1972) and Burch (1973, 1975b). Crawford's (1972) observations show that the female caruncle is a morphologically protean structure, which may have some value as an interspecific discriminant. This line of inquiry remains to be exploited, however, and extant concepts of speciation in *Carunculina* depend solely on conchological data. The correct number and nomenclature of Atlantic drainage species are moot, and the combination *C. pulla* is employed here for all Carolinian populations in deference to Johnson's debatable decisions.

References: Burch (1973, 1975b), DNER (1973), Emerson and Jacobson (1976), Fuller (1974c), Johnson (1970), Wilson (1916); see list following introduction.

Bates, J. M. 1966. A new species of *Carunculina* (Unionidae: Pelecypoda) from the Savannah River, South Carolina. Occas. Pap. Mus. Zool. Univ. Mich. No. 646:1-9.

Call, R. E. 1896. A revision and synonymy of the *parvus* group of Unionidae. Proc. Indiana Acad. Sci. 1895:109-125.

Coker, R. E. 1915. The common and scientific names of fresh-water mussels. U. S. Bur. Fish. Econ. Circ. No. 15:1-4.

Crawford, M. J. 1972. Observations on some Louisiana Unionidae. Unpub. M. S. thesis, La. State Univ., Baton Rouge, LA. 67 pages.

Johnson, R. I. 1972. The Unionidae (Mollusca: Bivalvia) of peninsular Florida. Bull. Fla. State Mus., Biol. Sci. 16:181-249.

Mermillionid, W. 1973. An investigation for the natural host of the glochidia of *Toxolasma parva*. Undergrad. res. paper, La. State Univ., Baton Rouge, LA.

Murray, H. D., and A. B. Leonard. 1962. Handbook of unionid mussels in Kansas. Univ. Kansas Mus. Nat. Hist. Publ. No. 28, Lawrence, KS. 184 pages.

Nature Conservancy, The. 1975. Rare and endangered species of South Carolina. The Nature Conserv., Arlington, VA. 41 pages.

Elliptio marsupiobesa Fuller CAPE FEAR SPIKE

Description: The rather small size, wedge-like shape, and shiny, yellowish periostracum of the shell of this species serve to distinguish it from other members of the genus. In addition, the gravid female bears a marsupium that is uncommonly obese for this genus. Illustrations were provided by Fuller (1972) and Burch (1975b).

Distribution: Range -- North Carolina endemic; unequivocally known only from several localities in Cape Fear River near Fayetteville, Cumberland and Bladen cos.; single specimen possibly referrable to this species recently collected in the Northeast Cape Fear River.

Habitat and Mode of Life: The Cape Fear Spike has been found at and near the type locality only in a peculiar, coarse, yielding substrate composed of fine sediment mixed with finely divided clay and organic debris. The specimen from the Northeast Cape Fear River that may be this species was taken in deep, fine sediment. The greatly swollen marsupium of this species implies great larval production, and this correlates with the species' commonness at its type locality. That it appears to be neither abundant nor widespread suggests a damaged relationship to its glochicial host(s).

Status: *Endangered*. The species is known definitely only from three sites in the Cape Fear River in Bladen and Cumberland counties. This reach of the river receives some organic enrichment, presumably from Fayetteville and neighboring municipalities, as well as sedimentation from probable sheet erosion (ANSP 1971). These factors alone are sufficient to jeopardize most fresh-water mussels, but, in view of this species' tolerance of a certain amount of sediment, threats to its glochidial host(s) are probably a greater difficulty. The gradual attrition of the Cape Fear Spike under these circumstances is highly probable, but a more immediate threat is posed by proposed or authorized dams and impoundments above Fayetteville (USACE 1975). The usual effects of dams, including cold water bottom-release and an "artificial tide" regime, minimize shallow water habitats and their suitability to mussels, as well as many other

forms of aquatic life. No protective measures are known to be in effect or proposed for the Cape Fear Spike. Reconsideration of the impoundment activities referred to above, improvement of extant and prospective municipal and industrial effluents, measures for curbing point and non-point sources of erosion, and identification of its glochidial host(s), all are things that can contribute to preservation of this handsome and unusual animal that is peculiar to the state of North Carolina.

Remarks: In its slender lateral outline, with pointed posterior, *Elliptio marsupiobesa* resembles *E. dilatata* (Rafinesque) of the Mississippi basin and Gulf drainage, a not closely related congener that is commonly called Ladyfinger or Spike. The latter name is especially appropiate to the shape of this species and similar Atlantic drainage members of the genus. This fact, and recognition of the river to which *E. marsupiobesa* is presumably unique, lie at the root of the vernacular name coined for this report.

References: Burch (1975b), USACE (1975); see list following introduction.

ANSP. 1971. Cape Fear River surveys 1969-1970 for E. I. duPont de Nemours & Company. Dept. Limnol. Acad. Nat. Sci. Phila., Philadelphia, PA. 112 pages.

Fuller, S. L. H. 1972. *Elliptio marsupiobesa*, a new fresh-water mussel from the Cape Fear River, North Carolina. Proc. Acad. Nat. Sci. Phila. 124:1-10.

Elliptio waccamawensis (Lea) WACCAMAW SPIKE

Description: This species is readily distinguished from other *Elliptio* in the state by its limited range, angular lateral outline, and very sharp posterior shell ridge (Figures 1 and 2). Conchologically somewhat similar animals occur in the Waccamaw River as far south as Horry County, South Carolina. The shell is easily confused with that of males of the Lake Waccamaw population representing the *"Lampsilis" radiata* complex. The differences are discussed in the *"L." radiata* account, and compare Figures 1 and 3. Illustrations of this species were published by Burch (1973, 1975b), Emerson and Jacobson (1976), and Johnson (1970).

Distribution: Range -- North Carolina endemic; only recorded from, and apparently restricted to, Lake Waccamaw, Columbus Co.

Habitat and Mode of Life: The preferred habitat is shallow-water areas and the clean- or muddy-sand floor of Lake Waccamaw. In spite of the fame of the Waccamaw Spike and the ease with which it could be studied, almost nothing is known about its natural history. It is reasonably assumed that the glochidial host(s) occur among the Lake Waccamaw ichthyofauna as considered by Hubbs and Raney (1946). However, J. H. Gillespie (pers. comm.) has developed electrophoretic evidence that several of the species described by these authors scarcely differ genetically from populations in the Waccamaw River basin below the lake.

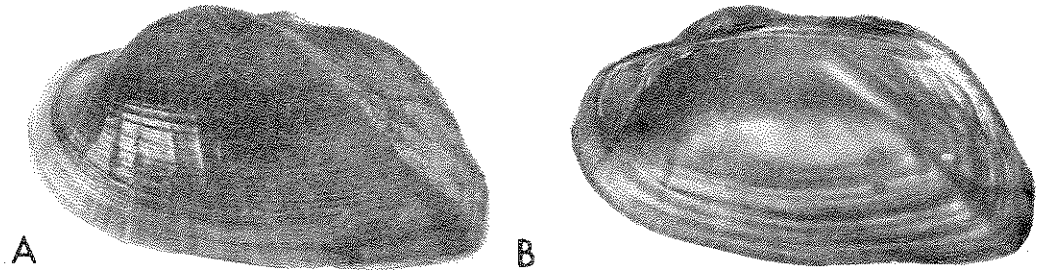

Figure 1. Lateral view of a juvenile shell of *Elliptio waccamawensis*, the Waccamaw Spike. Lake Waccamaw, Columbus County. Anterior left, posterior right in both figures. A. Outer (periostracal) surface. B. Inner (nacreous) surface. Actual length 36 mm. Note: inflation (breadth) of shell; radial, sculpted and/or pigmented rays on anterior surface; sharply carinate (keeled) posterior ridge; and raised radial sculpture on posterior slope. The "box-like" character of the outlines and surface ordinarily abates with age. Compare with the Waccamaw Mucket (Figure 3).

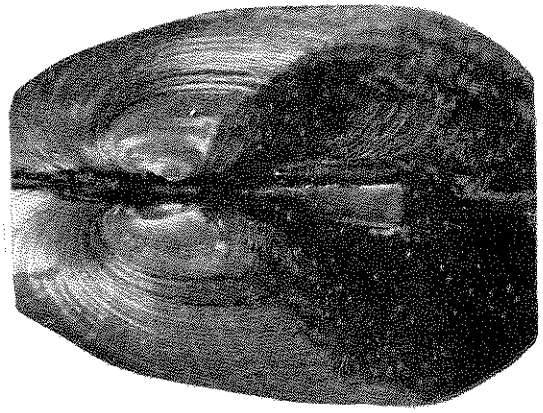

Figure 2. Magnified dorsal view of shell in Figure 1. In addition to characters mentioned above, note the "beak sculpture", the few, concentric ridges on the umbones or oldest part of the shell, which is typical of the genus *Elliptio*.

Status: *Endangered*. The Waccamaw Spike's very restricted geographical range would alone qualify it for this category, but the accelerating land development that promises ultimately to girdle Lake Waccamaw guarantees the terminal jeopardy of most of its denizens. Unless this change is subjected to the most assiduous quality control, the still rather pristine sands of the lake floor will become befouled by sediment, plus organic materials and their attendant vegetable growth. Such changes are inimical to most lacustrine benthic organisms. The present trend toward centralized sewerage in the community of Lake Waccamaw (K. E. Wright, pers. comm.) could have results either beneficial or disastrous for the lake. In addition, use of the herbicide Silvex in canals adjacent to the lake probably endangers its inhabitants, including mussels (DNER 1973). Knowledge of the Waccamaw Spike's glochidial host(s) would facilitate efforts to conserve this species. Its *Endangered* status, as determined by this Committee, is consistent with earlier opinions: "rare and endangered" (Stansbery 1971), "endangered" (DNER 1973), and "rare throughout entire range and in danger of extinction" (Heard 1975).

Honesty compels us to note that the Waccamaw Spike is not "rare" at present, though it promises to be so soon.

Remarks: The rationale supporting the vernacular name, Waccamaw Spike, is analogous to that used in the case of the Cape Fear Spike, *E. marsupiobesa*.

References: Burch (1973, 1975b), DNER (1973), Emerson and Jacobson (1976), Heard (1975), Johnson (1970), Stansbery (1971); see list following introduction.

Hubbs, C. L., and E. C. Raney. 1946. Endemic fish fauna of Lake Waccamaw, North Carolina. Miscell. Publ. Mus. Zool. Univ. Michigan No. 65:1-30.

"Lampsilis" radiata (Gmelin) complex, Lake Waccamaw population — WACCAMAW MUCKET

Description: The population in question is considered unique by members of this Committee (Fuller, Imlay, and Williams) who conducted a naiad survey of the Waccamaw River basin, and adjacent basins and subbasins, just prior to the Symposium. This mussel exhibits conspicuous sexual dimorphism of the shell, and the female resembles no other species in Lake Waccamaw, while the male is conchologically almost indistinguishable from *Elliptio waccamawensis* of either sex (Figures 1 and 3). However, the postbasal mantle margin of the Waccamaw Mucket is darkly pigmented (Figures 5 and 6) in both sexes, whereas this is true of neither sex of the Waccamaw Spike. A sense of the differences between the Waccamaw Mucket and related Carolinian populations can be gained by comparing Figures 3 through 6. Illustrations of more or less conchologically typical morphs (or subspecies) in the *"L." radiata* complex can be found in Athearn and Clarke (1962), Burch (1973, 1975b), Clarke (1973), Clarke and Berg (1959), Emerson and Jacobson (1976), Johnson (1970), and Ortmann (1919).

Distribution: Range -- North Carolina endemic; confined to Lake Waccamaw, Columbus Co. Similar but distinguishable populations occur sporadically in the river below the lake.

Habitat and Mode of Life: The *"Lampsilis" radiata* complex is wide-ranging in North America. Understandably, an enormous variety of habitats is involved. Atlantic drainage members of this complex, on the other hand, are most characteristic of tidal portions of rivers and creeks, and of waterways (like Lake Waccamaw) close to the sea. Populations do, of course, occur much farther upriver in certain basins. They favor a clean, sand bottom, but a softer, muddy bottom is sometimes tolerated. Regardless of habitat type, few populations have yet been detected in North Carolina. Most of them, like the Waccamaw Mucket, flourish at present.

Reproduction: One at least nominal member of the *"Lampsilis" radiata* complex, *"L." r. luteola* of the Mississippi basin and perhaps elsewhere, uses a large number and variety of glochidial hosts (Fuller 1974c). Complementary information was provided by Kakonge (1972) and Tedla and Fernando (1969 and others). It is unsound to impute one mussel's hosts

to another, even closely related, species, but to infer from the information above that the Waccamaw Mucket has more than one host seems very reasonable. Refer to the discussion of *Elliptio waccamawensis* immediately preceding.

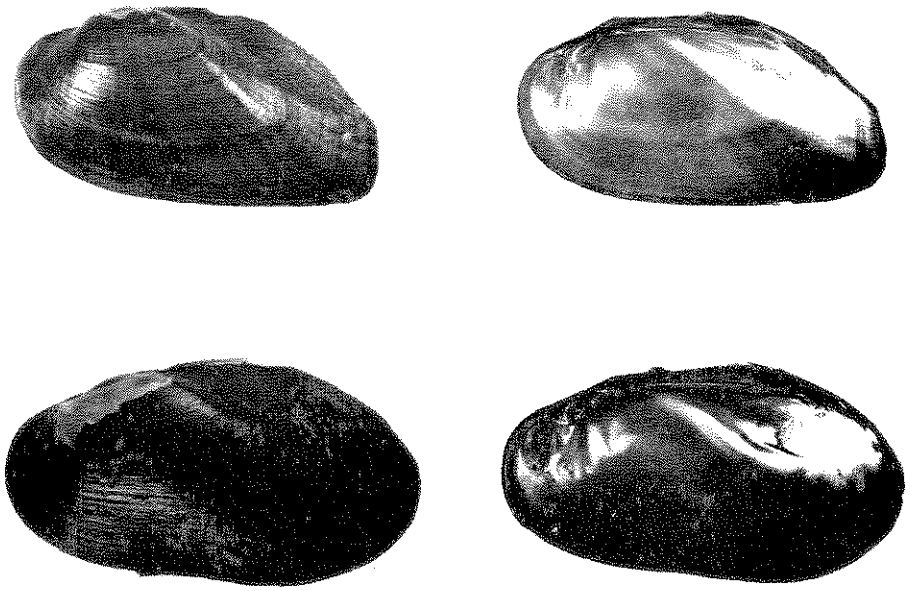

Figure 3. Lateral views of male (above) and female (below) shells of the Lake Waccamaw representative of the *"Lampsilis" radiata* complex (Waccamaw Mucket). See Figure 1 for positioning. Actual length of male 57 mm, female 65 mm. Note degree of sexual dimorphism (compare with Figure 4), and resemblance of male shell to that of the Waccamaw Spike (Figure 1).

Status: *Endangered.* The rationale is essentially identical to that for *Elliptio waccamawensis* above.

Remarks: The vernacular name chosen for the Lake Waccamaw population derives from the fact that the name "Mucket" has long been of widespread use for species of *Lampsilis* and conchologically similar genera in the Mississippi basin. An irony is that the *"L." radiata* group is not true *Lampsilis* at all. In *Lampsilis* the female postbasal mantle margin is modified into a fish-like flap whose entirety can move in a sinuous fashion, thus serving as a lure for predatory fish. When these disturb the flap they also disturb the nearby marsupium, and are showered with glochidia. Kraemer (1970) wrote an interpretation somewhat at variance with this, the traditional one. In the *"L." radiata* complex, on the other hand, the postbasal mantle margin is comparatively poorly modified. It is rather broad, roughened, and deeply pigmented (Figures 5 and 6), to be sure, but there is no piscene flap, and motor activity is confined to a region a short distance anterior from the incurrent mantle aperture. Here the

mantle margin consists of a ribbon of tissue (Figure 5), which can be extruded from between the valves of the shell and then retracted suddenly. On the other hand, this "ribbon" is obsolete in some specimens (Figure 6). These morphic and functional modifications of the postbasal mantle margin are unique. They appear to have been mentioned first by Welsh (1969), whose observations were recently confirmed in the Mississippi basin and Atlantic drainage by two members of this Committee (Fuller and Imlay). We are preparing a new genus-group name for this complex of mussels.

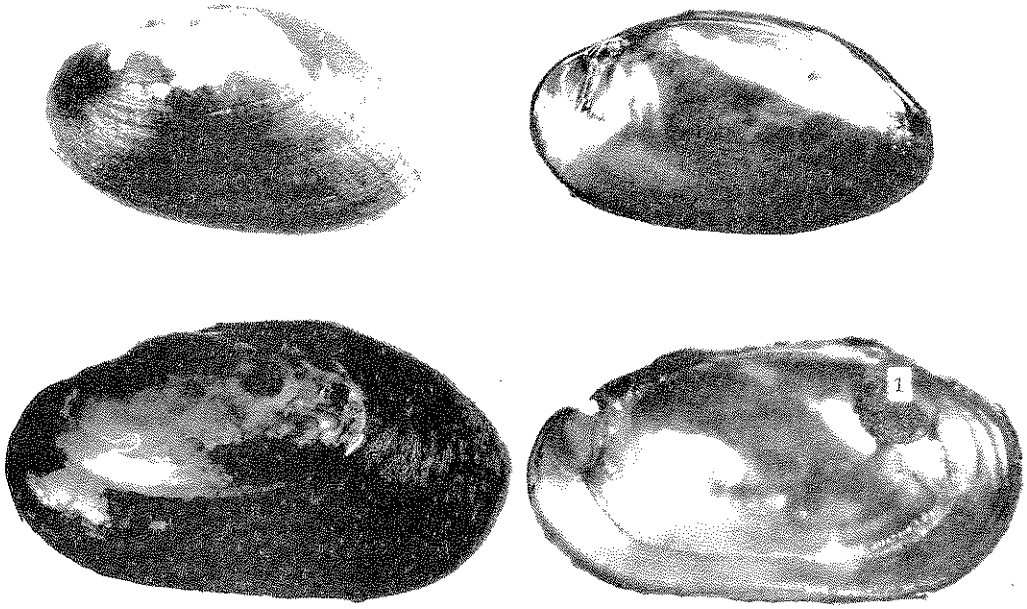

Figure 4. Lateral views of male (above) and female (below) shells of the Orton's Pond, Brunswick County, representative of the *"Lampsilis" radiata* complex. Actual lengthof male 64 mm, female 79 mm. Note lesser degree of sexual dimorphism compared with Figure 3. Also note malformed ("blister") pearls on posterior adductor muscle scar (1) and anteriad along pallial or mantle scar. These can be induced by viruses and/or unionicolid water mites (Fuller 1974c). The notch in the upper left margin of the female valve is from erosion and/or corrosion of the shell, part of the pathology of mussel senescence.

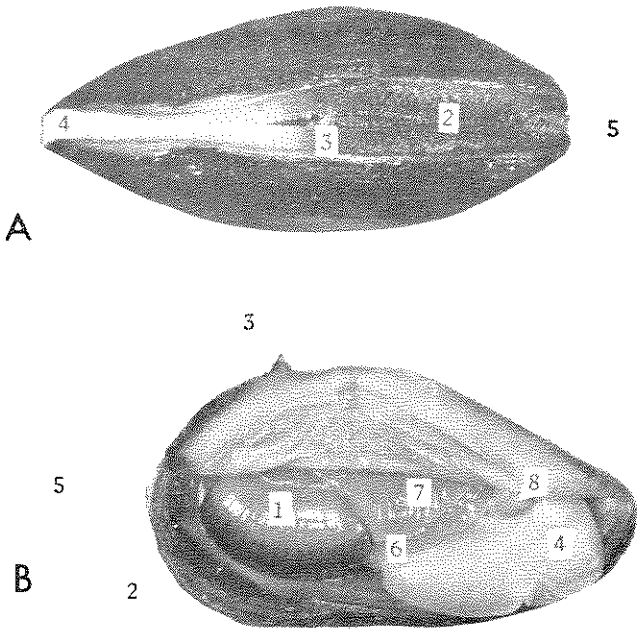

Figure 5. Ventral (A) and lateral (B) views of females from the Orton's Pond population. Actual length ca. 80 mm. In A anterior is left. In B posterior is left, the right shell valve has been removed, and the underlying mantle sheet has been everted upwards (dorsad). Note: charged or loaded marsupium of left gill (1); broad, rough (papillose), and darkly pigmented postbasal mantle margin (2); "ribbon" of tissue on postbasal margin (3); foot (4); incurrent mantle aperture (5); anterior part of inner demibranch of gill (6); non-marsupial portion of outer demibranch of gill (7); and labial palpi (8). These features may serve as an introduction to the internal morphology of fresh-water mussels, but species other than *"Lampsilis" radiata* exhibit different details of the marsupium and postbasal mantle margin.

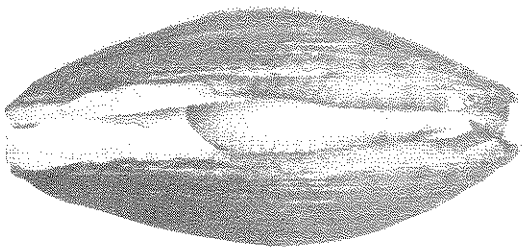

Figure 6. Ventral view of a gravid female of the *"L." radiata* complex from the Kennebec River, Maine. Actual length ca. 80 mm. Note absence of a "ribbon" of tissue along mantle margin (see Figure 5). Although more weakly developed than in Figure 5, pigment extends the length of mantle margin (see Figure 9). Such specimens occasionally occur in Carolinian populations. The charged marsupium of the left gill is visible within the posterior mantle cavity.

References: Burch (1973, 1975b), Clarke (1973), Clarke and Berg (1959), Emerson and Jacobson (1976), Fuller (1974b,c), Johnson (1970), Ortmann (1919), Tedla and Fernando (1969); see list following introduction.

Athearn, H. D., and A. H. Clarke, Jr. 1962. The freshwater mussels of Nova Scotia. Nat. Mus. Canada Bull. No. 183, Contr. Zool., 1960-1961: 11-41.

Kakonge, S. A. K. 1972. The ecology of some metazoan parasites of, and their effect on, small stream fishes and fry. Unpub. Ph.D. dissert., Univ. Waterloo, Ontario, Canada. 163 pages.

Kraemer, L. R. 1970. The mantle flap in three species of *Lampsilis* (Pelecypoda: Unionidae). Malacologia 10:225-282.

Welsh, J. H. 1969. Mussels on the move. Natural History 78:56-59.

Prolasmidonta heterodon (Lea) ANCIENT FLOATER

Description: This is a small mussel, whose shell rarely achieves so much as 38 mm (1 1/2 in.) of length. The epithet *heterodon* ("different tooth") emphasizes the chief distinguishing characteristic of this species, which is the only known North American fresh-water mussel that consistently has two lateral teeth on the right valve, but only one on the left. All other laterally dentate Nearctic species have two lateral teeth on the left valve and one on the right. However, atypical lateral dentition can occur in this species, as well as in others. Accordingly, the beginning student of North Carolina mollusks should be aware of other discriminants for this species: female shells are somewhat more obese (i.e., laterally inflated) than those of males, and shells of both sexes become increasingly arcuate with advancing age. In North Carolina, the Ancient Floater can be confused only with young members of the genus *Elliptio*, from which it can be distinguished by its mottled but colorful mantle margin. Useful aids in identification include Burch (1973, 1975b), Clarke and Berg (1959), Emerson and Jacobson (1976), Johnson (1970), and Ortmann (1919).

Distribution: Range -- Atlantic drainage; North Carolina, sporadically north into Canada.

North Carolina -- Neuse (Johnson 1970, Walter 1956) and Pamlico (D. H. Stansbery, pers. comm.) river systems.

Habitat and Mode of Life: Very little is known about the natural history of the Ancient Floater. However, something may be said of its habitat, which is itself none too clear. It is usually encountered in stable stream floors of sand and/or fine gravel, but, like most other members of the subfamily Anodontinae, it has a considerable tolerance of sediment overlying formerly clean streambeds.

Reproduction: This species is known to breed in winter (Ortmann 1919). Its extensive and broken range suggests (1) that several fishes serve as glochidial hosts, but none has been implicated (Fuller 1974c); and (2) that these host species, like the mussel itself, exhibit rather strong preferences for certain habitats whose disturbance leads to elimination of host and parasite alike.

Status: *Endangered.* The Ancient Floater's relict distribution suggests that it was already failing prior to settlement by European and African man. Also, because of its small size, it was probably no more than an occasional and inadvertent item in the diet of aboriginal man and certain other mammals known to prey upon fresh-water mussels, like the raccoon and muskrat. Habitat destruction is hastening *P. heterodon* toward extinction. Although recent discoveries have expanded knowledge of its range, the number of known populations is dwindling. We are aware of a healthy population in Connecticut that was eliminated from a tiny, sandy stream by sedimentation from construction of a single house. The only thriving population known to us occurs in New Hampshire, and the last "stronghold" of the species appears to be the Connecticut River system of New England. In North Carolina this species is in great jeopardy. The only recently discovered specimens are from the Tar River, and, despite numerous attempts, Walter's (1956) 20-year-old Neuse River records have not been confirmed.

The Ancient Floater remains one of the most rare, elusive, and vulnerable mollusks in the state and the nation. Our deliberations have confirmed an earlier decision (DNER 1973) to confer endangered status upon this species, support Clarke's (1970) contention that this form (as *Alasmidonta heterodon*) is probably endangered, and verify Stansbery's (1971) contention that it is "rare and endangered." The federal Office of Endangered Species is preparing to register it in the same status nationwide. No protective measures have yet been provided for the species, but the prospect of its addition to the federal list is encouraging. It is obvious that any effort to curb any form of pollution would benefit any species, endangered or otherwise, but such efforts would be especially practicable and beneficial in the case of this species, whose known populations are so few. A program of protection of specific habitats at specific localities should be implemented at once, especially with reference to thriving populations. There is reason to believe that they might yet be effectively guarded and preserved. Coordination of federal, state, and local laws would be required. In North Carolina there must also be an effort to discourage further channel modifications of the Neuse and Tar rivers and their tributaries.

While the Ancient Floater lacks great and unequivocal value in commercial and esthetic terms, it has great significance in biological science. As one of rather few North American fresh-water mussels with a naturally relict distribution, this species still offers an opportunity to learn much about what is necessary to a mussel's survival. That sort of information is invaluable for our efforts to save other organisms. Apart from legal and physical protection, this species needs research into various aspects of its biology, especially the identity and nature of its dominant glochidial host in the wild. Protection of the latter may be the salvation of the former.

Remarks: The naturally discontiguous range and its suggestion of great antiquity are responsible for the vernacular name, Ancient Floater, newly coined for this report, and for the elevation here of the subgeneric name, *Prolasmidonta,* to generic rank. Additional support for this taxonomic adjustment is the presence of lateral teeth and of sexual dimorphism of the shell. Both characters are foreign to members of the genus *Alasmidonta,* where the Ancient Floater is usually classified. On

the other hand, both are typical of *Pegias fabula* (Lea), also often placed in *Alasmidonta*, but the shells of these two species are quite unlike (Blankenship 1971; Burch 1973, 1975b; Neel and Allen 1964). Emerson and Jacobson (1976) have offered an alternative common name, Inverted Mussel, for this species.

References: Burch (1973, 1975b), Clarke and Berg (1959), DNER (1973), Emerson and Jacobson (1976), Fuller (1974c), Ortmann (1919), Stansbery (1971), Johnson (1970); see list following introduction.

Blankenship, S. 1971. Notes on *Alasmidonta fabula* (Lea) in Kentucky. Nautilus 85:60-61.

Clarke, A. H., Jr. 1970. Papers on the rare and endangered mollusks of North America. Discussion of Dr. Stansbery's paper. Malacologia 10: 21-22.

Neel, J. K., and W. R. Allen. 1964. The mussel fauna of the upper Cumberland basin before its impoundment. Malacologia 1:427-459.

Walter, W. M. 1956. Mollusks of the upper Neuse River basin, North Carolina. J. Elisha Mitchell Sci. Soc. 72:262-274.

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GASTROPODA; BASOMMATOPHORA; PLANORBIDAE
(Ramshorn Snails)

Taphius eucosmius eucosmius Bartsch — GREENFIELD RAMSHORN

Description: This snail, recorded only from Greenfield Pond, Wilmington, is readily distinguishable from other Carolinian planorbids. It is very small, about 6 mm (1/4 in.) in breadth, and has "two rather broad, bright chestnut bands" against a "yellowish horn color" background (Bartsch 1908).

Distribution: Range -- North Carolina endemic; type and only known population lived (or lives) in Greenfield Pond, Wilmington, New Hanover Co.

Habitat and Mode of Life: The only account of this species ever written (Bartsch 1908) did not include a description of its habitat. We infer that it is rather like that of *Helisoma magnificum*, the Cape Fear Ramshorn, discussed later. Nothing is known about any aspect of its natural history, including reproduction.

Status: Presumed *Extinct*. All attempts by members of the Committee to find this animal in recent years have failed. This viewpoint essentially replicates that expressed earlier (DNER 1973) as "endangered" and "possibly extinct."

Remarks: In the same paper describing this form, Bartsch (1908) also described *T. e. vaughani* from Louisiana. Within recent years J. P. E. Morrison (pers. comm.) found the latter subspecies alive and, on the basis of this material, suspects that Bartsch's taxa are better referred to the

Central American genus *Taphius* than to *Planorbis*. If this interpretation proves correct, and if these two animals are conspecific, the Greenfield Ramshorn should be called *Taphius e. eucosmius*. Derivation of the vernacular name is obvious.

References: Bartsch (1908), DNER (1973); see list following introduction.

Helisoma magnificum (Pilsbry) CAPE FEAR RAMSHORN

Description: This rare species resembles other, more commonly encountered, Ramshorns, which are natural objects familiar to naturalists, watermen, aquariists, and rural fossickers alike. Exceeding 25 mm (1 in.) in any given dimension, this is the North American giant of its family. Its angular, swollen aspect also serves to separate it from other Carolinian planorbids, which are smaller and/or coplanar. It was figured by Pilsbry (1903) and Wolf (1908).

Distribution: Range -- North Carolina endemic; Greenfield Pond, Wilmington, New Hanover Co. Questionable in Orton's Pond, near Wilmington, and lower Cape Fear River.

Habitat and Mode of Life: Bartsch's (1908) account provides the only relevant information. He found the species common in uprooted vascular vegetation that, he inferred, had probably been blown inshore from deeper waters of the pond. The inference is reinforced by his observation that the adults are blind.

Reproduction: In a largely unsupervised, and sometimes abandoned, "experiment," Bartsch (1908) was able to "induce" breeding, as well as great mortality. Wolf (1908), the incomparable pioneer aquariist, apparently never had an opportunity to rear this species. Also see Status.

Status: *Threatened*. In spite of the very limited known range and number of populations of *Helisoma magnificum*, as well as its possible extinction, we have elected to place this species in this category on the strength of J. P. E. Morrison's (pers. comm.) report of enormous, presumably planorbid eggs in Orton's Pond near Wilmington some years ago. If Morrison's suspicion that these were eggs of the Cape Fear Ramshorn can be proven correct, this snail would stand every chance of being successfully conserved, because this pond persists as a wildlife refugium, in effect. On the other hand, premature jubilation should be somewhat allayed. Pilsbry's (1903) "type locality" was probably in error, and Bartsch (1908) failed to find this species elsewhere than Greenfield Pond in spite of apparently assiduous search. To search for it today in the Cape Fear or any other river, or in any lentic body of water, is doubtless hopeless. In view of its not being mentioned in Baker's (1945) monumental monograph on the family Planorbidae, this Ramshorn was evidently not available to him, more than three decades ago. Also, at the time of his Orton's Pond investigation, Morrison did not find this species at Greenfield Pond, and three members of this Committee (Fuller, Imlay, and Williams) failed to discover it there in November, 1975. An intensive

search for surviving populations of the species is needed; to find that it lives would be a dramatic feather in the Tarheel cap. Understanding of its adult blindness could shed light upon aspects of human medicine, and we have here a potentially important experimental animal. Any efforts to preserve or improve environmental quality at Greenfield or Orton's Pond would be of great value.

Remarks: Pilsbry (1903) ascribed his original specimens to the lower Cape Fear River. Judging by its inflated shell, rather fragile for one so large, Bartsch (1908), whose account of the matter reads rather as a detective story, suspected that this species was an inhabitant of quiet waters. He traveled to southeastern North Carolina and, triumphantly, found the object of his search living populously in Greenfield Pond. That Pilsbry's ascription was incorrect is probable; that Greenfield Pond is (or was) the only locality productive of the species, more so (but see Status, above).

Two nomenclatural problems are relevant here. First, Pilsbry (1903) described the Cape Fear Ramshorn in the genus *Planorbis*. Modern practice has been to refer this species to *Helisoma*. Best generic ascription of planorbid species depends upon knowledge of soft-tissue anatomy, but these aspects of this species are scarcely described (Bartsch 1908). The correct generic placement of *H. magnificum* remains moot, although conchological characters certainly argue for *Helisoma*. The second problem concerns the vernacular name. Wolf (1908) introduced Cape Fear River Snail for this species. The appellation "Riversnail" is best reserved for members of the family Pleuroceridae. In addition, there is no reason to suppose that the Cape Fear River is relevant to this snail. However, partially in deference to Wolf, who was in at least some respects before his time, we choose to name this species for the peninsula or basin (but not necessarily the river) Cape Fear. The word "Ramshorn" has long been of widespread use for members of the Planorbidae because of the characteristic shape of most of their shells. A winning, alternative common name for *H. magnificum*, Magnificent Ram's Horn, was contributed by Emerson and Jacobson (1976). The name Giant Ramshorn is a likely alternative that might be considered by the as yet non-existent group that will eventually standardize the vernacular names of Nearctic non-marine mollusks.

References: Baker (1945), Bartsch (1908), Emerson and Jacobson (1976); see list following introduction.

Pilsbry, H. A. 1903. The greatest American *Planorbis*. Nautilus 17: 75-76.

Wolf, H. T. 1908. The molluscs, vermes and hydrozoa of freshwater. In: Goldfish Breeds and Other Aquarium Fishes. Innes, Philadelphia, PA.:215-248.

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GASTROPODA; PULMONATA; POLYGYRIDAE
(Polygyras, Helices, and relatives)

Mesodon clarki nantahala (Clench and Banks) NOONDAY HELIX

Description: Since this species, like *M. jonesianus*, has several conchologically similar congeners, we refrain from a possibly misleading verbal description. Refer to the accounts and figures provided by Clench and Banks (1932) and Pilsbry (1940).

Distribution: Range -- possible North Carolina endemic; Nantahala Gorge and Handpole Brook, Swain Co. (Hubricht 1970); may occur elsewhere, including nearby Tennessee.

Habitat and Mode of Life: This species forages in litter of wooded slopes.

Status: *Threatened.* The geographic range of *M. c. nantahala* is probably at least as restricted as that of the *Endangered* species, *M. jonesianus* (discussed earlier), but the ambiguous taxonomic rank of this at least nominal subspecies, and our limited knowledge of it, lead us to place the Noonday Helix in this category. Earlier opinions (Hubricht 1972, DNER 1973) interpreted this Helix as "endangered." The U. S. Fish and Wildlife Service has proposed that *M. c. nantahala* be federally registered as a *Threatened* species, saying: "This species is restricted to the Blowing Spring area of Nantahala Gorge and Handpole Brook in Swain County, North Carolina. Widening of U. S. 19 to four lanes, as has been proposed, could destroy most of the known colonies of this subspecies."

Remarks: The Noonday Helix is a nominal subspecies whose current taxonomic and biological status may be that of a subspecies (Pilsbry 1940) or a species (Clench and Banks 1932). We have followed Pilsbry's interpretation, which is more recent and sophisticated. However, the relationship of the snail to *M. clarki* (Lea) and its many forms remains unresolved. If the Nantahala Gorge form of *M. c. clarki* proves to be a unique biological entity, the Noonday Helix is probably endangered in virtue of its apparently narrow geographic and ecologic range. If not, this animal probably deserves no jeopardy status at all. This is a good example of the sort of creature that requires further research before an unequivocal "ruling" on its status in this context can be made.

The vernacular name introduced in this report depends upon the fact that, according to Stewart (1970), in Cherokee "nantahala" means "'middle (noonday) sun,' originally applied to a place where perpendicular cliffs kept the sun from shining until noon." An alternative is "Clark's Nantahala middle-toothed land snail," provided by the U. S. Fish and Wildlife Service.

References: DNER (1973), Hubricht (1970, 1972), Pilsbry (1940); see list following introduction.

Clench, W. J., and G. S. Banks. 1932. Descriptions of some land snails of southwestern North Carolina. Nautilus 46:14-18.

Stewart, G. R. 1970. American Place-names. Oxford Univ. Press, N. Y., NY. 550 pages.

Triodopsis soelneri (J. B. Henderson) WACCAMAW HELIX

Description: The following combination of identifying characters is drawn chiefly from Grimm (1975) and Burch (1962): size about 13 mm (1/2 in.); periostracum dark red-brown and shiny; spire moderately domed; whorls 4.5 to 5.0 in number; umbilicus scarcely perforate; and aperture teeth limited to one lengthy, low, arcuate parietal tooth. The shell was figured by both authors, and Pilsbry (1940). The lip is broad, white, and reflected in adults, and thin and sharp in juveniles. An additional, unillustrated discussion of morphology is in Vagvolgyi (1968).

Distribution: Range -- North Carolina endemic; small area between Lumber and Cape Fear rivers in parts of Bladen, Brunswick, Columbus, and Jones counties (Grimm 1975, Hubricht 1970).

Habitat and Mode of Life: The Waccamaw Helix is a native of piney woods or cypress swamps. About one snail per 10 square meters can be found during wet periods, but congregations appear in association with trash on the woodland floor.

Reproduction: At least under laboratory conditions, the Waccamaw Helix has rather high fecundity. Snails will lay clutches of six to eight eggs every month or two throughout the year. In nature the species is little less prolific. They are not very active during the hottest parts of summer, and hibernate only during the coldest periods of winter.

Status: *Threatened.* The adaptability of *T. soelneri* to man's activities was intimated above. Clearing land, draining swamps, and the like probably will not extinguish this species, but it is threatened with extinction as a subtle, indirect consequence of man's modifying woodlands. The geographic range of *T. soelneri* partially overlaps that of *T. fallax messana* Hubricht, a closely related form that is presently tolerant of a wider variety of habitats, including roadsides (Grimm 1975), which is an unnatural habitat. Hybrids between these two taxa (figured in Grimm 1975) are known, and we fear that habitat disturbance will provide opportunity for accelerated hybridization until pure *T. soelneri* is eliminated as a genetic entity. The phenomenon has precedent: *T. f. vannostrandi* (Bland) is being absorbed genetically by *T. f. fallax* (Say) and *T. f. hopetonensis* (Shuttleworth) in disturbed habitats through much of its range. Genetic disappearance of the Waccamaw Helix may be considered. Our decision on its status represents an advance beyond an earlier opinion (Clarke 1970) that this animal is possibly in some degree of jeopardy.

Remarks: The common name of this snail refers to the fact that most of its scattered populations occur in the Waccamaw basin. Recent apprehension that the species will be lost by hybridization contrasts sharply with the scarcely decade-old work by Vagvolgyi (1968), who emphatically referred to the morphological integrity of the Waccamaw Helix.

References: Burch (1962), Hubricht (1970), Pilsbry (1940); see list following introduction.

Clarke, A. H., Jr. 1970. Papers on the rare and endangered mollusks of

North America. (See D. S. Dundee's discussion of Dr. Clench's paper). Malacologia 10:36-37.

Grimm, F. W. 1975. Speciation within the *Triodopsis fallax* group (Pulmonata: Polygyridae) -- a preliminary report. Bull. Amer. Malacol. Union Inc. 1974:23-29.

Vagvolgyi, J. 1968. Systematics and evolution of the genus *Triodopsis* (Mollusca: Pulmonata: Polygyridae). Bull. Mus. Comp. Zool. 136:145-254.

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BIVALVIA; HETERODONTA; UNIONIDAE
(Fresh-water Mussels)

Elliptio sp. WACCAMAW LANCE

Description: The shell of this mussel is long and narrow in lateral view, its dorsal and ventral margins are almost parallel, and its ends are oddly blunt (Figure 7). This animal appears to be restricted to Lake Waccamaw, although other sources (e.g., DNER 1973) have indicated it (as *Elliptio folliculata*) elsewhere. Whether or not the Waccamaw Lance is legitimately to be considered a species remains moot, but it is certainly a morphologically and probably genetically unique population, and thus deserves to be considered a unique biological entity. This population belongs conchologically to the group of *E. lanceolata* (Lea) and might be confused with other members of the complex, one of which is illustrated herein (Figure 8).

Figure 7. Lateral views of the shell of an aged Waccamaw Lance, a member of the *E. lanceolata* complex. Lake Waccamaw, Columbus County. Actual length 93 mm. Erosion and corrosion of the periostracum, and "blister pearls," both pathological features, are visible on the external and internal surfaces of the shell, respectively.

Distribution: Range -- North Carolina endemic; unequivocally known only from Lake Waccamaw, Columbus Co.

Habitat and Mode of Life: The Waccamaw Lance is especially common in slightly muddy sand among submerged vascular plants, under several feet of water.

Reproduction: This species is obviously reproductively successful in congenial habitat and in the presence of one or more glochidial hosts. These may be sought among those fishes listed by Hubbs and Raney (1946) for Lake Waccamaw.

Status: *Threatened,* and quite likely *Endangered.* The latter assignment would be in harmony with previous assessments of the Waccamaw Lance (as *Elliptio folliculata,* at least in part) as "rare" (DNER 1973) and "rare and endangered" (Stansbery 1971). Comments made under Description above, and the discussion of *E. waccamawensis* provided earlier, are pertinent.

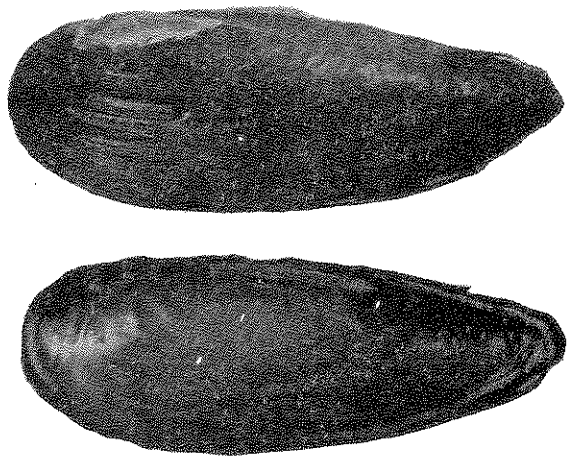

Figure 8. Lateral views of the shell of a member of the *E. lanceolata* complex from the Chowan River, Gates County. Actual length 86 mm. Note the dissimilarity between this morph and the Waccamaw Lance (Figure 7). This shell could pass for *Ligumia nasuta,* but the two are easily separated by soft-tissue discriminants (compare Figures 9 and 14.

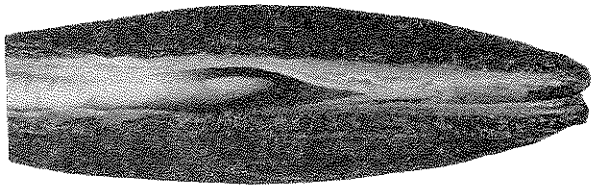

Figure 9. Ventral view of the postbasal portion of another specimen of the *E. lanceolata* complex from the Chowan River population. Mantle margin features that are characteristic of *Ligumia nasuta* are absent (Figure 14).

Remarks: The group of *E. lanceolata* is in need of taxonomic revision, which will probably clarify the nomenclatural status of the population known here as the Waccamaw Lance. For the time being, this vernacular name is used to designate the population in question (but see Figure 8). In any event, the Waccamaw Lance appears to be a unique animal by whatever name. This common name is drawn from the name of

the typical lake and from the membership of this population in the *E. lanceolata* complex.

References: DNER (1973), Stansbery (1971); see list following introduction.

Hubbs, C. L., and E. C. Raney. 1946. Endemic fish fauna of Lake Waccamaw, North Carolina. Miscell. Publ. Mus. Zool. Univ. Michigan No. 65:1-30.

Fusconaia masoni (Conrad) ATLANTIC PIGTOE

Description: The shell of this mussel reaches little more than about 38 mm (1 1/2 in.) in length, and in lateral view is shaped rather like a rhombus. The lateral outline is variable, however, as is the color. Figures are in Burch (1975a) and Fuller (1974a). The latter paper also figures the soft tissues, several of whose characters are important in identification: the marsupium occupies the entire gill, and its contents (ova or glochidia) are usually a vivid shade of red like much of the tissues, especially the muscles. These characters are unique among North Carolina mussels. Also, the incurrent papillae are arborescent, a feature shared in the state only by the common *Uniomerus tetralasmus* (Say), not considered in this report. The latter, however, has a very different shell (see Burch 1975b, Pennak 1953, and others). The Atlantic Pigtoe can be confused in North Carolina only with populations in the *Elliptio crassidens* complex, animals often with nondescript shells much like that of *F. masoni*, which were amply figured by Johnson (1970). Among other Atlantic drainage naiads it can be confused with *Lexingtonia subplana* (Conrad), but this species has only been confirmed from the James River system of Virginia (Ortmann 1914).

Distribution: Range -- Chowan system in Virginia, south into Ogeechee basin of Georgia.

North Carolina -- only known extant population in Cape Fear River near Fayetteville, Cumberland Co., at type locality of *Elliptio marsupiobesa* (Fuller 1972, 1974a); Johnson (1970) indicated others (see Remarks). Shells of recently dead individuals recorded from Rocky River system, Chatham Co. (R. M. Shelley, pers. comm.).

Habitat and Mode of Life: The Atlantic Pigtoe prefers clean, sandy streambeds of creeks or small rivers. Living in the characteristic substrate of *E. marsupiobesa*, the one known Cape Fear River population of *F. masoni* is atypical of the species. Its rarity throughout its range suggests poor coordination with at least its dominant glochidial host(s) in nature.

Reproduction: Barren in autumn and gravid in late spring (Fuller 1974a), this species appears to be bradytictic. Under conditions congenial in terms of host(s) and habitat, it reproduces adequately, but its rarity suggests some breakdown in these relationships.

Status: *Threatened.* Because of the very limited known distribution of the Atlantic Pigtoe in North Carolina and elsewhere, it is definitely

vulnerable to environmental disturbance. For example, further impoundment threatens the Cape Fear River population, as well as the *Endangered* species, *Elliptio marsupiobesa*. Although this population is the only one known in the state at this time, it is likely that there are others, and only *Threatened* status seems warranted. Further research into Carolinian mussel distribution may well support ultimate *Endangered* status. Other needed research must be concerned with identifying and protecting its glochidial host(s). Unfortunately, no protective measures of any kind are currently available to the species. This is especially unfortunate because it figures prominently in ongoing research into evolution and other aspects of the biology of fresh-water mussels. The Atlantic Pigtoe is additionally significant as the only tetragenous mussel in the Atlantic drainage, a distinct biogeographical province. As such, the Cape Fear River population (and possibly others) figures among the unique zoological features of North Carolina. This Committee's decision to interpret the mussel as *Threatened* is an understandable sequel to earlier opinions. *"Fuscinia merris"* has been considered "rare and endangered" (Nature Conservancy 1975). This misspelling probably represents *"Fusconaia merus [mera]"* which probably refers to *Unio merus* Lea, a taxon based on Savannah River basin material from South Carolina and probably a synonym of *F. masoni* (see Johnson 1970; Fuller 1974a, 1975). Heard (1975) described this species, as *Pleurobema (Lexingtonia) masoni*, corrected to *Fusconaia masoni*, in these terms: "very rare or extinct in part of present or past range, respectively".

Remarks: All of Johnson's (1970) records of *Pleurobema masoni* below the James basin are probably *F. masoni*. There is little likelihood of "contamination" by *Lexingtonia subplana*. The name "Pigtoe" is widely used in reference to Mississippi basin and Gulf drainage members of *Fusconaia* and conchologically similar genera. Fuller (1974c) introduced the name Atlantic Pigtoe for this species because it is the only representative of this vernacular group in the Atlantic drainage.

References: Burch (1975a,b), Fuller (1974a,c), Heard (1975), Johnson (1970), Pennak (1953); see list following introduction.

Fuller, S. L. H. 1972. *Elliptio marsupiobesa*, a new fresh-water mussel (Mollusca: Bivalvia: Unionidae) from the Cape Fear River, North Carolina. Proc. Acad. Nat. Sci. Phila. 124:1-10.

_____. 1975. Fresh-water mussels (Mollusca: Bivalvia) in the Chowan river system of Virginia. ASB Bull. 22:54. Abstract.

Nature Conservancy, The. 1975. Rare and endangered species of South Carolina. The Nature Conserv., Arlington, VA. 41 pages.

Ortmann, A. E. 1914. Studies in najades (Part 3). Nautilus 28:28-34.

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The five species of fresh-water mussels discussed below are considered to be of *Special Concern* in North Carolina. They and/or their populations in the state are believed or known to be in varying degrees of jeopardy, but are not considered to be in imminent danger of extinction or threatened by definite phenomena. Further research will probably demonstrate that some or all should be reassigned, doubtless to a higher category in most cases.

BIVALVIA; HETERODONTA; UNIONIDAE
(Fresh-water Mussels)

Alasmidonta varicosa (Lamarck) BROOK FLOATER

Remarks: This species is easily distinguished from other Carolinian mussels by a unique combination of characters: (1) elongate shape; (2) vivid coloration (yellow to orange) of muscle tissues, especially the foot; (3) weak pseudocardinal teeth and obsolete laterals; and (4) radial ridges on the posterior slope. Good illustrations were published by Clarke and Berg (1959), Johnson (1970), and Burch (1973, 1975b). The Brook Floater is known to range from the Savannah River system in South Carolina into the St. Lawrence system in Canada (Johnson 1970). Its characteristic habitat is the sand floors or gravel riffles of small, upland, rapidly flowing, oxygen-rich streams in upper portions of river systems. This species is a relative rarity throughout its range, but it has a certain metropolis in New England, where this sort of stream is called a brook -- hence the vernacular name. The status of *A. varicosa* is based on its rarity; it has been recorded only twice in North Carolina. Fortunately, there are some additional, unpublished records for the state, notably in the Cape Fear River system (R. M. Shelley, pers. comm.). Howard and Anson (1922) identified glochidial hosts of the closely related *A. marginata,* a characteristically Mississippi River basin congener. As listed by Fuller (1974c), these may serve as reliable guides to establishing the identities of glochidial hosts of the Brook Floater. Such research would be in the very best interest of this species, as would be any additional biological information. Because of the scattered, upland, small-stream nature of its favored habitat, the chief probable danger to the species is non-point-source pollution that could physically damage its habitat and/or poison it and its larval hosts. These kinds of adversity can endanger organisms so subtly and rapidly that Heard's (1975) ominous opinion of the Brook Floater as "rare throughout entire range and in danger of extinction", though perhaps partly ill informed, could suddenly become fact. In addition, scientific and avocational collecting can damage individual populations, while posing no threat to the species unless too extensive.

References: Burch (1973, 1975b), Clarke and Berg (1959), Fuller (1974c), Heard (1975), Johnson (1970); see list following introduction.
Howard, A. D., and B. J. Anson. 1922. Phases in the parasitism of the Unionidae. J. Parasitol. 9:68-82.

Anodonta couperiana Lea BARREL FLOATER

Remarks: The newly introduced common name is, in great measure, a play on words compounded of its conchological obesity and the word "cooper" (or the Middle English "couper"), a maker of barrels. Emerson and Jacobson (1976) have suggested another common name, Couper's Freshwater Mussel.

The Barrel Floater is most abundant and commonly encountered in peninsular Florida, but it ranges northward in the Atlantic drainage into at least the Cape Fear River basin of North Carolina (Johnson 1965, 1970, 1972; Fuller 1971), where it has not been frequently encountered. Because it is at the periphery of its range in this state and thus understandably rare, we have interpreted it as of *Special Concern*, but not due to man's activities. Indeed, as a Floater, it is tolerant of slack water, sedimentation, and other consequences of drainage modification, so impoundments probably pose it little or no threat. This species can be confused in North Carolina with a common close relative, *Anodonta imbecillis*, the Paper Floater, but the latter's dorsal and ventral margins are subparallel and almost straight, whereas the ventral margin of *A. couperiana* is convexly rounded. Johnson (1965) made the differences clear, and other aids in identification include Johnson (1970, 1972), Burch (1973, 1975b), and Emerson and Jacobson (1976).

It appears that no glochidial hosts are yet known for the Barrel Floater (Fuller 1974c), but Heard (1975) has provided interesting information about other aspects of its reproduction. This species includes populations with many hermaphroditic individuals, a commonplace in the genus, and breeds during a brief period of winter, which is atypical of the genus. Heard (1975a) has expressed the belief that *A. couperiana* is "very rare or extinct in part of present or past range, respectively". This contrasts with this Committee's assessment and its forerunner (DNER 1973), that the Barrel Floater is of undetermined status in North Carolina. Heard's point of view was based largely upon observations on this species in its metropolis, and further data may well demonstrate that our opinion is naive, and that *A. couperiana* is in grave danger in this state.

References: Burch (1973, 1975b), DNER (1973), Emerson and Jacobson (1976), Fuller (1974c), Heard (1975), Johnson (1970); see list following introduction.

Fuller, S. L. H. 1971. Macroinvertebrates (exclusive of insects). In: Cape Fear River surveys 1969-1970 for E. I. duPont de Nemours & Co. Dept. Limnol. Acad. Nat. Sci. Phila., Philadelphia, PA. pp. 28-37, 105-107.

Heard, W. H. 1975a. Sexuality and other aspects of reproduction in *Anodonta* (Pelecypoda: Unionidae). Malacologia 15:81-103.

Johnson, R. I. 1965. A hitherto overlooked *Anodonta* (Mollusca: Unionidae) from the Gulf drainage of Florida. Breviora No. 213:1-7.

_____. 1972. The Unionidae (Mollusca: Bivalvia) of peninsular Florida. Bull. Fla. State Mus., Biol. Sci. 16:181-249.

Elliptio lanceolata (Lea) YELLOW LANCE

Remarks: The fresh-water mussel genus *Elliptio* (Spikes and Lances) includes elongate representatives (the Lances) in the southern Atlantic and eastern Gulf of Mexico drainages. The most recent monographic treatment of Lances in the Atlantic drainage is that of Johnson (1970), who recognized three species: *E. shepardiana* (Lea) of the Altamaha River basin of Georgia, which has nothing to do with the animal under consideration here; *E. arctata* (Conrad), originally described from the Mobile River basin in Alabama, whose occurrence anywhere in the Atlantic drainage was questioned by Fuller (1972); and *E. lanceolata* (Lea), which Johnson thought to range in the Atlantic drainage from Pennsylvania into Georgia. This last taxon is the earliest described of the Lances and, accordingly, the one to which all other relevant taxa in the Atlantic drainage and elsewhere must be compared. During recent years, Johnson's concept of *E. lanceolata* has been attacked. There can be little doubt that the "*lanceolata*-group" of *Elliptio* includes more than one biological species of mussel (Fuller 1971, 1972; Johnson 1970, 1972; Ortmann 1919; and others). It is probable that *E. angustata* (Lea) is such a one. This at least nominal species has been fairly well characterized by Blood (1975), Morrison (1972, 1973), and Riddick (1973). Judged by Johnson's descriptions and illustrations, *E. lanceolata* has a yellowish shell of gently rounded lateral outline, whereas *E. angustata* has a darker shell of subrectangular lateral outline. They were originally described from the Cooper and Tar rivers in South and North Carolina, respectively. Unfortunately, the relationships of these species (or morphs) to their congeners remain imperfectly described. The yellow, essentially North Carolinian entity is thought to be in jeopardy, but the confusion between it and *E. angustata* is great and thought to be responsible for the following at least partly contradictory opinions. *Elliptio angustata* has been considered "rare and endangered" by D. H. Stansbery (Nature Conservancy 1975). *Elliptio lanceolata* was thought "rare and endangered" (Stansbery 1971) and "rare" (DNER 1973), but Heard (1975) stated that this taxon is "not rare and endangered, although at least once listed as so". These contrasting appraisals cast doubt upon the wisdom of including any Atlantic drainage Lance in this report, but there is no doubt that at least one such biological entity is in some jeopardy in North Carolina.

References: DNER (1973), Heard (1975), Johnson (1970), Ortmann (1919), Stansbery (1971); see list following introduction.

Blood, F. B. 1975. A morphometric identification key of the Unionidae (Mollusca: Bivalvia) in the Pamunkey River system, Virginia. Unpub. MS thesis, Va. Commonwealth Univ., Richmond, VA. 40 pages.

Fuller, S. L. H. 1971. A brief field guide to the fresh-water mussels (Mollusca: Bivalvia: Unionacea) of the Savannah River system. ASB Bull. 18:137-146.

_____. 1972. An undescribed structural feature in the marsupium of *Elliptio lanceolata* (Lea 1828) (Unionidae). Nautilus 86:85-86.

Johnson, R. I. 1972. The Unionidae (Mollusca: Bivalvia) of peninsular Florida. Bull. Fla. State Mus., Biol. Sci. 16:181-249.

Morrison, J. P. E. 1972. Sympatric species of *Elliptio* in North Carolina. Bull. Amer. Malacol. Union 37:38-39.

Morrison, J. P. E. 1973. Sympatric species of *Elliptio* in the St. Johns River, Florida. Bull. Amer. Malacol. Union 38:14.
Nature Conservancy, The. 1975. Rare and endangered species of South Carolina. The Nature Conserv., Arlington, VA. 41 pages.
Riddick, M. B. 1973. Freshwater mussels of the Pamunkey River system, Virginia. Unpub. MS thesis, Va. Commonwealth Univ., Richmond, VA. 105 pages.

"Lampsilis" ochracea (Say) TIDEWATER MUCKET

Remarks: This species includes an enormous Lake Waccamaw population (Figure 14), which, like all populations in this lake, is in danger. The only additional and extant known populations in North Carolina apparently occur in the tidal Chowan River near Eure, Gates County, and in the Tar River near Pinetops, Edgecombe County (R. M. Shelley and K. E. Wright, respectively, pers. comm.). The Tidewater Mucket is doubtless more widespread in the state, but until this is established it should be considered of *Special Concern*. The Waccamaw population has special significance for North Carolina and natural science because it is the only really large one known.

"Lampsilis" ochracea ranges from the Savannah River system in Georgia northward in the Atlantic drainage into Canada (Johnson 1970). Throughout this range it can be confused with *L. cariosa* (Say), the Yellow Mucket, which is a true *Lampsilis* (see the earlier account of the Lake Waccamaw representative of the group of *"L." radiata*). As such, it has a piscene mantle flap, whereas the Tidewater Mucket has none (Figure 16). This simple discriminant readily separates these two species, and shell material is usually separable with reference to Johnson (1947, 1970), Clarke and Berg (1959), Ortmann (1919), Burch (1973, 1975b), and Emerson and Jacobson (1976). The Tidewater Mucket also has a characteristic ecological range. Although not actually confined to tidal portions of river systems, it is never found far from the Atlantic coast. This suggests that, like the Alewife Floater (see *Anodonta implicata*), its dominant glochidial host is an anadromous fish. Little else is known or believed about this mussel's reproduction. It is evidently bradytictic (Johnson 1970) and capable of great population development in congenial circumstances. Favorable habitat is usually a sandy floor beneath shallow water, often in lakes and smaller streams. Varying habitat can induce ecophenotypic conchological variation in this species, but the soft tissues preserve an essentially constant character. This character is unique among naiades and requires creation of a new genus for the Tidewater Mucket (Fuller and Bereza, in preparation). Morrison's (1975) assignment of this species to the Mississippi basin and western Gulf drainage genus *Leptodea* (Paper Shells) is in error (Bereza and Fuller 1975). The vernacular name that we have chosen for this mussel refers to its optimal habitat and to the fact that in the Mississippi basin "Mucket" is commonly applied to shells of *Lampsilis* and of members of genera that conchologically resemble that genus (Coker 1915). An alternative name, Ocher Lamp Mussel, proposed by Emerson and Jacobson (1976), refers to an ordinary color of the shell and to the presumed etymology of *Lampsilis* (but see Rafinesque 1820, and Lindahl 1906).

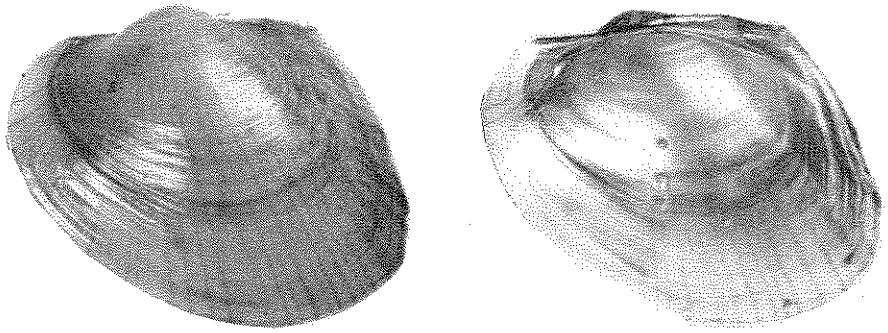

Figure 10. Lateral views of the shell of a juvenile female Waccamaw Mucket, *"Lampsilis" ochracea*. Lake Waccamaw, Columbus County. Actual length 31 mm. Compare with Figure 11, a mature female from a riverine population.

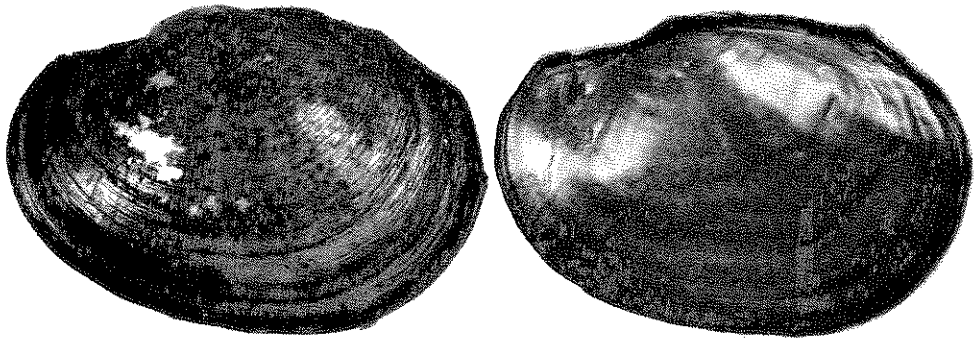

Figure 11. Lateral views of the shell of an adult female *"Lampsilis" ochracea* from the Chowan River, Gates County. Actual length 75 mm. Compare with the juvenile female from a lacustrine population above.

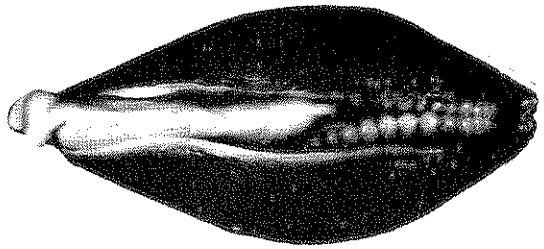

Figure 12. Ventral view of a gravid female *"Lampsilis" ochracea* from the Chowan River population. Actual length 71 mm. The charged marsupia of both gills are conspicuous within the posterior portion of the mantle cavity (compare with Figures 5 and 6). Note the absence here of the broad, papillose, and usually highly pigmented postbasal mantle margin (commonly bearing a "ribbon" of tissue) which is characteristic of the *radiata* group. Note the foot and incurrent mantle aperture (see Figure 5), and the fewer, more discrete portions ("ovisacs") of the marsupium in comparison with the marsupium in Figure 6.

References: Burch (1973, 1975b), Clarke and Berg (1959), Emerson and Jacobson (1976), Johnson (1970), Ortmann (1919); see list following introduction.

Bereza, D. J., and S. L. H. Fuller. 1975. Notes on *"Lampsilis" ochracea* (Say)(Mollusca: Bivalvia). ASB Bull. 22:42. Abstract.

Coker, R. E. 1915. The common and scientific names of fresh-water mussels. U. S. Bur. Fish., Econ. Circ. No. 15:1-4.

Johnson, R. I. 1947. *Lampsilis cariosa* Say and *Lampsilis ochracea* Say. Occas. Pap. on Mollusks 1:145-156.

Lindahl, J. 1906. Orthography of the names of the Naiades. J. Cincinn. Soc. Nat. Hist. 20:235-243.

Morrison, J. P. E. 1975. Maryland and Virginia mussels of Lister. Bull. Amer. Malacol. Union Inc. 1974:36-39.

Rafinesque, C. S. 1820. Monographie des coquilles bivalves fluviatiles de la rivière Ohio, contenant douze genres et soixante-huit espèces. Annales Generales des Sciences Physiques 5:287-322.

Villosa constricta (Conrad) NOTCHED RAINBOW

Remarks: This is a small species, rarely achieving 38 mm (1 1/2 in.) in length, with usually black periostracum and pronounced sexual dimorphism. The posterior end of the female shell is constricted, pinched, or notched -- hence the specific epithet and the vernacular name. This character is unique among Atlantic drainage naiades. Good figures occur in Johnson (1970) and Burch (1973, 1975b), and these publications also permit facile separation of the Notched Rainbow from other, sympatric *Villosa*. This species ranges from the Santee-Cooper system into the James system of Virginia, and there are numerous records for North Carolina (Johnson 1970). These are scattered, however, and, while *V. constricta* is hardly a rare animal, it is not common and is seldom plentiful. Because of these data and because of extant and proposed waterway modifications in North Carolina we consider the Notched Rainbow of *Special Concern* here. Nothing is known of its reproduction. The favored habitat is a clean, sand floor among rocks in the shallows of a smaller, often upland stream, though it will occur in rivers and in mud.

References: Burch (1973, 1975b), Johnson (1970); see list following introduction.

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The seven species considered below are of *Undetermined* status because so little is known about them, either in general or in North Carolina. Further knowledge will probably necessitate assigning some of them otherwise, doubtless to categories of greater jeopardy in some cases.

GASTROPODA; MESOGASTROPODA; PLEUROCERIDAE (Riversnails)

Spirodon dilatatum (Conrad) KANAWHA RIVERSNAIL

Remarks: Like almost all Pleuroceridae, the genus *Spirodon* is in taxonomic confusion and has received little or no attention since Tryon's (1873) monograph and Goodrich's work (catalogued by Rosewater 1959). This situation will be greatly remedied by two forthcoming studies, a monograph of *Spirodon* and a catalogue of the Pleuroceridae, both by W. J. Clench, who has provided most of the information on which this account is based. The Kanawha Riversnail occurs in the Kanawha and Monongahela River drainages of the Ohio River sub-basin and, in North Carolina, is known from at least four localities in the New River drainage, in Alleghany, Ashe, and Watauga counties. A proposed dam across the New River that would create Moores Ferry Lake in Grayson County, Virginia, and Alleghany County, North Carolina, would surely destroy most if not all populations of fluviatile mollusks that it affected, including this species, which requires rapidly moving, well oxygenated water over a rocky substrate. However, the Ashe and Watauga county populations of the snail should not be harmed by this project. Accordingly, although the Kanawha Riversnail has been listed as *Endangered* in North Carolina (DNER 1973), it probably does not warrant any rank beyond *Undetermined*. Further research into the geographic and ecologic distributions, as well as the population structures, of North Carolina and other *S. dilatatum* would be rewarding, and might reveal that it is in greater jeopardy at state and/or national levels than we know. Such investigation, unfortunately, would be immediately impeded by difficulty in identifying this animal. In North Carolina it is readily confused with its Atlantic drainage counterpart, *S. carinata* (Brugière), which ranges from the upper Pee Dee River basin in North Carolina northward into the Susquehanna basin in Pennsylvania. Each of these two species is so conchologically variable that to illustrate either in a manner less than monographic is pointless and misleading. Refer to Clench's forthcoming monograph, and to Tryon's (1873) account of *"Anculosa" dilatata*. The rationale for the vernacular name, Kanawha Riversnail, should be clear from the foregoing remarks.

References: DNER (1973), Tryon (1873); see list following introduction.

Rosewater, J. 1959. Calvin Goodrich; a bibliography and catalogue of his species. Occas. Pap. on Mollusks 24:189-208.

GASTROPODA; STYLOMMATOPHORA; ENDODONTIDAE
(Endodontid Land Snails)

Anguispira paucicostata Kutchka — MOUNT MITCHELL SNAIL

Remarks: This is a great rarity that is known only from Mount Mitchell, North Carolina, and may be extinct. In any case, it should be sought assiduously in an effort to clarify its status and to resolve relevant taxonomic problems. The species may be only a "freak" representative of some other member of this genus, but it appears to be valid. It may be anticipated on logs, in ravines, and in and on talus at night after rain, when snails are commonly most active. Pilsbry (1948) figured this snail, and his work must be consulted in any effort to distinguish this species or morph from its congeners. It has twice been listed as *Endangered* (DNER 1973, Hubricht 1972). Derivation of the vernacular name used here should be obvious from the previous remarks. Every North Carolina naturalist can be excited by the mystery that surrounds the Mount Mitchell Snail, which is perhaps the rarest of zoological oddities in the state. The person is to be congratulated who next finds this snail alive, damages no living specimens, and reports the discovery in a responsible fashion.

References: DNER (1973), Hubricht (1972), Pilsbry (1948); see list following introduction.

GASTROPODA; STYLOMMATOPHORA; POLYGYRIDAE
(Polygyras, Helices, and relatives)

Mesodon archeri Pilsbry — CHEROKEE HELIX

Remarks: The Cherokee Helix is admitted to this report on the strength of its probable occurrence in North Carolina. It was originally described from nearby Polk County, Tennessee. The species was figured by Pilsbry (1940) and Burch (1962). Little or nothing has been published in regard to its natural history. The rationale behind our status assignment should be clear in view of these remarks. Equally obvious is the necessity of research into its biology, including its presence or absence in this state. Our common name for the species introduced in this report is in respect for the Cherokee Nation, which included the region inhabited by the Cherokee Helix. The species has elsewhere been listed as *Endangered* (Hubricht 1972).

References: Burch (1962), Hubricht (1972), Pilsbry (1940); see list following introduction.

Mesodon orestes Hubricht — AVENGER HELIX

Remarks: Almost nothing is known of this species, recently described and illustrated by Hubricht (1975). The type and apparently only known locality is Waterrock Knob, Blue Ridge Parkway, Haywood County, North Carolina, at an elevation of 1,860 m (6,200 ft.). The status of the Avenger Helix will probably adjust upward once more is learned about

it. The vernacular name refers to the attributes of Orestes, a mountain-dwelling figure in Greek mythology who avenged the murder of his father, Agamemnon, by slaying his mother, Clytemnestra, and Aegisthus.

Editor's Note: There is probably no sadder story in the annals of molluscan lexicography.

References: Hubricht, L. R. 1975. Four new species of land snails from the eastern United States. Nautilus 89:1-4.

BIVALVIA; HETERODONTA; UNIONIDAE
(Fresh-water Mussels)

Alasmidonta triangulata (Lea) TRIANGLE FLOATER

Remarks: This Floater was not recorded from North Carolina by Johnson (1970). Its inclusion in this report depends upon Fuller's (1971) record of a single juvenile *Alasmidonta* of debatable identity from the Cape Fear River near Fayetteville, Cumberland County. The interested student is hereby alerted to the possible presence of the Triangle Floater in this state. It is known in the Atlantic drainage from the Ogeechee, Savannah, and Santee-Cooper river systems in Georgia and South Carolina. Its detection in North Carolina will depend on distinguishing it from the closely related *A. undulata* (Say), which, according to Johnson (1970), ranges from the Santee-Cooper system northward through the Atlantic drainage into southern Canada. In addition to Johnson's monograph, aids in the identification of the Triangle Floater are Burch's manuals (1973, 1975b). Almost nothing is known of the natural history of *A. triangulata*. The two specimens recorded by Fuller (1974b) from the Savannah River were taken in muddy sand beneath less than 61 cm (2 ft.) of water. There can be no doubt that this species is naturally a great rarity, and its prospects for survival are poor, considering these forbidding points of view: "rare and endangered" in the eastern Gulf of Mexico drainage (Athearn 1970); "rare and endangered" (Stansbery 1971); "rare and endangered" in South Carolina (Nature Conservancy 1975); and "rare throughout entire range and in danger of extinction" (Heard 1975). It is probable that the Triangle Floater is presently represented by so few individuals that research in the interest of conservation is by now out of the question. The only hope is that relaxation or elimination of point- and non-point-source stresses might promote a resurgence of the species. Although logically of *Undetermined* status in North Carolina, this species is assuredly *Endangered* in the nation.

References: Burch (1973, 1975b), Fuller (1974b), Heard (1975), Johnson (1970), Stansbery (1971); see list following introduction.

Athearn, H. D. 1970. Discussion of Dr. Heard's paper. In: A. H. Clarke, Jr. (Ed.). Papers on the rare and endangered mollusks of North America. Malacologia 10:28-31.

Fuller, S. L. H. 1971. Macroinvertebrates (exclusive of insects). In: Cape Fear River surveys 1969-1970 for E. I. duPont de Nemours & Company. Dept. Limnol. Acad. Nat. Sci. Phila., Philadelphia, PA. pp. 28-37, 105-107.

Nature Conservancy, The. 1975. Rare and endangered species of South Carolina. The Nature Conserv., Arlington, VA. 41 pages.

Anodonta implicata Say ALEWIFE FLOATER

Remarks: The Alewife Floater ranges from southern Canada southward in the Atlantic drainage into the Potomac River basin in the District of Columbia (Johnson 1970). This was the accepted range of this species until R. M. Shelley (pers. comm.) collected and correctly verified the identity of a specimen from the upper Cape Fear River basin in North Carolina. Nothing else is known about the Alewife Floater in the state, but a few additional points may help with research into this species. Useful aids in identification include Ortmann (1919), Johnson (1946, 1970), Clarke and Berg (1959), Burch (1973, 1975b), and Emerson and Jacobson (1976). The species can be confused only with *A. cataracta* Say, the Pond Floater, with which it is often sympatric, but the former can be distinguished by its typically much thicker and heavier shell with coppery nacre, uniformly dark periostracum, and greatly thickened anteroventral margin. Largely confined to lower portions of river systems, *A. implicata* has a characteristic distribution, much like the Tidewater Mucket discussed earlier in species of *Special Concern*. This distribution probably depends on the migratory habits of the Alewife, *Alosa pseudoharengus* (Osteichthys; Clupeidae), which is the mussel's dominant glochidial host in nature (Johnson 1946). Davenport and Warmuth (1965) implicated several other species during laboratory experiments. The relationship between the Alewife and its Floater is an especially graphic example of the almost universal and utter dependence of mussels on fish. Specifically, recent resurgence of *A. implicata* and local domination by this species of the formerly much more plentiful *A. cataracta* in the Connecticut River system, Hartford County, Connecticut, may be correlated with increasingly successful Alwife runs resulting from improved water quality (Fuller, unpub.). Clearly, the Alewife Floater can reproduce with great success in favorable circumstances, but, with the exception that it appears to be bradytictic (Johnson 1946, 1970), nothing further is known about its reproduction. The derivation of the vernacular name should be obvious. An alternative name, Confused River Mussel, is available (Emerson and Jacobson 1976); the reference is to the Latin *implicatus*, "confused".

References: Burch (1973, 1975b), Clarke and Berg (1959), Emerson and Jacobson (1976), Johnson (1970); see list following introduction.

Davenport, D., and M. Warmuth. 1965. Notes on the relationship between the freshwater mussel *Anodonta implicata* Say and the alewife *Pomolobus pseudoharengus* (Wilson). Limnol. & Oceanogr. 10:R74-R78.

Johnson, R. I. 1946. *Anodonta implicata* Say. Occas. Pap. on Mollusks 1:109-116.

Ortmann, A. E. 1919. A monograph of the naiades of Pennsylvania. Part III. Systematic account of the genera and species. Memoirs Carnegie Mus. 8:1-384.

Elliptio sp. FILE SPIKE

Remarks: This indeterminate (and perhaps new) species is known from the very large Lake Waccamaw population, and would be considered officially *Endangered* by this Committee were there not another, conchologically similar form common in Orton's Pond near Wilmington, New Hanover County, which is quite safe at present. Lacking further information, we interpret the File Spike as of *Undetermined* status for the moment. At least the Lake Waccamaw population (Figure 13) can be separated from sympatric *Elliptio* by its yellow-brown periostracum, subrectangular outline, and raised growth rests (file-like to the touch), to which the common name refers. Nothing further is known of this animal's natural history. It can be confused with *Uniomerus tetralasmus*, but the latter has arborescent papillae at the incurrent aperture and none at the excurrent (Fuller 1971), whereas any *Elliptio* has simple papillae at both. References in aid of identifying *U. tetralasmus* are provided in the account of *Fusconaia masoni*, a *Threatened* species discussed earlier.

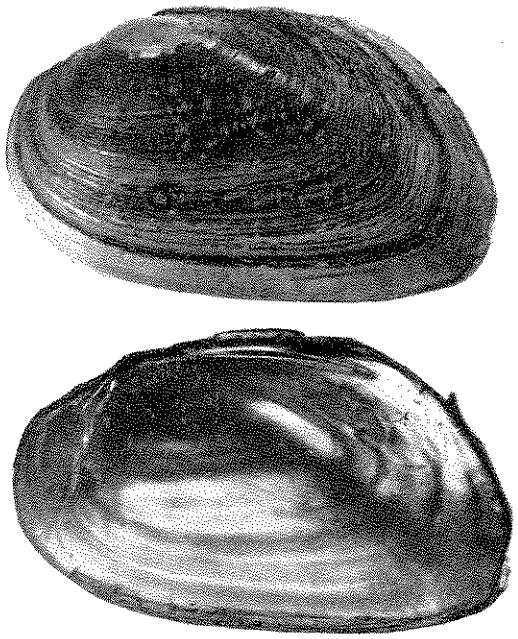

Figure 13. Lateral views of a shell of the File Spike, a taxonomically indeterminate member of the genus *Elliptio*. Lake Waccamaw, Columbus County. Actual length 39 mm. Note the well developed, rather evenly spaced periostracal ridges, which lend this morph its vernacular name.

References: Fuller, S. L. H. 1971. A brief field guide to the fresh-water mussels (Mollusca: Bivalvia: Unionacea) of the Savannah River system. ASB Bull. 18:137-146.

Ligumia nasuta (Say) EASTERN PONDMUSSEL

Remarks: The name "Pond Mussel" is widely used for *Ligumia subrostrata* (Say) of the Mississippi basin and western Gulf drainages. It is equally appropriate for the Atlantic drainage taxon, *L. nasuta*. The two nominal species are often considered conspecific, but, now that Bereza et al. (1976) have demonstrated soft-tissue discriminations between them, it has become practical to entertain two vernacular names, the Western and Eastern Pondmussels, respectively. Johnson (1970) recorded the eastern species from the Great Lakes and St. Lawrence River system southward into the James River system of Virginia, but, on the basis of soft-tissue evidence, M. J. Imlay and S. L. H. Fuller verified R. M. Shelley's (pers. comm.) record of shells of *L. nasuta* from the tidal Chowan River near Eure, Gates County, North Carolina. Because this is the only record of this species from the state, and because it is also very likely to be more widespread, it is reasonably considered as of *Undetermined* status. Further records may be forthcoming only slowly because the Eastern Pondmussel is easily confused with certain morphs in the group of *Elliptio lanceolata* (Figure 12). Separation, however, is facilitated by the strongly pigmented and weakly papillose postbasal mantle margin of *Ligumia*, as opposed to the absence of such features from *Elliptio* (compare Figures 13 and 18). Like the Tidewater Mucket and the Alewife Floater, the Eastern Pondmussel is a characteristic species of lower parts of river basins, including tidal regions, although it commonly occurs much farther upbasin than do these other two species (e.g., see Smith 1974). The presumption that such distribution does not indicate glochidial parasitism on an anadromous host fish is strengthened by the fact that Lefevre and Curtis (1912) recorded only certain non-migratory fishes of the family Centrarchidae as hosts for *L. subrostrata*. In spite of the Eastern Pondmussel's distributional success, it is seldom abundant, especially in fluviatile bodies of water. However, its habitat predilections are catholic. In addition to Johnson's (1970) illustrations, Emerson and Jacobson (1976) figured *L. nasuta* and added a common name, Nose Mussel, the reference being to the Latin *nasutus*, "having a large nose."

References: Emerson and Jacobson (1976), Johnson (1970); see list following introduction.

Bereza, D. J., M. F. Vidrine, and S. L. H. Fuller. 1976. Anatomical differences between *Ligumia nasuta* (Say) and *L. subrostrata* (Say) (Mollusca: Bivalvia: Unionidae). ASB Bull. 23:43. Abstract.

Lefevre, G., and W. C. Curtis. 1912. Studies on the reproduction and artificial propagation of fresh-water mussels. Bull. U. S. Bur. Fish. 30:105-201. Separately issued as Bur. Fish. Doc. No. 756.

Smith, D. G. 1974. The mollusca of the Mill River system: its [their] systematics, ecology and Recent distribution. Paper for Zool. 385 (Special Problems), Univ. Massachusetts, Amherst, MA. 148 pages.

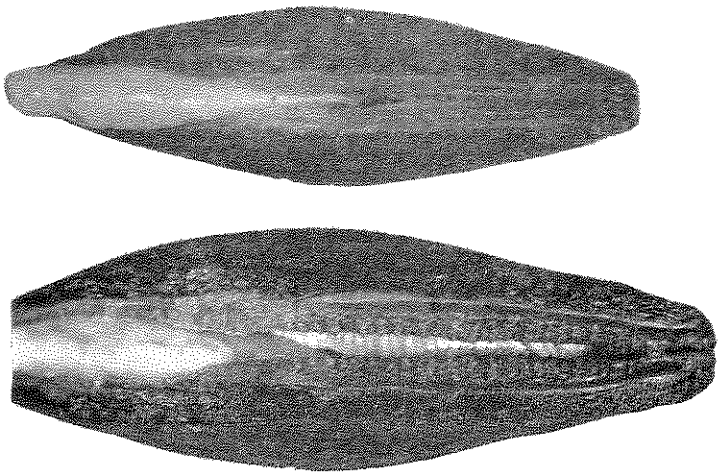

Figure 14. Ventral views showing the postbasal mantle margins of a male (above) and a female (below) Eastern Pondmussel, *Ligumia nasuta*, from the Chowan River, Gates County. Actual lengths ca. 90 mm. The whitish mass within the mantle cavity of the female is the charged marsupium of the left gill. Compare it, plus the broad, darkly pigmented, and papillose mantle margin (especially well developed in the female), to analogous aspects of other lampsilines (Figures 5, 6, and 12). Note, also, the absence of such features from even the conchologically similar members of the genus *Elliptio* (Figures 8 and 9).

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Discussion

Frank Barick: I wonder if you would comment further on the nature of the factors that might adversely affect these mussels in the Cape Fear River, particularly, as well as the Tar. Would channel dredging operations have any effect on the critters?

Fuller: Yessir, all channel work of any kind whatsoever, no exceptions, will have adverse impact, not just on the mussels but on other benthos as well. Other problems that I didn't mention are associated, for instance, with dams, artificial tides, long term changes in water level -- irregular, unpredictable, violent oscillations, commonly -- cold water, anoxic water, and sedimentation problems which exist already because of agrarian practices. I could go on and on, in addition to the one or two that I alluded to during the course of the talk. I hope that responds to you adequately, for the moment.

Susan Bondurant: Could you tell me how, if anyone knows, the Chinese clam gets introduced into waters such as these? Or have there been any studies done on other times when the Chinese clam has come in and crowded out the indigenous species?

Fuller: There is very little, if any, direct evidence that the Chinese clam outcompetes the other critters there. There is a lot of circumstantial evidence to this effect, however. I don't know of any experimental evidence. There have been many studies done on the clam, but none of them has come to grips with either question that you raise. We don't know for sure how they are introduced. We have circumstantial evidence that suggests various things, but we do not know.

Bondurant: I'm sorry, I may be naming the slide wrong. But, I thought I heard you say that it has been known to crowd out indigenous species. This is the small, yellow one . . .

Fuller: Yes, I follow you. I tried not to be so positive about that. I intended to say "it is thought to" or "there is circumstantial evidence that". If I spoke more positively that was a mistake on my part.

Bondurant: Well, the reason for my question -- I was thinking it would be a smart developer that put a couple down in a lake, to get rid of some of our . . .

Fuller: Well, yeah, yeah, that's a fiendish possibility. May even be true. He could have got them at 'most any aquaria shop. They are being, unfortunately, widely disseminated in the aquarium trade. That's one way they get around.

Ed Menhinick: With the interest in control of *Corbicula*, would it perhaps be worthwhile to study its ecology in its native land, with particular regard to population control in hopes that some predator or something might be discovered?

Fuller: I think that would be wonderful. There are two objections to that idea. Number one, we're not absolutely sure of what its native land is. It wound up on the west coast in the '30's. First wild population was discovered on the west coast about 1938. It probably escaped from live food markets. We don't know that for sure, and we don't know where the first populations came from. We don't know that all *Corbicula* in this country are indeed *manilensis*. We are operating in the dark. Second problem is that if any of these fatherlands, one or more, are in the hands of Communist political systems, we're probably not going to get a chance to go in there and do very much research.

Jerry Deakle: How extensive is the problem with mollusks throughout eastern North Carolina with respect to the rivers and larger bodies of water?

Fuller: I would say that there's probably no single body of water anywhere in the United States that is not under some kind of adverse pressure owing to man's activities. I cannot speak for every single river system in this state, unfortunately. I haven't worked them all; I fear nobody has. The problems are more extensive, though, I guarantee you, than can be inferred from the few examples I've thrown up here on the screen, and my remarks about them. That's a rotten answer and I don't know -- you'd have to ask me more detailed questions, and I invite you to do so subsequently. Be happy to talk.

Tom Quay: Vince Bellis, you work in the freshwater systems of eastern North Carolina. You got any comment on that?

Vince Bellis: I was thinking of asking a question, because I know the Tar River. I'm a botanist; I was impressed by the fact that all these clams pretty much looked alike to me. And then I began to wonder -- we are planning on talking to our local legislator about some of these problems, and I was, in my mind, wracking my brain for a way to convince this legislator that these things are worth anything except that maybe the Indians ate them 200 years ago. Maybe, if you could, give us some advice as to what to say to this man.

Fuller: Hmmm. Well, *we* probably look pretty much alike to the clams. It's a matter of developing an oriented, experienced acuity of vision in this area. As you know perfectly well as a botanist, you can't imagine the mosaic that confronts me whenever I walk along a roadside. I can't . . . well, never mind, I'm not a botanist. Seriously, though, that is a very practical and pressing problem and I believe that this country needs to make these kinds of data, identities, concepts, part of public education from the ground up. I don't see any reason why it can't be done. We need better trained eyes, all of us. More specifically, law enforcement personnel are going to have to be radically educated. They're going to have to become, man and woman, as good as I am at picking these things up. They're going to have to, and its not just clams. This would be true of all the creatures, fishes and plants and what not. Otherwise, we can pass thousands of laws and they're still going to keep slipping through our fingers down the tubes because nobody out there knows what to protect

and what not to. Another pretty generalized answer.

Bondurant: I have a specific comment, Vince, in reference to that. The same argument used awhile ago in regard to plants can be used with your legislator, being that, even though they may look alike, their secretions are different just as ours are different, and it may be one of these very mollusks' secretion that furnishes us the cure for cancer. Who knows? Throw that out to him and see what he says.

Marc Imlay: The fact is that mollusks rarely get cancer. They have already isolated a cancer-inhibiting drug from one genus.

Editor's Note: For a recent discussion of "cancers" in mollusks, see: Scarpelli, D. G., and A. Rosenfield (Eds.). 1976. Molluscan Pathology. Marine Fisheries Review 38(10):1-50. It is also pertinent to Dr. Imlay's comment that two United States institutions have recently committed a total of over $116,000 for the study of an unidentified substance in the liver of clams which is known to retard tumor growth in mammals (BioScience. 1977. 23:229).

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[1]Rowland M. Shelley provided the following additional information on *Corbicula* which, unfortunately, could not be assembled until after the camera-ready copy had been completed: "*Corbicula manilensis* is known from the following North Carolina bodies of water: Lake Norman (Duke Power Co., pers. comm. from John S. Garton); Lake Wylie (Lemat, D. R., and C. M. Weiss. 1973. Distribution of benthic macroinvertebrates in Lake Wylie, North Carolina-South Carolina. Publ. No. 331 Dept. Environ. Sci. Engrg., Sch. Public Health, Univ. North Carolina, Chapel Hill, NC); Cape Fear River near crossing of NC hwy. 42 on Lee-Chatham Co. border near Corinth (Carolina Power & Light Co., pers. comm. from R. Hobbs); and a closed system cooling lake at the Louis V. Sutton Plant on US hwy. 421 north of Wilmington, New Hanover Co. (CP&L Co., pers. comm. from R. Hobbs). Thus, *Corbicula* is established in the Catawba, Cape Fear, and Waccamaw river systems. It was first discovered in Lake Norman three to four years ago and has since increased tremendously. Its presence in the Sutton Plant lake, which is close to the lower Cape Fear River, and in the river itself near Corinth, implies that it may occur in the entire Cape Fear River below NC highway 42."