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The Changing Molluscan Community

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Commencing in 1956, personnel of the Division of Limnology and Ecology at the Academy of Natural Sciences of Philadelphia have conducted environmental surveillance of the middle Potomac River on behalf of the Potomac Electric Power Company (Pepco) and its steam electric station (SES) at Dickerson, Montgomery County, Maryland. The study area and sampling points are figured by Roback (1978). In this account the expression "study area" is defined as the Potomac River reach thus figured and studied by the Academy.

The present narrative concerns the non-insect component of the macroinvertebrate animals in the study area. For the purpose of a rather brief review, this component is phyletically and prohibitively diverse. Consequently, the clams and snails (Mollusca: Bivalvia and Gastropoda, respectively) have been chosen to represent the lot. The choice is otherwise well advised because the mollusks are a most species-rich element of the fresh-water macrobenthos and because they offer a wide variety of environmental adaptations. Their ecological intricacies illustrate numerous aspects and themes of symbiosis (predation, parasitism, nutrition, reproduction, etc.) that must be considered during any attempt to interpret an ecosystem.

Methods and Procedures

Most molluscan samples were collected by eye and hand, but the Needham scraper has been a helpful tool where the riverbed is muddy, and a heavily framed dipnet has been used to sweep submerged vegetation, deadfall, woody trash, undercut banks, etc. Either instrument is thrashed about in the river in order to free its contents from sediment, whereupon the cleansed material is dumped into a neutrally colored pan, where it is sorted in a little habitat water.

In the early years of Academy surveillance, samples were killed and stored in alcohol, but, given the advances in malacological preservation technique (*vide,* e.g., Runham *et al.,* 1965), our investigations now attempt to realize voucher material of lifelike appearance. Specimens are anesthetized, fixed, then "graded up" through increasing concentrations of ethanol into a storage strength of 70 percent by volume. Tissue fixation occurs in formalin of not more than 5 percent by volume (local tap water is the solvent in both fluids). Stupefaction is caused by menthol crystals thinly sprinkled over habitat water (in the case of pulmonate snails) or by sodium nembutal in water (bivalves and operculate snails).

Specimens vouching for these samples are housed among the records collections in the Invertebrate Zoology Section of the Division of Limnology and Ecology at the Academy of Natural Sciences of Philadelphia. Exceptions are "sight records," for which no voucher material exists. There are many reasons that can lie behind a "sight record": loss of sample, failure to secure one, etc., but during recent years the primary reason has been refusal to take samples. Academy investigators have grown more proficient at taxonomic identification in the field, and sampling a dwindling population, especially of taxonomically unequivocal organisms, is contemptible. The latter point is relevant to fresh-mussels, in particular, which are almost exterminated in the study area. At least the spirit of Public Law 93-205 (The Endangered Species Act of 1973) has been respected.

Identification of macroinvertebrate materials has proceeded in accord with the better taxonomic references of the day. The nomenclature and species concepts on which these taxonomic determinations are based are specified below.

The science and art of taxonomy evolve, but can always be revised, whereas another source of possible error, changing field and laboratory investigators, cannot. I am responsible for most data generated during and since 1965, but this narrative owes much to the efforts of F.A. Aldrich, J.M. Bates, C.F. Burgoon, J.B. DeWolf, R.R. Grant, Jr., F.E. Krueger, J.W. Richardson, C.W. Reimer, S.S. Roback, and C.B. Wurtz. These investigators and I have offered variable responses to such problems as taxonomic expertise, collecting capability and preference, etc.

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The different strengths of the various collectors surely have created some inconsistency over the years, but this difficulty, always minor, is now negligible because the study area non-insect macroinvertebrate fauna, especially the molluscan portion, is reduced to a core of animals that are tolerant of environmental disturbances and that are almost ubiquitous in time and space in this part of the Potomac. Indeed, this is the primary theme of the present account, which has two additional goals. One is evaluation of the contribution of thermal effluent to the degradation of this fauna. The second is communication of certain more important aspects of the natural histories of these organisms.

Molluscan Taxa

Fresh-Water Mussels (Bivalvia: Unionidae)

Mussels exhibit a symbiotically complex life cycle (Fuller, 1974), which includes an ordinarily obligate and brief period of dependence upon vertebrate hosts, where the larvae (glochidia) are parasitic. With only a single exception known in North America, the host invariably is a fish. Therefore, disruption of the ichthyofauna usually jeopardizes the mussel community, as well, by removing some or all of the only means that mussels have for reproduction and vagility. The relationship between mussel and fish is a classic example of the situation wherein plucking one string in the food web makes another string reverberate adversely elsewhere. Sadly, we do not even know the identity of so much as one host for most of the mussels in the study area. Any relevant information beknownst to me is included in the species discussions below. Such data are offered as aids in improved conservation and management of the fish and mussel resources and as a stimulus for further research into this essential area of knowledge.

The fishes, also, benefit by their symbioses with mussels. Glochidial infection is thought to induce in fish an immunity to "anchor worms" (Lernaeidae), a group of parasitic copepod crustaceans, which, especially in epidemic proportions, can be debilitating to the hosts (Wilson, 1916). (Now that the mussel fauna is almost gone, can anchor worm outbreaks be expected in the study area?) In a geographically parochial study, Tedla and Fernando (1969) realized data that counter Wilson's conclusions. Here is an opportunity for valuable research.) Another value of mussels to fish is nutritional, although this example is weakened by the current state of the mussel community. Many hosts are infected while feeding on expelled glochidia, and juvenile mussels, in particular, are eaten by bottom-feeding fishes. Not only the fish, but also the entire food web, profits by the presence of mussels, whose filter-feeding mode cleanses the water. Finally, the ecosystematic values of mussels are intensified by the great biomass and large number and variety of individuals in a thriving community.

The need for identification of Potomac basin mussels is met by Burch's (1973, 1975b) and Johnson's (1970) monographs. With the exception of *Lampsilis ventricosa cohongoronta* (Ortmann, 1912), their nomenclature and species concepts are used in the following accounts.

Elliptio complanata

The Common Spike (Fuller, 1977) is the "weed" mussel of the Atlantic drainage, where it is ecologically and geographically almost cosmopolitan. Old specimens can still be found in the study area. Farther below in the basin, as above the Great Falls of the Potomac (J.B. DeWolf, personal communication), *E. complanata* remains abundant. Recorded hosts are the Yellow Perch (Percidae), *Perca flavescens* (Mitchill) (Lefevre and Curtis, 1912; Matteson, 1948), and the Banded Killifish (Cyprinodontidae), *Fundulus diaphanus* (Lesueur) (Wiles, 1975).

Elliptio lanceolata

This identification conforms to Johnson's (1970) concept of the (Fuller, 1977) Yellow Lance, which, however, is surely a composite of two or more species. The epithet *lanceolata* is probably best applied to certain southern populations. The correct name(s) for Potomac basin representatives of the *lanceolata*-complex remain(s) moot. This Lance has been an unimportant species in the study area, where it has been encountered only once. More recently (1968), I found a few specimens in the Monocacy River where there was far less sediment than in the lower reaches of the Monocacy and the Potomac Rivers today. On the other hand, sediment is perhaps inaccurately implicated in the rarity of *E. lanceolata:* I know of flourishing Lance populations in heavily silted tidal creeks on the Eastern shore, for example. More probable is that this species was always naturally rare in the study area, perhaps because of host fish unavailability. Unfortunately, the host fish for this Lance is unknown (Fuller, 1974).

Lasmigona subviridis

The Green Floater (Fuller, 1977) is very tolerant of silation. During the last decade it has declined in the study area, but juveniles (reflecting successful recruitment) are still encountered. No glochidial hosts are recorded for *L. subviridis* (Fuller, 1974), but Lefevre and Curtis (1910, 1912) identified certain centrarchid and cyprinid fishes as hosts of certain at least nominally congeneric Mississippi basin mussels. Kakonge (1972) has recently tabulated five fishes as hosts of *L. compressa* (Lea), a possibly sybling species: Common Shiner, *Notropis cornutus* (Mitchill); Fathead Minnow, *Pimephales promelas* Rafinesque; Creek Club, *Semotilus atromaculatus* (Mitchill) (*all* Cyprinidae); Brook Stickleback, *Culaea inconstans* (Kirtland) (Gasterosteidae); and Rock Bass, *Ambloplites rupestris* (Rafinesque) (Centrarchidae). The available evidence strongly suggests that the investigator who is interested in identifying hosts of the Green Floater should concentrate initially upon the Cyprinidae, several of whose members are known from the study area (J.J. Loos, personal communication).

Alasmidonta varicosa

The Brook Floater (Fuller, 1977) is usually a peculiarity of small upland streams and is out of its element in the study area, where it has been recorded just once. This species has some tolerance of silt and favors riffles, so its rarity in the study area is probably caused by few or no suitable glochidial hosts. None is known (Fuller, 1974), but a sybling species, *A. marginata* (Say) of the Mississippi basin and the upper Susquehanna River basin in the Atlantic drainage, has several recorded hosts (Howard and Anson, 1922): White Sucker, *Catostomus commersoni* (Lacepede); Northern Hog Sucker, *Hypentelium nigricans* (Lesueur); Shorthead Redhorse, *Moxostoma macrolepidotum* (Lesueur) (*all* Catostomidae); *Ambloplites rupestris*; and Warmouth, *Lepomis gulosus* (Cuvier) (*both* Centrarchidae).

Anodonta cataracta

Next to *Elliptio complanata* (above), the Pond Floater (Fuller, 1977) is the most abundant and commonly encountered mussel of the northern Atlantic drainage and is the species that is most characteristic of impoundments and natural ponds. Understandably, *A. cataracta* has never been found commonly in the study area, with the noteworthy exception of a small colony that was discovered along the Virginia shore just downstream from the Dickerson SES during the late Sixties. The colony persisted until a few years ago, when it disappeared, probably because the river floor lost much of its sedimentary character at that point. Such physical factors are surely the cause of the poor success of this species in the study area, where congenial glochidial hosts are common enough (J.J. Loos, personal communication) to facilitate completion of the mussel's life cycle. Three fish hosts have been identified: *Catostomus commersoni* (Wiles, 1975); Carp (Cyprinidae), *Cyprinus carpio* Linnaeus (Lefevre and Curtis, 1910); Pumpkinseed (Centrarchidae), *Lepomis gibbosus* (Linnaeus) (Conner, 1905). Wiles (1975) implicated three more species: Threespine Stickleback, *Gasterosteus aculeatus* (Linnaeus); Fourspine Stickleback, *Apeltes quadracus* (Mitchill); and Ninespine Stickleback, *Pungitius pungitius* (Linnaeus) (*all* Gasterosteidae). The concerned experimentalist initially might usefully be guided by a knowledge of the hosts of a presumably sybling species, *Anodonta grandis* (Say) of the St. Lawrence River basin and the Interior Basins of the United States and of Canada (see Kakonge (1972) and Fuller (1974)).

Strophitus undulatus

The Strange Floater is that rarity amongst fresh-water mussels whose glochidia can facultatively metamorphose without parasitism (See Fuller, 1974). Fish hosts are known: *Semotilus atromaculatus* (A.D. Howard, *teste* R.L. Barney *in* Baker, 1928); *Fundulus zebrinus* Jordan and Gilbert (Cyprinodontidae), Rio Grande Killifish (Ellis and Keim, 1918); *Lepomis cyanellus* (Rafinesque); Green Sunfish (*ibid.*); and *Micropterus salmoides* (Lacépède), Largemouth Bass (Howard, *op. cit.*) (*both* Centrarchidae).

Ligumia nasuta

The Eastern Pondmussel (Fuller, 1977) is an Atlantic drainage species that is characteristically restricted to tidewaters. It is not expected in the study area and, in fact, was found there only once. Glochidial hosts of a nominal congener, *L. subrostrata* (Say) of the Mississippi basin and the Gulf drainage are known (Lefevre and Curtis, 1912), but none is suspected for *L. nasuta* except *Fundulus diaphanus* (D.J. Bereza, personal communication), itself an essentially tidewater fish.

Lampsilis ventricosa cohongoronta

As elsewhere in the Atlantic drainage (see Johnson, 1970), the Yellow Mucket (Fuller, 1977), *L. cariosa* (Say), was the only representative of its genus in the Potomac basin for millenia—until around the turn of the century, when the Pocketbook (Coker, 1915), *L. ventricosa* (Barnes), was introduced, probably as glochidia encysted on fish (Ortmann, 1912). The latter species spread widely and successfully at the expense of the former (Marshall, 1917, 1918, 1930), which apparently is now exterminated throughout much (and perhaps all) of the basin. Mussels are sedentary creatures as adults and, presumably, cannot actively compete with one another except for hosts held in common. Nothing is known about the Yellow Mucket's (Fuller, 1974), but several host fish are identified for the Pocketbook (Coker, *et al.*, 1921; Lefevre and Curtis, 1912; Reuling, 1919; Wilson, 1916): Bluegill, *Lepomis macrochirus* Rafinesque; Smallmouth Bass, *Micropterus dolomieui* Lacépède; *M. salmoides;* White Crappie, *Pomoxis annularis* Rafinesque (*all* Centrarchidae); *Perca flavescens;* and Sauger, *Stizostedion canadense* (Smith) (*both* Percidae). It is probable that the introduction of *L. ventricosa* was mediated by one of these species and that *L. cariosa* failed in competition for one or more of them, several of which were introduced to the Potomac basin late in the Nineteenth Century (Smith and Bean, 1899).

Fingernail, Pill, and Pea Clams (Bivalvia: Sphaeriidae)

Because of their small sizes in comparison to the unionids, sphaeriid clams are recorded less frequently and with greater taxonomic uncertainty. Not even the fine monographs by Herrington (1962) and Burch (1972, 1975a) obviate all difficulties in identification. Burch's species concepts and nomenclature are employed below because they are adequate for discussion of the limited study area fauna. The following discussion is brief because, as a group, the Sphaeriidae are far more tolerant of environmental disturbances than are the Unionidae and thus are less valuable to the present inquiry.

Another advantage of Burch's (1975a) latter work is that it permits easy distinction between Nearctic Sphaeriidae and *Corbicula manilensis* (Philippi), the Asiatic clam. This species has a well deserved reputation as a competitor for space required by indigenous benthos. This and other aspects of the "*Corbicula* problem" are reviewed in such recent papers as Britton and Murphy (1977), Fuller and Goulden (1976), Gardner *et al.* (1976), Rodgers *et al.* (1977), and Sinclair (1971). Two especially important sources for forthcoming information are *The Nautilus* (edited by R. Tucker Abbott, Delaware Museum of Natural History, Greenville) and *Corbicula Newsletter* (edited by Jack S. Mattice, Oak Ridge National Laboratory, Oak Ridge, Tennessee).

Corbicula manilensis is unrecorded from the Potomac, but is has the basin bracketed because the Asiatic clam already occurs in the Delaware River (Fuller and Powell, 1973) to the north and the James River (Diaz, 1974) to the south. It is only a matter of time before *C. manilensis* appears in the Potomac basin. Such is its vagility that to suppose that the Fall Line at the Great Falls of the Potomac will arrest its upstream mobility is indefensible. The Potomac River is greatly modified by man, and there is evidence (e.g., Fuller and Imlay, 1976) that human activities enhance the spread of *Corbicula.* There can be little doubt that the Asiatic clam will reach the study area in due course—in which case there will be additional cause for concern because of further evidence (Fuller and Richardson, 1977) that *Corbicula* competes actively with fresh-water mussels, to their detriment.

The study area sphaeriid fauna has consisted of indeterminate pea clams, *Pisidium* sp(p?). and two fingernail clams, *Sphaerium simile* and *S. transversum.* All species but the last have been rare and environmentally unimportant in the area, but *S. transversum* is significant. This species has been ecologically, geographically, and numerically prevalent in the study area, and it remains one of the dozen-odd non-insect macroinvertebrate survivors. For about the last half-century *S. transversum* has been recognized as very tolerant of organic loading, siltation, and attendant environmental damage (Zetek, 1918; Fuller, 1974). This species' durability in a troubled study area is thus easily understood. In addition, it is one of the few Nearctic sphaeriids whose "biology of adversity" is somewhat chronicled, by Gale (1969, 1972, 1973, 1977) and Thompson (1973).

Gill-bearing Snails (Gastropoda: Mesogastropoda)

Because of the justified assumption that the fortunes of a gilled animal are inextricably tied to water quality, "prosobranch" (or "operculate") snails are, as a group, considered sensitive to adverse water quality. The generalization, however meaningful, is partially excepted by those of the study area's gill-bearing snails that are tolerant of organic load and silt problems that plague (or plagued) the Potomac.

Valvata tricarinata

Recorded once, this species has been a great rarity in the study area. My experience of *Valvata* (including *V. tricarinata*) is that its members prefer submerged vegetative matter (deadfall, weed beds, milled timber, etc.), which is uncharacteristic of the area.

Amnicola limosa

This is another lover of weed beds (Horst and Costa, 1965), which have rarely been encountered in the study area.

Bithynia tentaculata

The Faucet Snail (Emerson and Jacobson, 1976) is a European exotic that first appeared in the Nearctic region (U.S., northern Mexico, and southern Canada) almost a century ago, but did not become an ecoforce until much later, when (and where) the native river snails (Pleuroceridae; e.g., *Goniobasis virginica,* below) began to fade. As a filter feeder, *B. tentaculata* endures the sediment accumulation that eliminates the grazing pleurocerids, and then it multiplies, eventually overrunning the space formerly occupied by the indigenous snails and, presumably, preventing their resurgence even though conditions may have improved (See Harman, 1968a, 1968b, 1974). The species was first noticed in the Potomac River many years ago (Pilsbry, 1932; Marshall, 1933) and occasionally was encountered by Academy personnel (i.e., since 1956). The Faucet Snail has recently become distinctly more populous in the study area, though still far from abundant. The largest individuals and colonies of my experience were found in crevices of submerged wood.

Gillia altilis

This tiny snail is easily confused with juveniles of the two foregoing species, but can be found in early Academy samples from the study area. I first (and last) encountered *G. altilis,* at Station 1, in 1965. It was then characteristic of silty rock pools, which habitat persists, but the species has apparently disappeared. (I am indebted to Dr. William J. Clench for the taxonomic determination of this species, which was illustrated by Stimpson (1865).)

Mudalia carinata

Once abundant in the swiftest riffles, this species, surely another victim of sedimentation, has not been found alive in the study area for several years and was never common (even at Station 1) after the middle Sixties.

Goniobasis virginica

Little more than a decade ago, this snail inhabited the study area in the untold tens of thousands. Now almost all are gone. There must be a minute refugial population lingering on, for occasional living specimens (but no juveniles) can still be found. This lack of recruitment and the increasing success of *Bithynia tentaculata* (above) suggest that *G. virginica* would probably be extinguished in the study area even if favorable conditions are restored. Not even the devastation of the fresh-water mussels is a loss to the area more dramatic than the effective extinction of *G. virginica.*

Campeloma sp.

Because of the troubled taxonomy of this genus (see, e.g., van der Schalie, 1965), I refrain from giving the study area's population of *Campeloma* a specific epithet. *C. decisa* (Say) is a tolerable, traditional name. *Campeloma* is an oddity among gilled snails in that it thrives on the very conditions (chiefly sedimentation and organic loading) that have been so inimical to its relatives in the study area. It is a mud-loving, burrowing scavenger that was once very common in the organically enriched weed bed along the Maryland shore at the upstream terminus of Station 1.

Sedimentation increased, during the Sixties but enrichment abated (as evidenced by near elimination of the weeds), and habitats like this, so congenial to *Campeloma*, largely disappeared. Consequently, this snail persists in the area, but marginally in comparison to its former local populousness. Ironically, this scavenger has declined partly because sedimentation abated during the Seventies. In addition, recent sediment seems to be more coarse, as though it originated from construction projects and storm sewers instead of as a result of soil erosion. I am instantly reminded of the gradual shift from rural toward urban land use in the middle Potomac watershed.

Lioplax subcarinata

This species is ecologically similar to the confamilial *Campeloma* (above), but was rarely recorded from the study area. This is understandable because, except for disjunct populations in North Carolina (Clarke, M.S.; Fuller, 1977) *Lioplax subcarinata* is at the southern end of its range in the Potomac basin (Clench and Turner, 1955). Whether this snail was ever an important faunal element in the study area is moot.

Air-breathing snails (Gastropoda: Basommatophora)

With the exception of the bivalve *Sphaerium transversum* (above), pulmonate snails are the only flourishing mollusks among the formerly rich study area fauna. As such, they are discussed here as a group (the component species are listed in Table 1). Because they use lungs for gas exchange, pulmonates require water chiefly for moisture and are to that degree independent of water and its varying quality (within toxic limits, of course). This independence is furthered by their favoring the water's margin, on soil and on floating objects. This habitat is especially characteristic of the genera *Physa* and *Lymnaea;* a partial exception is the fresh-water limpet *Ferrissia rivularis,* which is equally tolerant of riffle life. Pulmonates have fared well over the years in the study area. In terms of number and variety of species and of relative and absolute numbers of individuals, they have remained essentially as in 1965, when I first visited the area. Because of reductions in other aspects of the macroinvertebrate fauna, these snails are the dominant element.

Discussion

One readily infers from the foregoing remarks about the molluscan fauna in the study area that the damage that it has incurred during the last two decades can explicitly or implicitly be ascribed to several kinds of adversity: sedimentation, heightened water temperature, symbiotic relationships, and toxins.

(Scouring caused by floods can damage the macrobenthos, and this factor should be added to those just mentioned, especially in view of the considerable flooding experienced by the middle Potomac River during recent years. However, flooding can be natural or abetted by man-induced factors. There is no doubt that scouring—as in the cases of *Anodonta cataracta* and, perhaps, *Campeloma* sp. (above)—has harmed study area macroinvertebrates, including mollusks, but the contribution by human activities (deforestation, tillage, shopping mall construction, etc.) to flooding remains uncertain. Accordingly, while acknowledging that natural, possibly cyclical scouring may well be partially responsible for adverse effects discussed in this review, I presently refrain from extensive discussion of the flooding issue).

Accumulation of sediment has been widely documented as probably the chief "river killer" in America. Degradation of the middle Potomac River molluscan fauna is no exception to this premise. Sediment is indicted as the primary abuse leading to elimination of the grazing operculate snails and of most fresh-water mussels. Sediment reduces substrates for feeding and egg laying by these snails, and it provides a low-density substrate that is lethal for all stages of the mussel life cycle except for the brief period of larval parasitism. Probably not even embryonic stages are spared, for sediment (in this case suspended, not settled) (generally understood as turbidity) interferes with fish vision and behavior and thus obstructs the normal course of glochidial infection of the host.

It is useful at this point to emphasize that the two-decade decline of the non-insect macroinvertebrate fauna is largely a function of the decay of the mollusk community, especially its operculate and naiad sectors. In other words, in order to understand the *net* destruction of the non-insect invertebrate macrobenthos, only knowledge of the fates of certain mollusks is required. There is no point in burdening this narrative with graphical representation of the molluscan "decay-curves," for they closely approximate those for certain insects in Roback's (1978) companion piece in this "Proceedings."

Water temperature is an important issue in the present context only insofar as the Pepco Dickerson SES has an impact upon the study area's molluscan fauna. Recent data generated by the Academy indicate that, as would be expected, this SES has a quantitative impact upon the invertebrate macrobenthos. This impact has been detected only in the immediate vicinity of the Dickerson Plant and has no apparent effect upon the composition of the nearby molluscan assemblage or upon other qualitative aspects of the non-insect macroinvertebrate community. Fairly said is that thermal pollution has caused minor problems in the study area and that it is itself a minor problem in comparison to other depredations, caused chiefly by sediment.

Adverse symbiotic relationships are important matters for study area mollusks. Problems associated with the relationship between fishes and naiades were discussed above. Other problems have to do with actual and potential competition among mollusks. *Bithynia tentaculata,* the Faucet Snail, appears to seal the doom of grazing operculate snails in the study area. The fresh-water mussel *Lampsilis ventricosa cohongoronta* has thoroughly overrun its indigenous congener *L. cariosa* in the mainstem Potomac River. The legitimately anticipated appearance of *Corbicula manilensis,* the Asiatic clam, in the Potomac basin will probably destroy most mussels' chances of resurgence even if present environmental adversities are reversed. Subtle, biological phenomena sometimes deserve the label "pollution" as much as do physical and/or chemical factors.

In any discussion of the decline of a biotic fraction anywhere, the role of toxic substances must be considered. Such a role has hardly been demonstrated in the study area, but the failure of certain mollusks (e.g., *Anodonta cataracta*) in otherwise at least somewhat congenial habitats hints at the presence of toxins. Additional, chemically sophisticated research is required before this question can be resolved.

What caused the middle Potomac River molluscan community to "turn the corner" into decline? The reasons are unclear, although sedimentation and turbidity appear to be major factors. The timing of this "cornering" is somewhat more clear. According to J.H. Hendrickson, Jr. (personal communication), analysis of presence/absence data for "pollution-tolerant" and "-intolerant" mollusks after the method of Bross (1958) shows that the molluscan community at a given station underwent significant change in either 1967 or 1968. In other words, the "turning point" came approximately 10 years ago or in the late Sixties, as already suggested.

The results are tragic. Most of the affected mollusks are extinguished in the study area or their populations have sunk probably below recruitment level. Moreover, this decline is paralleled in other macroinvertebrate groups, even among such reputedly "tolerant" animals as aquatic earthworms, whose representation has shrunk essentially to the (fortunately) easily recognized *Branchiura sowerbyi* Beddard (concept of Brinkhurst, 1968), which remains common in the rootstocks of "water willow" throughout the study area.

On the other hand, there is some cause for hope. At least one fresh-water mussel, *Lasmigona subviridis,* the Green Floater, is reproducing in the study area, however marginally. Another example is the species-rich assemblage of unusual bryozoans that can still be found: *Urnatella gracilis* Leidy (Entoprocta) and *Hyalinella punctata* (Hancock) and *Paludicella articulata* (Ehrenberg) (*both* Ectoprocta) (concepts of Bushnell, 1974). Like the occurrence of the snail *Bithynia tentaculata,* the presence of these filter-feeding animals indicates that suspended sediment is a problem less than precipitates in the area. Finally, I recently took gemmule-bearing (and therefore identifiable) colonies of the sponge (Porifera) *Heteromeyenia latitenta* (Potts) (concept of Penney and Racek, 1968) from riffles in the Monocacy River just above its confluence with the Potomac. So rarely encountered is this organism that almost nothing is known about its natural history (Harrison, 1974) other than Bushnell's (1971) account of a possibly aberrant population in Middle America. Some jewels remain to reflect the glory that was the Potomac fauna not long ago, but, given the biotic difficulties afoot in the upper basin (see other papers in this volume), one can only wistfully anticipate the better.

Summary

Surveillance by the Academy of Natural Sciences of Philadelphia on behalf of the Pepco Dickerson SES over the last 20 years revealed that the middle Potomac River non-insect macroinvertebrate community has gravely declined. This decline is largely a matter of the failure of the molluscan fauna. This failure, in turn, has been caused by great reductions of the faunas of gilled snails and fresh-water mussels. Graphical representations of these losses are similar to those offered by Roback (1978) for certain study area insects.

There is some prospect that these zoological misfortunes could be reversed were relevant environmental problems rectified: a small number of macroinvertebrate rarities persists in testimony to what the Potomac basin could support, were it given adequate conditions.

The present inadequate conditions consist of at least sedimentation, adverse water temperature, the onslaught of exotic organisms, and the effects of toxic pollutants. The impact of toxins remains moot, and that of alien organisms is largely potential as yet. Thermal effects are local and quantitative and have no apparent further impact upon the composition of the non-insect macroinvertebrate community. Any historical effects have long since been veiled by sedimentation, which has reduced the study area community essentially to a core of species that are more or less notoriously tolerant of environmental disturbances. These animals are dominated by the pulmonate snails.

Certain other topics and factors that have doubtless influenced this community require a great deal of further elucidation. These include changing quantity and composition of sediment; possibly cyclical, natural events (e.g., flooding); scouring as a result of high water and/or coarse sediment; changing land use in the middle Potomac watershed; and interactions among these.

Table 1

List of molluscan taxa encountered in the study area (as defined in the Introduction). Taxonomic problems remain in the genera *Pisidium, Campeloma,* and *Physa.* Authorities for specific determinations are given in the text. The suprafamilial classification of the Bivalvia follows Newell (1965). The suprageneric gastropod classification is that of Taylor and Sohl (1962). The species concepts and nomenclature of Harman and Berg (1971) are usually those employed here for pulmonate snails (Basommatophora).

Phylum Mollusca
Class Bivalvia
Subclass Palaeoheterodonta
Order Unionoida
Family Unionidae

Elliptio complanata (Lightfoot)
E. lanceolata (Lea)
Lasmigona subviridis (Conrad)
Alasmidonta varicosa (Say)

Anodonta cataracta (Say)
Strophitus undulatus (Say)
Ligumia nasuta (Say)
Lampsilis ventricosa cohongoronta (Ortmann)
Family Sphaeriidae
Sphaerium simile (Say)
S. transversum (Say)
Pisidium sp(p?).
Class Gastropoda
Subclass Streptoneura
Order Mesogastropoda
Family Viviparidae
Campeloma sp.
Lioplax subcarinata (Lea)
Family Valvatidae
Valvata tricarinata (Say)
Family Hydrobiidae
Amnicola limosa (Say)
Bithynia tentaculata (Linnaeus)
Gillia altilis (Lea)
Family Pleuroceridae
Mudalia carinata (Bruguière)
Goniobasis virginica (Gmelin)
Subclass Euthyneura
Order Basommatophora
Family Lymnaeidae
Lymnaea humilis (Say)
L. columella (Say)
Family Physidae
Physa sp.
Family Planorbidae
Menetus dilatatus (Gould)
Helisoma trivolvis (Say)

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