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MALACOLOGIA

Proceedings of the American Malacological Union

Symposium on Rare and Endangered Mollusks

UNITAS MALACOLOGICA EUROPAEA

IV European Malacological Congress

The Fourth European Malacological Congress will be held in Geneva, Switzerland, from September 7 to 11, 1971. It will follow a one-day meeting of museum curators in charge of Mollusca, devoted to the discussion of curatorial problems and collaboration. The meetings will take place in the new Museum of Natural History and in the University buildings. All malacologists are cordially invited.

The Congress fee is S. Fr. 30.- (about U S $ 7.00) for members and corresponding members of U.M.E., S. Fr. 40.- (about U S $ 9.00) for non members, and S. Fr. 15.- (about U S $ 3.50) for students and accompanying persons.

Accommodation will be arranged by the Tourist office in hotels and the Student hostel.

If you are interested and have not received the circulars, please contact the president, Dr. E. Binder, for more detailed information.

Address: IV European Malacological Congress
Museum of Natural History
CH- 1211 Geneva 6, Switzerland

MALACOLOGISTS INTERESTED IN AFRICA. --- During the last week in November 1969, a meeting was held at the Musée Royal de l'Afrique Centrale, Tervuren, Belgium, which was attended by various people interested in the study of land and freshwater mollusks of Africa, south of the Tropic of Cancer, including Madagascar (Malagasy), the adjacent islands and part of Arabia. This group decided to issue a newsletter once a year, beginning in the spring of 1970, giving names and addresses of researchers interested in this region, as well as lists of their papers and current researches, notes on the location of African type specimens in museums, proposed expeditions to Africa, specialized bibliographies and addresses for inquiries. This newsletter will be called *ACHATINA*. Copies of it will be available at no cost to *bona fide* workers who cooperate in this scheme. The terms of reference will be restricted to taxonomy and zoogeography; medical aspects will be outside the area of interest. A long term project is to compile an annotated bibliography of all the papers dealing with non-marine molluscs of this area.

Those interested should contact Dr. J.-J. VAN MOL, c/o Section des Invertébrés non Insectes, Musée Royal de l'Afrique Centrale, Tervuren, Belgium.

PAPERS

on the

RARE AND ENDANGERED MOLLUSKS OF NORTH AMERICA

Edited by Arthur H. Clarke

National Museum of Natural Sciences
National Museums of Canada
Ottawa

Based on a *Symposium on the Rare and Endangered Mollusks of North America*
sponsored by the American Malacological Union and presented on
July 16, 1968 at Corpus Christi, Texas

FOREWORD

The papers presented here document crisis situations which will be of concern to all persons who care about the preservation of our unique North American fauna. Through expanded industrial development, increased water pollution, widespread habitat disruption, and over-collecting, more than 400 native species of mollusks are in imminent danger of extinction. At least 1000 others will soon be endangered if present trends continue.

All of the scientists who participated in the American Malacological Union's *Symposium on Rare and Endangered North American Mollusks* possess special knowledge and several of them are among our most distinguished malacologists. All of the assessments, presented here, are therefore authoritative. Excerpts from some of the papers speak for themselves.

"We are left with the inescapable conclusion that we are gradually destroying upwards of a thousand endemic species of freshwater mollusks." (David H. Stansbery).

"There is a [large] complex of hydrobiid gill-breathing snails in North American brackish water that is headed for extinction even before the species are scientifically described or named." (Joseph P. E. Morrison).

"About 1953, land clearing and the building of fishing camps and other tourist attractions eliminated just about all of the hammock land [on Lower Matecumbe Key] and, of course, a few more color forms of *Liguus* peculiar to this key. The same type of destruction has occurred along the entire series of Keys from near Miami to Key West." (William J. Clench).

"Among the [marine] species that are being over-collected in certain limited areas are *Strombus gigas*, *Cassis madagascariensis*, *Pleuropoca gigantea*, *Cyrtopleura costata*, *Cymphoma gibbosum*, *Melongena corona*, and edible clams, scallops and oysters." (R. Tucker Abbott).

"Viewed from the most pessimistic angle, it might be stated that all land mollusks indigenous to the western part of the United States are endangered to some degree." (Allyn G. Smith).

The objectives of the symposium and of this publication are to call attention to the present threats to species survival, to make available within a single reference preliminary lists of our rare and endangered mollusks, and to provide some basis for their planned conservation. Corrections and necessary additions to these lists are solicited. Individuals and organizations are urged to do what they can to conserve and protect our endangered native species and to preserve them from destruction.

A. H. C.

CONTENTS

1. INTRODUCTION

The magnificent freshwater mollusk fauna of southeastern North America was discovered by C. S. Rafinesque, Thomas Say, Isaac Lea, T. A. Conrad, and other celebrated naturalists who, between 1816 and 1850, described hundreds of unique new species from that region. Influenced by a benign climate, varying topography, abundant calcium and fortunate geological history, a hundred million years of uninterrupted evolution had produced there the most diverse and luxuriant freshwater molluscan fauna known to exist on earth.

As the country became more densely populated streams were dammed; cattle, sewage and industrial wastes poisoned the waterways; and, one after another, rivers became unfit for mollusks and other aquatic animals. During the nineteenth and twentieth centuries most of the rivers became partially or wholly polluted and their mollusk faunas were destroyed (see paper by D. H. Stansbery, this publication). For example the Powell, Clinch, Holston, French Broad and Hiwassee rivers, all major tributaries of the upper Tennessee River, were previously unsurpassed for their rich mollusk populations. By 1950 only the Clinch and portions of the Powell remained unspoiled.

On June 10, 1967 a retaining wall collapsed at Carbo, Virginia sending 130 million gallons of toxic industrial waste flooding into the Clinch River. In Virginia alone an estimated 163 million fish were killed. Effects of the poison on the mollusk fauna were then unknown but the worst was feared.

Malacologists have long been aware of the gradual depletion of the North American fauna but most had felt, with some justification, that nothing could be done. But the call for action signalled by the Clinch River disaster was too imperative to ignore. On July 31, 1967 an Executive Council of the American Malacological Union appointed the writer as Chairman of a Committee to recommend action for the preservation of the rare and endangered mollusks of North America.

Clearly the first assignment of the Committee was to assess the problem and to identify those species of mollusks which are now rare and in danger of extinction. It was decided that a symposium on this subject should be held during the next annual AMU meeting and its results published. During the next few weeks malacologists possessing special knowledge of the survival status of marine, freshwater and terrestrial mollusks of both eastern and western North America were asked to participate. The response was most gratifying. All of the workers who were asked to present papers promptly accepted and most of the invited discussants also agreed to help.

The *Symposium* took place on July 16, 1968 in Corpus Christi, Texas during the 34th annual meeting of the American Malacological Union. Carefully prepared papers from 14 malacologists were read. Audience participation was enthusiastic and much valuable supplementary information was thereby brought forth.

All of the contributed papers which have been released by their authors for publication are presented here. Some have been revised but most are printed essentially as they were delivered. These collected papers constitute the first attempt to enumerate the rare and endangered mollusks of North America or, for that matter, of any continental molluscan fauna.

The purpose of this publication is to focus attention on the species mentioned and to stimulate corrective action wherever possible. Every land management agency of national, regional, and local governments is invited and requested to do what it can. "Individuals, organizations, and interested agencies are urged to employ all means available to them toward achieving greater security for all wildlife. Only by united appropriate action will we prevent other species from joining the list of those now extinct." (1966, *United States Department of the Interior, Resource Bulletin*, 34: iii).

It had been hoped that the *Symposium* might also provide some basis for planned conservation or, if necessary, for propagation of these species. Fundamental information of this sort has already been published by the U.S. Department of the Interior's Bureau of Sport Fisheries and Wildlife (*op. cit.*) for the rare vertebrates of North America and by the International Union for Conservation of Nature and Natural Resources (1966, the *Red Data Books*) for rare mammals and birds of the World. We had proposed to use these works as models. It was soon obvious that although the geographical distribution of most rare North American mollusks is reasonably well-known (often to their detriment) we know almost nothing about the ecology, life history or population structure of most of them. Critical areas for research are therefore plainly indicated.

Biologists are becoming increasingly convinced that our generation has a profound obligation to conserve our natural environment for the practical and esthetic benefit of future generations of man. Some are also deeply concerned with our moral obligation to preserve rare species for the benefit of the species themselves. Either cause is more than sufficient and it is proper that the American Malacological Union should assume a leading role in fostering the conservation of our North American molluscan fauna.

A. H. C.

MALACOLOGIA, 1970, 10(1): 9-22

AMERICAN MALACOLOGICAL UNION SYMPOSIUM
RARE AND ENDANGERED MOLLUSKS

2. EASTERN FRESHWATER MOLLUSKS (I) THE MISSISSIPPI AND ST. LAWRENCE RIVER SYSTEMS

by David H. Stansbery

The Ohio State Museum of The Ohio Historical Society
Faculty of Population and Environmental Biology of
The Ohio State University, Columbus, Ohio 43210, *U.S.A.*

THE EXTENT OF THE FAUNA

The conditions for speciation of stream dwelling animals has been nearly ideal in eastern North America for many million years. One of the results has been the origin of what is probably the richest freshwater mollusk fauna in the world. While true of nearly all groups of freshwater mollusks represented, it is especially striking in the stream forms: 1) the river snails of the Family Pleuroceridae and 2) the naiads of the Family Unionidae. Tryon (1873: XXXVII) notes that:

> "We have, in North America, nearly five hundred recognized species of shells belonging to the various genera of Strepomatidae [= Pleuroceridae]. So considerable a moiety of these are to be found to be inhabitants of the upper Tennessee River and its branches in East Tennessee and North Alabama, and of the Coosa River in the latter State, that we quite agree with Mr. Lea in regarding that region as the great centre of this kind of animal life."

It should be added that these species are endemic to eastern North America and most probably outnumber the combined melanian species of the rest of the world.

The abundance of naiads or "unios" in both species and numbers of individuals proved to be no less spectacular. In his synopsis of the naiads of the world Simpson (1900: 505) recognizes:

> "about one thousand species and 82 varieties of Unionidae. . . Of these 533 species and 55 varieties belong in North America. . ."

Subtracting the few western North American species we find that eastern North America has roughly half the known species of river snails and half the known species of naiads in the world and together they total about a thousand species. With a very few exceptions these species are found nowhere else in the world.

A RESUME OF THE POST-COLUMBIAN HISTORY OF THE FAUNA

Although the prehistoric North American Indians utilized prodigious quantities of these mollusks (Stansbery, 1966: 42) their harvests apparently had little effect on the survival of these species. A comparison of the shells recovered from prehistoric mounds and midden heaps with pioneer lists reveals that the species composition of our streams had not changed appreciably for at least six to eight thousand years prior to pioneer settlement.

The factors which have been responsible for the decimation of our freshwater mollusks have increased in both number and intensity as our population has grown. With the initial clearing of the forests and tilling of the soil great quantities of humus-rich topsoil was washed into our streams. This loss to early agriculture was also a loss to stream life through a reduction of dissolved oxygen and an increase in organic acids. The removal of topsoil decreased the ability of the land to hold water, hence

producing greater floods in the wet seasons and dryer droughts in the dry part of the cycle. Each exaggerated extreme took its toll of stream life. Over a century ago Higgins (1858: 550) wrote:

> "Gentlemen who collected the shells of this vicinity in early times, found many species in great abundance which have at this day either totally disappeared or are represented by occasional straggling specimens, and all species, with but few exceptions, have gradually decreased in numbers, . . This remarkable decrease and extinction among the mollusca, may, to a great degree be accounted for, when we consider the immense change which the surface of the country has undergone. The change of the wilderness into a highly cultivated country, the immense area of forest which has yielded to the plow; the decrease in the volume of the water in our rivers and creeks,. . ."

The fine silts and clays which followed the topsoil into our streams may well have had a smothering effect on some species by the simple effect of clogging of gills or stimulating excess mucus secretion. In the early days the rivers were commonly the direct recipients of lumbermill sawdust, brewery slops, and slaughterhouse refuse (Trautman, 1957: 18). With the coming of community sewage systems, raw domestic sewage was added without benefit of treatment. The discovery of new energy resources in the form of coal and petroleum led directly to an upsurge of technology and a mushrooming of industry. Not only did the mining and drilling operations add new pollutants in increasing amounts to our waters but the industries they supported contributed a whole new spectrum of soluble and insoluble wastes to our already overloaded rivers.

Ortmann (1909) was so moved by the wholesale destruction of mollusks and crustaceans that he wrote a paper on "The destruction of the fresh-water fauna in western Pennsylvania." In addition to polluting industries of many diverse kinds he also cites the "*damming up of certain rivers*." He notes that:

> "By this process [damming] the rivers, which originally possessed a lively current, with riffles, islands, etc., have been transformed into a series of pools of quiet, stagnant water, ... It is most destructive to mussels, most of which require a lively current. Dams also prevent free migration, for instance of fishes, and thus they must be an obstacle to the natural restocking of the rivers..."

Ortmann seems to have been the first biologist to correctly diagnose the true effect of impoundments on stream life. It is easy to understand why he, being the first, grossly underestimated the effects damming could have on our stream life. It is to be regretted that many biologists (perhaps most) have yet to recognize that nearly all of the exceedingly rich freshwater fauna of eastern North America evolved in or adjacent to a riffle or shoal habitat. To the extent that we change our streams into long chains of lakes -- to this extent do we eradicate this unique biological heritage.

More and more in recent years sand and gravel firms have turned to the alluvial deposits of our stream beds as a source of materials. These operations in addition to the dredging involved in stream channel "improvement" and quarry washing operations have their effect felt for miles downstream. For reasons as yet unknown, a dredged section of stream will not regain a naiad fauna for as much as a decade or more.

The advent of the chemical pesticide industry over the past twenty years has given additional cause for concern since the bulk of most of these toxins are washed into our streams. Their precise effects on our freshwater mollusks have yet to be documented in detail.

Malacologists over the years have not been blind to the increasingly damaging effects man has had on our stream environments and the organisms living there. Ortmann followed his work in Pennsylvania (which formed the basis of his 1909 paper cited above) with a survey of the naiads of the upper Tennessee Drainage System. At the

conclusion of his paper (Ortmann, 1918: 525) he records:

> "In view of the gradual, slow but steady, deterioration of the fauna in consequence of stream-pollution, there is great danger that the fauna will largely become destroyed, and that it will be impossible, in the future, to duplicate this collection."

I have collected the upper Tennessee with some thoroughness. Ortmann's fear has been largely realized. The rivers which make up the headwaters of the Tennessee (Powell, Clinch, Holston, Nolichucky, French Broad, Little Tennessee and Hiwassee) are, in large part, destroyed. Where the fauna has not been greatly reduced or eliminated by pulp mill liquors, salt plant effluent, wood extracting plants, paper mills, etc., the high dams of the Tennessee Valley Authority have done so. There are still a few streams, however, having something which approaches the original fauna. The Powell and Clinch Rivers just above Norris Reservoir still afford conditions where the industrious collector may take as many as thirty species from a single site. How long these conditions will last cannot be predicted but I suspect not very long. There is already agitation for additional dams on both rivers and concerted efforts are being made to industrialize this section of "Appalachia." I would not be surprised to witness the eradication of most elements of the Cumberlandian Fauna within the next several decades. We have excellent reason to expect it.

In 1924 Ortmann brought the influence of damming on the naiad fauna at Mussel (Muscle) Shoals to the attention of American scientists with an article in *Science*. He expressed the concern that the richest of all known naiad sites (at least 70 species in 31 genera) was being destroyed. Efforts to assess any changes in that particular fauna since Ortmann's day have been made (Stansbery, 1964: 25). Extensive collecting produced specimens of less than half of the original fauna. Over the five years since that time Professor Paul Yokley of Florence State College has made every reasonable effort to add to the recent list. His persistent labors with commercial collecting gear and SCUBA equipment have resulted in the recovery of single specimens of four additional species.

Mr. Billy Isom informs me that the original Mussel Shoals lie today beneath 19 feet of muck behind Wilson Dam, at the bottom of Wilson Reservoir. The "glory of the mussel shoals" discovered originally by Conrad (1834: 12) and lamented by Ortmann (1924: 565) has indeed become history.

In more recent times Van der Schalie (1938, 1945, 1947, 1958, 1960) has been outspoken in his criticism of dams and pollution and has cited evidence which abundantly supports his position. The impoundment of the lower Tennessee, known as Kentucky Lake, has been studied by Bates (1962: 232). He found the faunal assemblage of the old river channel to be essentially the same as the pre-impoundment composition. All individuals so taken were found to be adults (10+ years) with juveniles being absent. It would seem that impounding either stopped effective reproduction or the survival of the young in these populations leaving only the pre-impoundment individuals to live out their life expectancies. More recent collections from the same area support this conclusion.

We are left with the inescapable conclusion that we are gradually destroying nearly a thousand endemic species of freshwater mollusks. This fauna was millions of years in coming into being and is in the process of being eliminated in only a century or two. -- And all this before we have even begun to seriously investigate their potential value.

RARE AND ENDANGERED SPECIES

It should be noted at the outset that my knowledge of the status of standing-water species in general, and non-naiad species in particular, is too scant to determine which are either rare or endangered today. Although the stream forms, especially the naiads,

are far better known, the observations offered below are obviously only as valid as the extent of my field experience and that of my several colleagues.

A "rare and endangered species" is defined, for the purposes of this paper, as any species which is known living today from only one or a very few populations having a restricted range. Even though a species may be reduced to an estimated 10% or less of its former abundance it is not included unless it fits the above criteria.

For some species the time for concern appears to be past. A number of species of the Genus *Dysnomia* Agassiz (= *Epioblasma* Rafinesque) have not been collected alive nor have fresh specimens of their shells been found in nature for at least half a century despite a concerted effort to find them. They are included here (see Pls. 1 and 2) in order to give a reasonably complete record and with the hope that one or more surviving populations may yet be discovered. Such species are, however, presumed extinct and shall be so listed until valid evidence of their continued existence is obtained.

CLASS GASTROPODA

Subclass PULMONATA
  Order BASOMMATOPHORA
    Family PHYSIDAE
    Family LYMNAEIDAE
    Family PLANORBIDAE
    Family ANCYLIDAE
Subclass PROSOBRANCHIA
  Order MESOGASTROPODA
    Family VIVIPARIDAE
    Family VALVATIDAE
    Family HYDROBIIDAE
    Family PLEUROCERIDAE

Insufficient data for Evaluation of Species Status

Genus *Io* Lea, 1831.

Io fluvialis Say, 1825. A few relict populations remain in the Powell, Clinch, and Nolichucky Rivers. It is absent from most of its former range.

Genus *Lithasia* Haldeman, 1840. (Includes *Angitrema* Hald.)

Most of the small stream species still persist in isolated localities. Most of the large river species are either extinct or existing as very small populations in the rapid water below dams.

Genus *Pleurocera* Rafinesque, 1819.

Many headwater species still persist although most of the species characteristic of large rivers are either greatly reduced or extinct.

Genus *Goniobasis* Lea, 1862.

Most of the species of this typical headwater genus still survive.

Genus *Eurycaelon* Lea, 1864.

A few populations of at least one species yet survive in the headwaters of the Tennessee River system.

Genus *Anculosa* Say, 1821. (= *Leptoxis* Raf.)

Some species of this genus may still be found in numbers on the rocky riffles of many medium to small streams of the southern part of the Ohio River system in Kentucky, Tennessee and Virginia.

Genus *Spirodon* Anthony, 1873. (= *Mudalia* Haldeman, 1840, of authors)

The few species of this genus still survive in rivers of the east central Atlantic drainage and in the headwaters of the New and Holston rivers of the Mississippi basin.

CLASS BIVALVIA

Order UNIONOIDIA

Family MARGARITIFERIDAE Ortmann, 1911.

Cumberlandia monodonta (Say, 1829).

Remnants of this species still live in the Powell and Clinch Rivers with scattered individuals in the Tennessee River proper. The Green River of Kentucky has at least one small population but the only population of substantial size presently known is found in the Gasconade River of the Ozark Plateau in Missouri.

Family UNIONIDAE (Fleming, 1828) *sensu* Ortmann, 1911.

Subfamily AMBLEMINAE Morrison, 1955.

Fusconaia cuneolus (Lea, 1840).

A single population remains in the Clinch River in Virginia.

Fusconaia edgariana (Lea, 1840).

Small relict populations remain in the Clinch and Paint Rock Rivers. The only known population of size is in the Powell while one persisting until 1967 in the lower Elk River, Tennessee, has apparently since been destroyed by quarry washings.

Quadrula intermedia (Conrad, 1836).

A few scattered small populations yet remain in the Powell, Clinch and Duck Rivers. Known until recently from the Elk River, Tennessee.

Quadrula sparsa (Lea, 1841).

This form stands between *Q. metanevra* and *Q. intermedia* but merges with neither. A single population remains in the Powell River in Tennessee.

Quadrula cylindrica (Say, 1817).

The big river form *cylindrica* appears to be reduced to a few populations in the Ouachita Mountains of Arkansas and Oklahoma, but the headwater form *strigillata* still lives in a number of small headwater populations of the Ohio system.

Plethobasus cicatricosus (Say, 1829).

Known today from a population in the Tennessee River below Wilson Dam in Alabama.

Plethobasus cooperianus (Lea, 1834).

Occasional specimens are still taken from the Tennessee River in Tennessee and Alabama.

Lexingtonia dolabelloides (Lea, 1840).

Individuals rarely taken yet in the Powell, Clinch and Holston Rivers. Duck and Paint Rock Rivers have small local populations.

Pleurobema clava (Lamarck, 1819).

This once common widespread Ohioan species still remains in several small disjunct headwater populations in Ohio. Occasional specimens are taken in the Wabash River of Indiana and the Green River of Kentucky.

Pleurobema pyramidatum (Lea, 1831).

In recent years this naiad has been found only in the Green River of Kentucky, the Clinch River above Norris Reservoir, and rarely from the Tennessee River proper.

Lastena lata (Rafinesque, 1820).

Although extirpated from nearly all its former range this species still lives in the Green River at Munfordville, Kentucky, and the Clinch River above Norris Reservoir. A population in the Elk River persisted until 1967.

PLATE 1. Extinct Unionidae

FIG. 1. *Dysnomia flexuosa* (Rafinesque, 1820). OSM 10369.1, male, "Ohio River," 18 ?, length = 58 mm.

FIG. 2. *Dysnomia flexuosa* (Rafinesque, 1820). OSM 10369.2, female, "Ohio River," 18 ?, length = 69 mm.

FIG. 3. *Dysnomia stewardsoni* (Lea, 1852). OSM 10371.2, male, "Tuscumbia, Ala.," 18 ?, length = 39 mm, from Henry Moores Collection.

FIG. 4. *Dysnomia stewardsoni* (Lea, 1852). OSM 10371.4, female, "Tuscumbia, Ala.," 18 ?, length = 35 mm, from Henry Moores Collection.

FIG. 5. *Dysnomia arcaeformis* (Lea, 1831). OSM 10364, male, "Tenn. River, Alabama," 18 ?, length = 35 mm.

FIG. 6. *Dysnomia arcaeformis* (Lea, 1831). OSM 10363, female, "Holston River, Tenn.," 18 ?, length = 38 mm, from Henry Moores Collection.

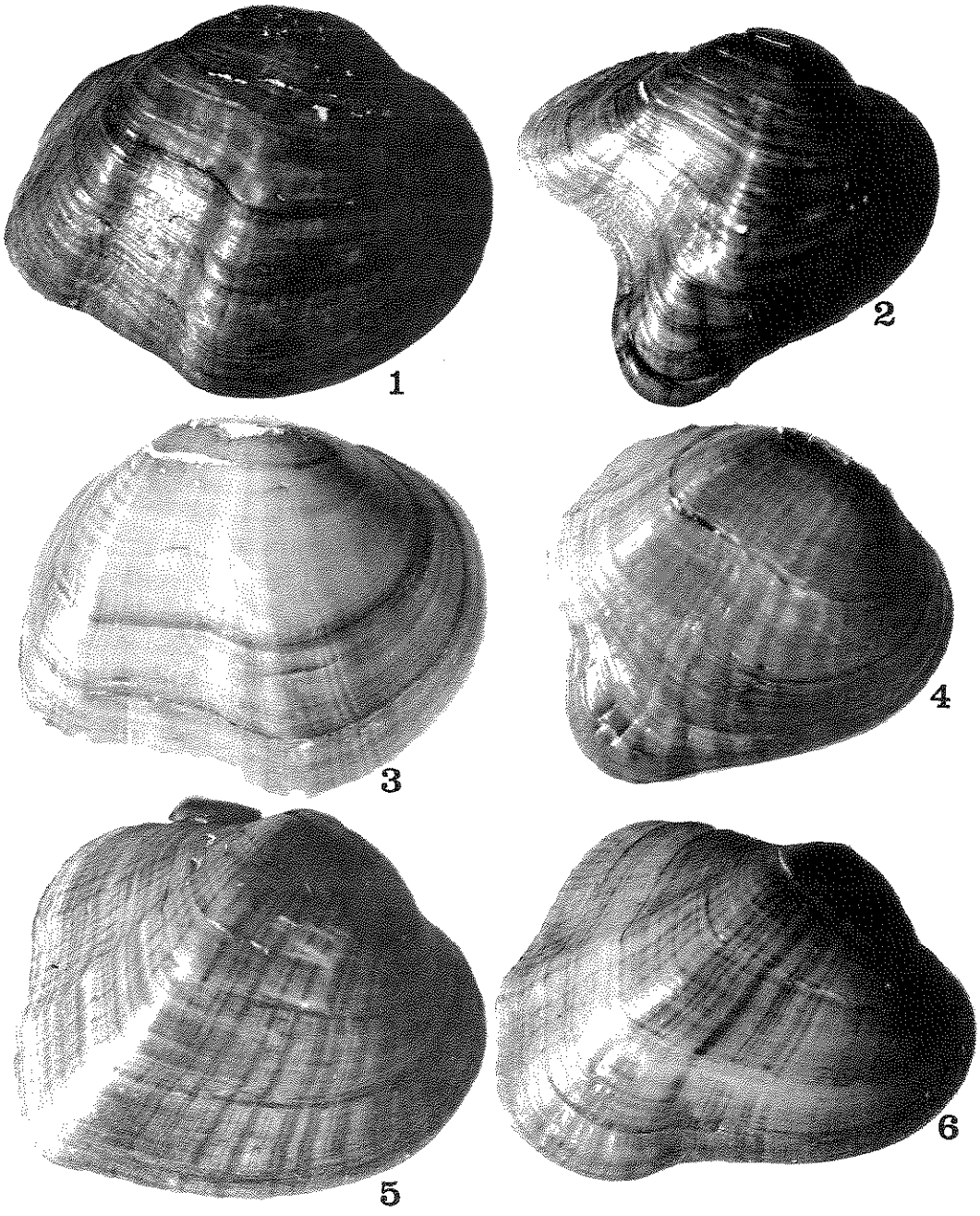
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PLATE 2. Extinct Unionidae

FIG. 1. *Dysnomia personata* (Say, 1829). OSM 10379.1, male, "Ohio River, Cin., O.," 18__?__, length = 40 mm, from Henry Moores Collection.

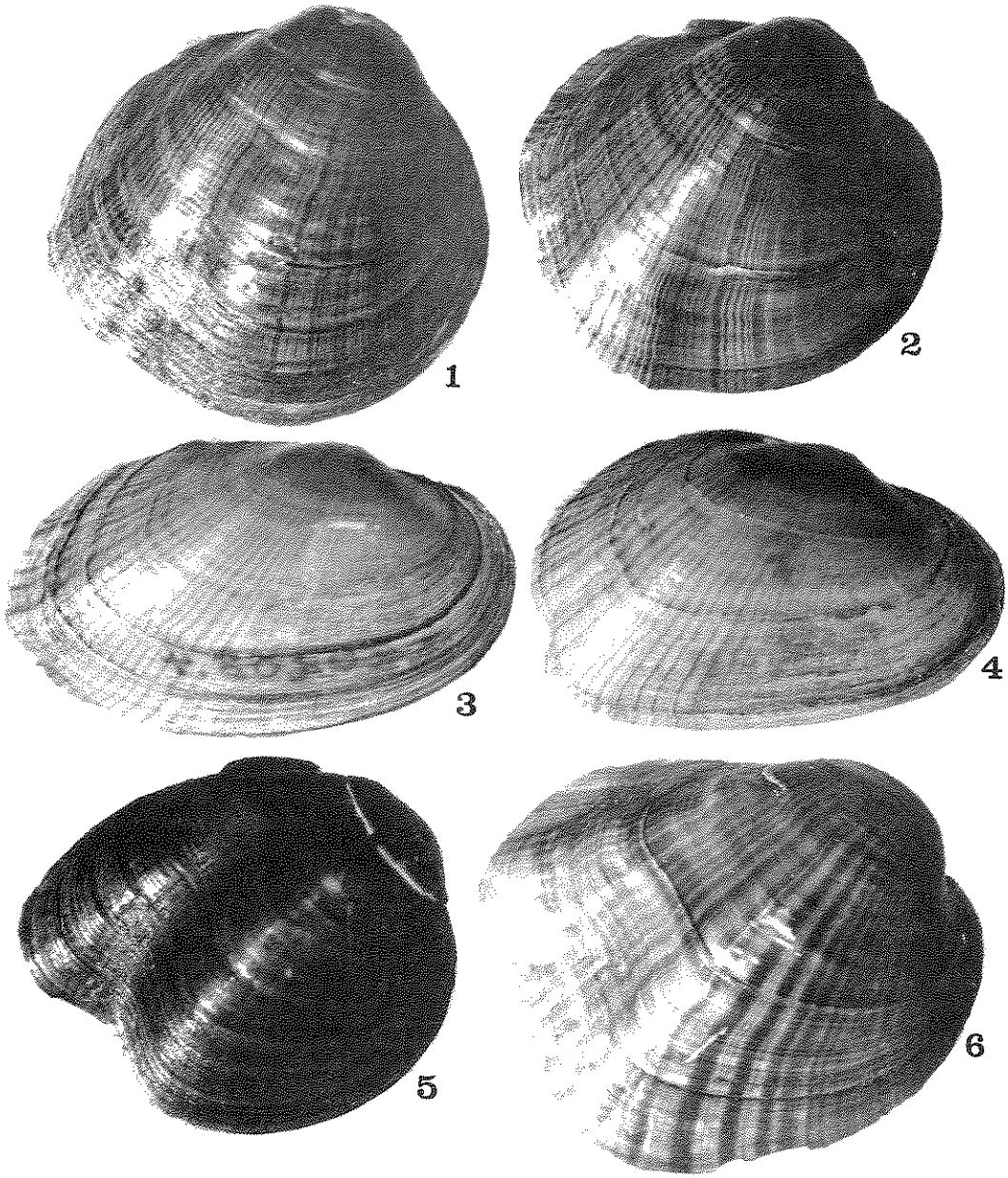
FIG. 2. *Dysnomia personata* (Say, 1829). OSM 10370.1, female, "Ohio River," 18__?__, length = 46 mm, from Henry Moores Collection.

FIG. 3. *Dysnomia lenoir* (Lea, 1843). OSM 20208.4, male, Stones River 1.2 miles west of Couchville, Davidson Co., Tenn., 2 Sept. 1965, length = 33 mm.

FIG. 4. *Dysnomia lenoir* (Lea, 1843). OSM 20208.1, female, Stones River 1.2 miles west of Couchville, Davidson Co., Tenn., 2 Sept. 1965, length = 27 mm.

FIG. 5. *Dysnomia propinqua* (Lea, 1857). OSM 4078, male, locale unknown, 18__?__, length = 35 mm.

FIG. 6. *Dysnomia sampsoni* (Lea, 1861). OSM 10395, male, "Wabash," 18__?__, length = 41 mm.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Subfamily ANODONTINAE (Swainson, 1840) sensu Ortmann, 1910.

Pegias fabula (Lea, 1836).

Never common, this species has become increasingly rare in recent years. Its range appears to have been reduced to a few isolated populations in the upper Cumberland River tributaries.

Simpsoniconcha ambigua (Say, 1825).

A species sporadic in distribution and seldom found in numbers anywhere in recent years. Its habitat in the silt beneath relatively large flat rocks may render its rareness more apparent than real.

Arkansia wheeleri Ortmann and Walker, 1912.

This species of the streams flowing out of the Ouachita Mountains has apparently never been found in numbers. The only recent record is from Kiamichi River in Oklahoma.

Subfamily LAMPSILINAE (von Ihering, 1901) *sensu* Ortmann, 1910.

Ptychobranchus subtentum (Say, 1825).

Remnant populations may still remain in the Rockcastle River of the upper Cumberland and the Duck River of the lower Tennessee. Two substantial populations are today found in the Powell and Clinch Rivers above Norris Reservoir.

Cyprogenia aberti (Conrad, 1850).

The range of this species has apparently been reduced to the Black and Ouachita Rivers of Arkansas.

Dromus dromus (Lea, 1834).

Formerly found throughout the Cumberlandian Faunal Region this species is now restricted to the Powell and Clinch Rivers just above Norris Reservoir.

Obovaria retusa (Lamarck, 1819).

A population still living in the impounded lower Tennessee had apparently not reproduced since impoundment and is expected to die out. The only known breeding population of this once widespread species is a small one in the Green River near Munfordville, Kentucky.

Leptodea leptodon (Rafinesque, 1820).

This species, rare since its discovery, has now all but disappeared east of the Mississippi River. In the last half century single specimens have been taken from the Green River of Kentucky, the Ohio River near Cincinnati, the Meramec River of Missouri, the Kiamichi River of Oklahoma and several each from the Gasconade River in Missouri and the Saline River of Arkansas. The expression "widespread and everywhere rare" fits this species perfectly.

Proptera capax (Green, 1832).

Although largely if not entirely gone from the entire Ohio River drainage, this species still survives in the White and St. Francis Rivers of Arkansas.

Carunculina glans (Lea, 1831).

The typical *C. g. glans* of the Ohioan Faunal Zone appears on the verge of extinction while its Cumberlandian counterpart *C. g. moesta* exists in some numbers in several headwater streams of the Cumberland Plateau and the Southern Appalachians.

Carunculina cylindrella (Lea, 1868).

A population of this exceedingly rare species still lives in the Paint Rock River system of northern Alabama.

Conradilla caelata (Conrad, 1834).

Originally found throughout the upper Tennessee this rare species is now restricted to several small populations in the Powell, Clinch and Duck Rivers of that region.

Villosa trabalis (Conrad, 1834).

The typical form *V. t. trabalis* may still be found in the Cumberland River just below the Cumberland Falls and in the Rockcastle River nearby. The purple nacred *V. t. perpurpurea* seems restricted to the upper Clinch River where it is very rare and to Copper Creek, one of its tributaries.

Villosa ortmanni (Walker, 1925).

Never known outside the Green River system in the Mammoth Cave region of south central Kentucky. Common today only in the vicinity of Munfordville.

Lampsilis orbiculata (Hildreth, 1828).

The typical form *L. o. orbiculata* may still be taken occasionally from the Tennessee River below Wilson Dam and Guntersville Dam and very rarely from its type locality, the Muskingum River in Ohio. The *L. o. higginsi* is known living today only from the upper Mississippi River. Related forms from the Gasconade, Black and Sabine Rivers of the Ozark-Ouachita are also rare and may constitute a third species or subspecies of this interesting complex.

Lampsilis virescens (Lea, 1858).

Never a common species nor widely distributed, *L. virescens* is found today only in the Paint Rock River of Alabama. Dredging operations there may render this species extinct within the year.

Dysnomia flexuosa (Rafinesque, 1820). Pl. 1, Figs. 1, 2.

This species has not been collected since 1900 in spite of repeated efforts to find it. It was apparently a species of shallow riffles in big rivers, a habitat which has been totally eliminated. It is presumed **extinct.**

Dysnomia arcaeformis (Lea, 1831). Pl. 1, Figs. 5, 6.

The entire range of this species is now under a series of impoundments. It has not been collected in over half a century and hence is presumed **extinct.**

Dysnomia lenior (Lea, 1843). Pl. 2, Figs. 3, 4.

The last known population of this species is now covered by the Priest Reservoir on the Stones River in Tennessee. The only records of this species during the last 50 years were from this site. It is presumed **extinct.**

Dysnomia sulcata (Lea, 1829).

The big river *D. s. sulcata* form having a purple nacre may be extinct but the white nacred *D. s. perobliquus* is still occasionally found in streams tributary to western Lake Erie or Lake St. Clair.

Dysnomia haysiana (Lea, 1834).

This rare species is today apparently restricted to that part of the Clinch River from St. Paul to Dungannon, Virginia, a distance of only about ten miles.

Dysnomia personata (Say, 1829). Pl. 2, Figs. 1, 2.

I know of no collections of this species made in this century. It is an Ohioan species once found in the shallows of the Ohio and a few of its largest tributaries. It is presumed **extinct.**

Dysnomia stewardsoni (Lea, 1852). Pl. 1, Figs. 3, 4.

A rare species even before the impoundments and apparently not collected in the last half century. It is presumed **extinct.**

Dysnomia lewisi (Walker, 1910).

Recorded from both the Tennessee and Cumberland River Systems up until the construction of Wolf Creek Dam on the Cumberland and the TVA Dams on the Tennessee. It has not been collected in over 20 years and hence is presumed **extinct.** *D. lewisi* is figured by Walker, 1910, *The Nautilus* 24(4): Pl.3, Figs. 3-5 and by Neel & Allen, 1964, *Malacologia* 1(3): 451.

Dysnomia biemarginata (Lea, 1857).

The big river *D. b. biemarginata* form has not been collected during this century and presumably has been extinct for some time. The headwater *D. b. turgidula* form was recently rediscovered in the Elk River of Tennessee but quarry washing operations in the summer of 1967 apparently destroyed most or all of the naiads in this area. It may yet be rediscovered in some undamaged tributary.

Dysnomia florentina (Lea, 1857).

The form *D. f. florentina* is apparently gone from the entire Tennessee System except for the South Fork Holston River in Virginia. A closely related species or subspecies, *D. f. walkeri*, has its range reduced to the lower Stones and Red Rivers of the Cumberland River system.

Dysnomia torulosa (Rafinesque, 1820).

Typical *D. t. torulosa* are still occasionally collected in commercial operations on the lower Ohio River (Kentucky-Illinois) (Parmalee, 1967) and from the Nolichucky River near its mouth in western Tennessee. It is gone throughout the rest of its previous range. The smooth headwater subspecies, *D. t. rangiana*, persists as a few populations in smaller streams in the Ohio and lower Great Lakes systems. In the southern Appalachians one may still find an occasional specimen of *D. t. gubernaculum* but it is apparently restricted to the Clinch River and is rare even there.

Dysnomia propinqua (Lea, 1857). Pl. 2, Fig. 5.

Never known outside the Tennessee System, this species has not been collected in over half a century. It is similar to both *D. torulosa* and *D. sampsoni* but apparently does not merge with either. It is presumed **extinct**.

Dysnomia sampsoni (Lea, 1861). Pl. 2, Fig. 6.

A smooth inflated form of the lower Wabash River which appears to merge with *D. t. rangiana* and may be simply a variant of that subspecies. It has not been collected for over 50 years and may well be **extinct** in spite of the relatively good condition of this river.

A review of the status of the 103 species of naiads now known from the Ohio River drainage system reveals that 41 readily qualify listing as rare and endangered and, of this latter number, at least 8 species are presumed to be extinct. All 8 species believed to be extinct are members of the Genus *Dysnomia* Agassiz (= *Epioblasma* Rafinesque). Species of this genus are characteristic of the riffle (or shoal) habitats of high gradient streams and the 8 extinct forms were recorded, with rare exception, from riffles of our largest rivers. This specific type of habitat has all but disappeared from the Ohio basin and is being further reduced with the construction of new and higher dams.

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Discussion of Dr. Stansbery's Paper

by Arthur H. Clarke

The eastern regions not considered by Dr. Stansbery or Dr. Heard, the North Atlantic Watershed and the Canadian Interior Basin, contain mostly widespread species whose ranges extend into undeveloped, sparsely settled regions. Although many local mollusk populations there have been killed by pollution, the species themselves are not yet endangered.

A possible exception may be the unionid *Alasmidonta heterodon* (Lea), a small, rare species known only from 5 river systems, *viz.* the Peticodiac in New Brunswick, the Connecticut and the Housatonic in New England, the Delaware in Pennsylvania and the Rappahannock in Virginia. Expansion of industrial pollution could eliminate this

species. There are no early records of its occurrence elsewhere and its discontinuous distribution may indicate that it is becoming extinct through natural causes.

According to the literature some species within the Canadian Interior Basin (i.e., the Hudson Bay Watershed combined with the Arctic Watershed) have been taken only at one or a few localities and might be presumed to be rare. Recent work (Clarke, in press) has shown that most of them are not rare and that some are even abundant. For example, *Acroloxus coloradensis* (Henderson), previously known only from 4 lakes in the Rocky Mountains, has been found in 5 other localities in eastern Canada and may be widely distributed. *Physa jennessi jennessi* Dall, previously recorded only from its type locality near Bernard Harbour in the Canadian Arctic has now been collected from about 30 localities along the arctic mainland coast and near both sides of Hudson Bay. It appears to be a common arctic species. *Physa jennessi skinneri* Taylor, another presumably rare taxon, is now known from approximately 100 localities within the Canadian Interior Basin alone and should be considered abundant. Of the 103 species and subspecies now recognized from that region none now appear to be in danger of extinction by man.

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AMERICAN MALACOLOGICAL UNION SYMPOSIUM
RARE AND ENDANGERED MOLLUSKS

3. EASTERN FRESHWATER MOLLUSKS (II) THE SOUTH ATLANTIC AND GULF DRAINAGES

by William H. Heard

Florida State University,
Tallahassee, Florida 32306, *U.S.A.*

INTRODUCTION

The eastern United States contains over 50 major drainage systems, as well as many smaller ones, between the St. Croix River on the Maine - New Brunswick, Canada, border and the Rio Grande River on the Texas - Mexico border. In addition, the interior drainages contribute to the very extensive Mississippi River and Great Lakes - St. Lawrence River watersheds.

The coastal drainages have been designated by Simpson (1900) and H. & A. van der Schalie (1950) as comprising the Atlantic and Apalachicolan, as well as part of the Interior Basin (= Mississippian), faunal regions for unionid mussels. The Atlantic region has been divided into a northern and a southern element, with the Potomac River drainage employed as the demarcation between the 2 parts. This report will cover the freshwater gastropods and bivalves of the South Atlantic Region from the Potomac River in Maryland to the St. Marys River on the Georgia - Florida border, peninsular Florida, the Apalachicolan Region, and the southern-most portion of the Interior Basin (i.e., the Alabama River system west to the Rio Grande drainage in Texas).

Unfortunately, there are significant gaps in our knowledge of the taxonomy, phylogenetic relationships, and geographical and ecological distribution of the mollusks of many of the drainages. Efforts have been made in recent years to correct our ignorance, and it is hoped that the effect of this symposium will be to stimulate both further and more intensive research in these areas.

THE NATURE OF THE FAUNA

In general, the streams flowing into the Atlantic Ocean and Gulf of Mexico contain rather endemic mollusk elements. Each region or subregion is characterized by the presence and/or absence of various genera and species, and even within a single region striking differences in the fauna may occur from one stream to another.

For example, one-half of the entire mollusk fauna of the Apalachicolan Region is endemic (e.g., *Notogillia* Pilsbry and *Quincuncina* Ortmann), about one-quarter also extends to the north and west, and the remaining nearly one-quarter extends southward into central Florida (Clench & Turner, 1956). Examining the mussel fauna (Unionidae) separately, one finds that one-fourth of the species are endemic, another quarter are related to eastern (South Atlantic) species, and half of the species have western (Interior Basin) affinities (van der Schalie, 1940).

Within this same Apalachicolan Region, different drainages often have different assemblages of mollusks, i.e., vary in the numbers and kinds of species present. In comparing the elements of the whole region, Clench & Turner (1956) clearly point out that the Apalachicola River (with its major tributaries, the Flint, Chattahooche and Chipola rivers) contains the greatest total number of species, the largest number of

species endemic to the region, and the largest number of species endemic to any single one of the drainage systems. In contrast, the Suwannee River drainage has fewer total species, has a proportionately smaller fauna which is endemic to the region, and altogether lacks species endemic to that drainage.

These relationships of endemism (both between and within regions) appear to occur throughout the coastal drainages in the eastern United States, while widespread species typify (in part) the much larger Interior Basin. If one compares freshwater mollusks regionally, however, it becomes immediately clear that the South Atlantic and Apalachicolan faunas are depauperate in relation to those of the southern part of the Interior Basin (particularly as concerns the large Alabama River system).

THE NATURE OF THE AREA

The drainage systems of the South Atlantic Region, peninsular Florida, the Apalachicolan Region and the southern part of the Interior Basin traverse one or more of the following physiographic provinces (as listed and described by Fenneman, 1938): Appalachian Mountains/Highlands, Valley and Ridge, Blue Ridge, Piedmont Plateau and Coastal Plain (both the Atlantic and Gulf portions). Short streams are usually confined to the Coastal Plain, while larger drainage systems may have tributaries flowing through several provinces. For example, the Coosa River tributary of the Alabama River system originates in the Blue Ridge and flows through the Valley and Ridge Province and the Piedmont Plateau before entering the Alabama River proper in the northern Gulf Coastal Plain. Another tributary, the Tombigbee River, flows largely through the Gulf Coastal Plain (a tributary of its own, the Black Warrior River, originates in the Appalachian Highlands) where it joins the Alabama River proper only about 25 miles from the Gulf of Mexico.

Striking differences in the freshwater mollusk fauna(s) occur between and occasionally within, different physiographic provinces. The Piedmont Plateau has a very sparse fauna, and most of the species of the rich fauna of the Coosa River occur in the Valley and Ridge Province. And frequently, the Coastal Plain assemblage is quite distinct from the composition found upstream in another province.

These phenomena are mentioned here to point out that within a single faunal region distinct elements of the biota may be found in different "zones" of the same drainage. These faunal elements may reflect a variety of circumstances, such as (1) a group which is adapted to living in small stream conditions versus a large river habitat, (2) an area which is comparatively "more favorable" for such factors as type and/or quantity of food or substrate conditions, or (3) preclusion of a part or all of the fauna because of industrial pollution.

Such generalities are frequently made to explain the presence or absence of species in/from an area without more specific information. It is particularly common to blame pollution for the absence of some or all biota, and while this conclusion may often be valid it is nearly always based on superficial observation. More detailed information concerning ecological requirements and hazards are in effect lacking, and such data are desirable for all species, and in particular for those which are localized in distribution and can be considered rare and/or endangered.

CHANGES IN THE FAUNA

It should be clear to all that the freshwater mollusk fauna(s) of the eastern United States has been altered and is continuing to change at an amazing rate, often in a disadvantageous direction.

The following categories of circumstances and the accompanying specific examples

reflect largely personal observations; a few conditions were taken from the literature. Further information is currently being assembled on the freshwater mollusks of peninsular Florida and the drainages of the South Atlantic Region, principally by the workers at Harvard's Museum of Comparative Zoology. More complete data will be provided when their studies are published.

Species of Decreased Abundance/Distribution

The natural ranges of many species of plants and animals are diminishing, largely due to human alteration of the environment(s). This circumstance is demonstrated, in part, by the reduced abundance of organisms in an area. Unless at least a few breeding individuals can be maintained, the population will become extinct. And if this course is followed by numerous populations, the species may be summarily reduced in its geographic distribution and perhaps eventually experience total extinction.

Pomacea paludosa Say (Gastropoda: Pilidae) occurs in southern Georgia and Alabama and throughout Florida. Because of the activities of the U.S. Army Corps of Engineers, large tracts of the Everglades in southernmost peninsular Florida have been drained. One result of this action has been the destruction of this snail's habitat, and consequently their numbers have decreased in this region. Similarly, the Florida kite, a bird which preys upon *P. paludosa* in the Everglades, is diminishing in numbers.

Another example concerns two unionid clams. In 1963 *Anodonta imbecilis* Say and *A. peggyae* Johnson occurred in approximately equal numbers in Lake Talquin (the type locality of *A. peggyae*!), a reservoir of the Ochlookonee River, Leon-Gadsdon County, Florida. Since that time, however, *A. imbecilis* has become all but extinct and *A. peggyae* has become drastically reduced in numbers in the impoundment. This situation has evidently been wrought principally by the Florida Fresh Water Fish and Game Commission which has administered rotenone to the reservoir to remove a pest fish, the grizzard shad (= *Dorosoma cepedianum*). After such treatment, the shore is littered with numerous decaying bivalves of several species.

Clench & Turner (1956) state that *Goniobasis albanyensis* Lea (Gastropoda: Pleuroceridae) probably formerly occupied the entire Apalachicola River system but that it now is confined to the Flint and Chattahoochee tributaries. Farming and consequent silting is listed as the cause of the decline not only of *G. albanyensis* but also of *G. boykiniana* (Lea) which is considered nearly extinct.

Notogillia wetherbyi Dall (Gastropoda: Hydrobiidae) is recorded by Clench & Turner (1956) as inhabiting the St. Johns, Suwannee and Apalachincola drainage systems. It has also been discovered as fossil along the McBride's Slough tributary of the Wakulla River in Wakulla County, Florida. For unknown reasons, it is extinct in that drainage now.

Extinct Species

Although several fossil species of freshwater mollusks have been described from the South Atlantic and Gulf Coastal drainages, very few have become extinct in comparatively recent times.

Ordinarily, a list of such species would include those of the genus *Tulotoma* Haldeman (Gastropoda: Viviparidae). However, in the past few years intensive collecting by Mr. Herbert Athearn of Cleveland, Tennessee, has located 1 living population each of 2 species, *T. angulata* (Lea) and *T. magnifica* (Conrad), in the Coosa River tributary of the Alabama River. The Coosa River is crossed by a number of dams, and the attendant impoundments as well as silting and pollution have served to drastically alter the original aquatic fauna(s). Consequently, the 2 populations of *Tulotoma* may represent the last remnants of this genus.

Among the pleurocerid snails, Clench & Turner (1956) list *Goniobasis catenoides*

(Lea), known only from the Chattahoochee River at Columbus, Georgia, as extinct, "apparently ... exterminated by river silt."

Extinct Communities

On occasion, one may find that a habitat previously visited has been destroyed and that the assemblage of mollusks at that site has been eliminated.

We are fortunate indeed to have such faunal lists as that prepared by Hinkley (1906) for the Yalobusha River (and other drainages) and that by Frierson (1911) for the Pearl River (in part), both in Mississippi. The Yalobusha and Pearl drainages presently receive substantial industrial effluents, and the former faunas at Grenada and Jackson (respectively) have been obliterated. Further downstream, beyond the recovery zone, one may again find elements of the fauna that formerly resided upstream. In the Pearl River at Columbia, Mississippi, approximately 100 miles downstream from Jackson, one can collect over 20 species of unionid mussels. But only upstream from the bridge (U.S. Hwy. 98), because immediately under the bridge the stream again receives an odorous contribution, the Columbia sewage. A striking zonation can be observed, and no mussels occur below the source of the effluent.

More horrifying still are examples of the extinction of the fauna of nearly entire drainages. A paper mill at Foley, Florida, voids its wastes into the Fenholloway River about 15 miles from the Gulf of Mexico. The entire fauna and flora of the main channel has been totally destroyed, and only remnants remain in the unaffected small tributaries. A similar situation, involving phosphate mining pollution, has effected the decimation of the fauna in the main channel of the Peace River in peninsular Florida.

DISCUSSION (THE ENDANGERED FAUNA)

The overall changes in the freshwater mollusk fauna(s) of the eastern United States brought about by human activities have been immense, although only a few examples have been cited here.

Examination of a drainage map of the United States reveals a paucity of natural lakes in the Atlantic and Gulf coastal states as compared to those of the northern areas which felt the impact of glaciation, one effect of which was to scour out depressions which became lake basins. Evidently the evolution of freshwater gastropods has followed accordingly. The majority of aquatic pulmonates are in the north, and most prosobranchs occur in the south. Nearly the entire fauna of the south is composed of gilled species, and as such it is more susceptible to disruption of the aquatic environment than the lunged basommatophorans of the northern lakes.

Most gilled aquatic mollusks are stream-dwellers, and they are affected if the stream is altered in some way such as by (1) dam construction and impoundment of stream water to provide recreational facilities, better navigation, and/or a source of electric power, (2) industrial pollution which affects the chemical content of the water (by robbing the stream of dissolved oxygen, adding toxic materials, and/or adding normally non-toxic materials in toxic quantities), and/or by (3) extensive farming which through erosion will increase the silt content of streams, a process tending to progressively destroy the aquatic fauna.

Although Birmingham, Alabama, lies several hundred miles upstream from the Gulf of Mexico and numerous dams occur along the Alabama-Coosa River waterway, attempts have been made to promote this city as a seaport. The aquatic mollusks of the drainage have already been extensively damaged by impoundment-production (as well as by silting and pollution), yet further efforts are underway to construct additional dams (with locks), threatening the remaining species.

Industrial plants are continually arising alongside or near streams, and while attempts to encourage conservation are everywhere these days there are too few and/or too weak laws to punish or correct violations. Plans for the construction of a paper mill on the Apalachicola River between Bristol and Blountstown, Florida, are now under consideration. Unless measures are taken for adequate treatment of the effluents, we will most certainly lose the mollusks of the main channel, particularly *Glebula rotundata* (Lamarck) (Pelecypoda: Unionidae), a large stream species which finds its eastward limit in this drainage.

The southern states are comparatively agricultural (e.g., cotton, peanuts, tobacco), and soil conservation must be practiced not only for human benefit of continued crops but also for the perpetuation of the aquatic fauna. Silting is often said to affect mollusks by interfering with their respiration and/or feeding, and by altering the substrate disadvantageously. Specific evidence, particularly of an experimental nature, is largely lacking, however.

One can and must conclude that all of our freshwater mollusks, not only those of the eastern United States, are endangered. The factors which have partially or totally destroyed such faunal elements continue to plague us. Particular concern should be afforded not only rare and/or diminishing species (e.g., the unionids *Pleurobema collina* (Conrad) of the James River, Virginia, and the Tar River, North Carolina; and *Elliptio spinosa* (Lea) of the Altamaha River drainage in Georgia (Boss & Clench, 1967)), but also those which are greatly restricted in range even though they may be abundant in it (e.g., the unionids *Elliptio mcmichaeli* Clench & Turner and *Quincuncina burkei* Walker of the Choctawhatchee River system in southern Alabama and the Florida panhandle (Clench & Turner, 1956)). If such streams are sufficiently changed in some way, these endemic forms will vanish.

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Discussion of Dr. Heard's Paper

by Herbert D. Athearn

Cleveland, Tennessee 37311, *U.S.A.*

My field work on the freshwater mollusks of the Gulf of Mexico drainage region began in 1941 and has been carried on intensively since 1954. During that period collections were made at about 500 stations. Many species were found to be abundant, others are common, and some are rare or very rare and have been found on only one or a few occasions. Other species previously reported from the region have never been collected by me.

Some species have apparently become very rare or perhaps even extinct during the past few years because of water pollution, dam construction or other habitat disruption. Dam construction on the Coosa River has eliminated almost all riffle habitats and has been particularly destructive to the rich, endemic fauna which previously flourished there.

Several of these now rare and endangered, or possibly extinct, species have already been mentioned by Dr. Heard. Unfortunately an additional large number should also be inserted into the preliminary list. These are as follows:

SOUTHERN AND CENTRAL TEXAS DRAINAGES

UNIONIDAE
- *Fusconaia friersoni* B. H. Wright 1896
- *Fusconaia lananensis* Frierson 1901
- *Fusconaia ridelli* Lea 1861
- *Quadrula aurea* Lea 1859
- *Lampsilis bracteata* Gould 1866

LOWER MISSISSIPPI AND ATCHAFALAYA RIVER TRIBUTARIES

PLEUROCERIDAE
- *Lithasia hubrichti* Clench 1965
- *Anculosa arkansensis* Hinkley 1915

UNIONIDAE
- *Margaritifera hembeli* Conrad 1838
- *Fusconaia missouriense* Marsh 1901
- *Arkansia wheeleri* Walker & Ortmann 1912
- *Ptychobranchus occidentalis* Conrad 1836
- *Lampsilis streckeri* Frierson 1927
- *Dysnomia florentina curtisi* Utterback 1915
- *Dysnomia lefevrei* Utterback 1915

TOMBIGBEE - ALABAMA - COOSA RIVER SYSTEM

NERITIDAE
- *Lepyrium showalteri* Lea 1861

VIVIPARIDAE
- *Lioplax cyclostomatiformis* Lea 1844

AMNICOLIDAE
Clappia cahabensis Clench 1965
Clappia clappi Walker 1909
PLEUROCERIDAE
Pleurocera foremani Lea 1842
Pleurocera showalteri Lea 1862
Goniobasis alabamensis Lea 1861
Goniobasis bellula Lea 1861
Goniobasis brevis Lea 1842
Goniobasis bullula Lea 1861
Goniobasis caelatura stearnsiana Call 1886
Goniobasis cahawbensis fraterna Lea 1864
Goniobasis capillaris Lea 1861
Goniobasis clausa Lea 1861
Goniobasis crenatella Lea 1860
Goniobasis fusiformis Lea 1861
Goniobasis gibbera H. H. Smith, Goodrich 1936
Goniobasis hartmaniana Lea 1861
Goniobasis haysiana Lea 1842
Goniobasis impressa Lea 1841
Goniobasis jonesi Goodrich 1936
Goniobasis lachryma Anthony, Reeve 1861
Goniobasis laeta Jay 1839
Goniobasis macglameriana Goodrich 1936
Goniobasis olivula Conrad 1834
Goniobasis pilsbryi Goodrich 1927
Goniobasis pupaeformis Lea 1864
Goniobasis pupoidea Anthony 1854
Goniobasis pygmaea H. H. Smith, Goodrich 1936
Goniobasis vanuxemiana Lea 1842
Gyrotoma alabamensis Lea 1860
Gyrotoma amplum Anthony 1860
Gyrotoma cariniferum Anthony 1860
Gyrotoma excisum Lea 1843
Gyrotoma hendersoni H. H. Smith, Goodrich 1924
Gyrotoma incisum Lea 1843
Gyrotoma laciniatum Lea 1845
Gyrotoma lewisi Lea 1869
Gyrotoma pagoda Lea 1845
Gyrotoma pumilum Lea 1860
Gyrotoma pyramidatum Shuttleworth 1845
Gyrotoma spillmani Lea 1861
Gyrotoma walkeri H. H. Smith, Goodrich 1924
Anculosa choccoloccoensis H. H. Smith, Goodrich 1922
Anculosa clipeata H. H. Smith, Goodrich 1922
Anculosa coosaensis Lea 1861
Anculosa foremani Lea 1842
Anculosa formosa Lea 1860
Anculosa griffithiana Lea 1841
Anculosa ligata Anthony 1860
Anculosa melanoides Conrad 1834
Anculosa modesta H. H. Smith, Goodrich 1922

Anculosa picta Lea 1860
Anculosa showalteri Lea 1860
Anculosa taeniata Conrad 1834
Anculosa torrefacta H. H. Smith, Goodrich 1922
Anculosa vittata Lea 1860

ANCYLIDAE

Rhodacmea cahawbensis Walker 1904
Rhodacmea filosa Conrad 1834
Rhodacmea gwatkiniana Walker 1917
Rhodacmea rhodacme Walker 1917
Neoplanorbis carinatus Walker 1908
Neoplanorbis smithi Walker 1908
Neoplanorbis tantillus Pilsbry 1904
Neoplanorbis umbilicatus Walker 1908
Amphigyra alabamensis Pilsbry 1906

UNIONIDAE

Fusconaia rubidula Frierson 1905
Quadrula archeri Frierson 1905
Quadrula stapes Lea 1831
Pleurobema aldrichianum Lea 1858
Pleurobema altum Conrad 1854
Pleurobema avellana Simpson 1900
Pleurobema concolor Lea 1861
Pleurobema decisum Lea 1831
Pleurobema favosum Lea 1856
Pleurobema fibuloides Lea 1859
Pleurobema furvum Conrad 1834
Pleurobema hagleri Frierson 1900
Pleurobema hanleyanum Lea 1852
Pleurobema hartmanianum Lea 1860
Pleurobema instructum Lea 1861
Pleurobema interventum Lea 1861
Pleurobema irrasum Lea 1861
Pleurobema johannis Lea 1859
Pleurobema lewisi Lea 1861
Pleurobema meredithi Lea 1858
Pleurobema murrayense Lea 1868
Pleurobema perovatum Conrad 1834
Pleurobema rubellum Conrad 1834
Pleurobema simulans Lea 1874
Pleurobema showalteri Lea 1860
Alasmidonta mccordi Athearn 1964
Strophitus alabamensis Lea 1861
Ptychobranchus foremanianum Lea 1842
Ptychobranchus greeni Conrad 1834
Obovaria curta Lea 1859
Plagiola lineolata Rafinesque 1820 (secure elsewhere)
Lampsilis altilis Conrad 1834
Lampsilis perovalis Conrad 1834
Lampsilis perpasta Lea 1861
Villosa propria Lea 1865
Dysnomia metastriata Conrad 1840

Dysnomia othcaloogensis Lea 1857
Dysnomia penita Conrad 1834

EASTERN GULF DRAINAGES: ESCAMBIA TO SUWANNEE RIVER

UNIONIDAE
Margaritifera hembeli Conrad 1838
Quincuncina burkei Walker 1922
Megalonaias boykiniana Lea 1840
Pleurobema pyriforme Lea 1857
Elliptio sloatianus Lea 1840
Alasmidonta triangulata Lea 1858
Medionidus penicillatus Lea 1857
Lampsilis australis Simpson 1900
Lampsilis binominata Simpson 1900
Lampsilis haddletoni Athearn 1964
Lampsilis jonesi van der Schalie 1934

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AMERICAN MALACOLOGICAL UNION SYMPOSIUM
RARE AND ENDANGERED MOLLUSKS

4. WESTERN FRESHWATER MOLLUSKS

by Dwight W. Taylor

Arizona State University,
Tempe, Arizona 85281, *U.S.A*

(Editor's Summary)

Dr. Taylor discussed in detail the nature of the fauna and the changes which are occurring. The full text of his paper is not available for publication but his list of recently extinct and/or rare and endangered species (status uncertain, and only those already named) is as follows:

Valvata virens Tryon, 1863. Clear Lake, and a lake near Watsonville, California.
Fontelicella idahoensis (Pilsbry, 1933). Snake River, southwestern Idaho.
Pyrgulopsis nevadensis (Stearns, 1883), Pyramid Lake, Nevada.
Durangonella mariae Morrison, 1945. Valley of Mexico.
Durangonella seemanni (Frauenfeld, 1863). Durango City, Mexico.
Planorbella traskii (Lea, 1856). Lakes in southern San Joaquin Valley, California.
Menetus opercularis (Gould, 1847). Mountain Lake, San Francisco, California.
Physa columbiana Hemphill, 1890. Columbia River below The Dalles, Oregon-Washington.
Physa humerosa Gould, 1855. Upper Gila River, Arizona-New Mexico.
Physa virginea Gould, 1847. Mountain Lake, San Francisco, California.

Discussion of Dr. Taylor's Paper

by Harold D. Murray

Trinity University, San Antonio, Texas 78212, *U.S.A.*

Dr. Taylor has carefully and accurately analyzed the numerous causes of the changes in the molluscan fauna of Western North America. Perhaps his most succinct statement is "...the greatest handicap to evaluating the endangered species is the general lack of knowledge of the fauna." That statement needs no further elaboration.

The definition of "Western North America" used by Dr. Taylor is adequate for the purposes and discussion he presents. This author would be inclined to extend the eastern border of his definition into the Great Plains possibly as far east as longitude 100. This eastward extension is possible not because of faunal similarities to the far western area but because the same factors in faunal changes also apply there.

This author is impressed by the vivid references to the rich endemic fauna of Cuatro Cinegas in northeastern Mexico. I wonder how many similar such habitats exist in the vast area of western United States.

I disagree with but one of Dr. Taylor's comments. He states that no field evidence of deleterious effects of introduced species of mollusks have been observed. At present, I know of one example located 30 miles north of San Antonio, Texas. *Melanoides tuberculatus* and *M.* (*Thiara*) *graniferus* have invaded the type locality of *Goniobasis comalensis* Pilsbry 1886 to the extent that *G. comalensis* is now extremely

difficult to find where it was once common. Furthermore, several other habitats where *G. comalensis* was once common are now predominately occupied by one or both of the above introduced species. It is possible that either *M. tuberculatus* or *M. graniferus*, or both, could in time find their way to some of the localities of endemic native species to which he refers and have serious effects.

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AMERICAN MALACOLOGICAL UNION SYMPOSIUM
RARE AND ENDANGERED MOLLUSKS

5. EASTERN LAND SNAILS

by William J. Clench

Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts 02138, *U.S.A.*

The preservation of our land mollusks is an almost impossible task. The allocation of small as well as large areas as National Parks or National and State forests will in a measure preserve some of our species. Other than in a limited number of cases, it would be impossible to prevent the extermination of certain species or races which have a very restricted distribution. What has occurred on the Lower Florida Keys is parallel if not similar to what has taken place over much of North America. Most of the area composing the Lower Florida Keys was and is privately owned and as such is subject to the whims, one way or another, of the owner of the property. A classic example is that of Lower Matecumbe Key, about midway in the Lower Keys.

I first saw this key during the winter of 1929. At that time Lower Matecumbe was relatively undisturbed. There was, of course, both the auto road and the Florida East Coast Railroad, both of which had a right-of-way cut through the length of the key. Hammock land was rather extensive and *Liguus* were abundant. About 1935 a very severe hurricane completely destroyed a group of beach hammocks along with *Liguus solidus dohertyi* Pflueger, a color form known only from these small hammocks. About 1953, land clearing and the building of fishing camps and other tourist attractions eliminated just about all of the hammock land and, of course, a few more color forms of *Liguus* peculiar to this Key. This same type of destruction has occurred along the entire series of keys from near Miami to Key West.

In general, the loss of our land mollusks is not due to pollution but to land clearing, strip mining, fire and other factors which destroy or completely change the natural habitat. At this time we have but little control over many of these factors.

Pesticides and weed killers cause an element of pollution, perhaps only in local areas where they are used, so far as it concerns the land mollusks. Both of these may be far more serious as a pollution problem in our freshwater streams due to surface run-off. In the North, during winter months, tons of salt are used to keep the highways free from ice. This same salt becomes a most important pollutant when carried into our roadside streams and ponds. Even trees and other vegetation along the highways are killed by the salt.

With relatively few exceptions most of our eastern land mollusks possess a fairly large distributional range. As a consequence, many or most of these species will be under "protective custody" in our National and State Parks and Forests.

Species and subspecies with a restrictive range or those known from but a single locality are far more difficult to protect. We are probably even unaware of the existence of many unique populations which need protection.

Factors given above will also hold for most of the West Indies. Rapid air transportation is making most of these tropical islands easily accessible and shortly these will be subjected to the ever increasing pressure of the tourist.

A curious factor which is detrimental to colonies of *Cerion* in Cuba is the quest for "sharp" sand for concrete and cement work. *Cerion* lives only along the upper strand line in Cuba and it is here where this type of commercial sand occurs. As a consequence areas along this strand line are completely destroyed. Bulldozers cut down as much as 6 feet into jumble of coral rock and sand, destroying the vegetation of bushes and small trees, and of course the colonies of *Cerion*.

Discussion of Dr. Clench's Paper

by Dee S. Dundee

Department of Biology, Louisiana State University, New Orleans, Louisiana 70122, *U.S.A.*

In considering rare and endangered eastern land snails, several questions come to mind. First, what exactly does rare mean? Does it mean those which once had a wide distribution but now are restricted to a few places? Or does it mean those that always have been restricted to a few places where they continue to maintain the population at a high level? Or does it mean those that have a wide range as a species but have the individuals widely scattered within that range? Or, does it mean all of these? One must resolve these questions before he can set about thinking clearly of the problem at hand.

Once a decision is reached about the meaning of rare, one must ask, if it is rare, then is it necessarily endangered? After wrestling with these questions and discussing them with my colleagues, I find that I am still confused. Therefore, I have had arbitrarily to select, as being rare, those snails which are, for one reason or another, now limited to one area (a State or less). I have decided that, even though they are rare, they are not necessarily endangered. Upon these premises I shall proceed with my comments.

Here we should consider some other questions: first, what will cause the extinction of any species? Dr. Clench has mentioned a few things: climatic factors such as hurricanes, the clearing of land by man, strip mining, fire, pesticides. There are, of course, many others such as other types of climatic changes, soil changes, biological introductions, and so on. Second, what general types of snails are most likely to disappear? Assuming that edaphic factors such as climate and soils remain somewhat constant (they never do) in the near future, it would appear, as Dr. Clench has pointed out, that those snails having a restricted range or those from a small locality, or in some cases, the larger, more conspicuous forms would be most likely to disappear. Those ranging widely over much of eastern North America may have their populations depleted by man, but they should survive and most probably will adapt to the new environments created by man (e.g., where did all of those which now live in flower and vegetable gardens and lawns live prior to 1609?). Next we must ask, which of the eastern land snails then are likely to become extinct? Or which, if any, should we protect? Here we must use our arbitrary decisions as to what is rare and, if it is rare, is it endangered. I have checked through the land snails of eastern North America and have arrived at the following possibilities. Dr. Clench mentions only one, *Liguus*, which is truly North American. I believe that others *may* also be considered. I certainly am *not* proposing that we include all of these in a list of rare and endangered forms. I only ask that my colleagues consider these in the light of their experiences and help me decide.

(After the session various malacologists contributed deletions and additions and the following list is the result.)

Pomatiasidae:	*Opisthosiphon bahamensis* (Pfeiffer)	Florida
Oleacinidae:	*Varicella gracillima floridana* (Pilsbry)	Florida
Polygyridae:	*Triodopsis soelneri* (Henderson)	North Carolina
	Stenotrema hubrichti Pilsbry	Illinois
	Polygyriscus virginianus (P. R. Burch)	Virginia
	Polygyra hippocrepis (Pfeiffer)	Texas

Pupillidae:	*Bothriopupa variolosa* (Gould)	Florida & Yucatan
	Sterkia eyriesi rhoadsi (Pilsbry)	Florida
Sagdidae:	*Hojeda inaguensis* (Weinland)	Florida Keys - Bahama Islands
Zonitidae:	*Vitrinizonites uvidermis* (Pilsbry)	North Carolina, Tennessee
	Pilsbryana tridens (Morrison)	Oklahoma, Texas
	P. aurea (Baker)	Tennessee
	Paravitrea roundyi (Morrison)	Oklahoma
	P. variabilis (Baker)	Tennessee, Oklahoma
	P. aulacogyra (Pilsbry & Ferriss)	Arkansas
	Clapiella saludensis (Morrison)	South Carolina
Bulimulidae:	*Liguus fasciatus* (Müller)	Florida
	Orthalicus reses (Say)	Florida
	O. floridensis (Pilsbry)	Florida
	Drymaeus dormani (Binney)	Florida
	D. dominicus (Reeve)	Florida
Cerionidae:	*Cerion incanum* (Binney)	Florida

It is very difficult to really decide if some of these are endangered; one really needs to be working with the groups to know for sure.

A final question, and one which will be very unpopular, is this: should we worry about our rare species of eastern land snails? When one considers that the molluscs are a very old group dating back 600 million years, one must realize that there surely have been many species which lived and became extinct in that much time. Many of them doubtlessly were as desirable as those about which we now are concerned. In fact, those which concern us now may have taken the places of some of the earlier ones. Perhaps the destruction of these present day forms is merely the next evolutionary step in the scheme of things with man being the evolutionary agent. A prominent ecologist has pointed out that, despite the fact that man is severely changing the landscape, there *are* organisms adapting to those changes and filling the niches of those wiped out by the changes. This whole question is a very philosophical one and has many ramifications but it *is* one which we should consider. Dr. Clench pointed out in his opening statement that the preservation of land molluscs is an almost impossible task.

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RARE AND ENDANGERED MOLLUSKS

6. WESTERN LAND SNAILS

by Allyn G. Smith

Department of Invertebrate Zoology, California Academy of Sciences, San Francisco, California 94118, *U.S.A.*

INTRODUCTION

Viewed from the most pessimistic angle, it might be stated that all land mollusks indigenous to the western part of the United States are endangered to some degree. The rapid growth of the West has been spectacular and indications are that this will be accelerated in the future. While this is particularly true of the States west of the Rocky Mountains, to a much lesser degree has it affected Alaska, western Canada and Mexico, but even in these broad areas such growth is beginning to be felt. This massive advance in civilization, brought about by what amounts to a population explosion, brings with it the construction of more and ever wider freeways for motor traffic; bigger and higher dams that cause the flooding of beautiful, scenic cañons; bigger airports and similar projects that take over more and more wild land, scar the countryside and destroy land-snail habitats right and left. Developers are creating new towns and housing projects. The industrial trend is creating a movement from the central cities into outlying areas. This, with the air pollution and garbage disposal problems that result, bodes ill for the future of many western land snails, none of which can survive out of their natural habitats. There are a few species of land mollusks that do tolerate the advance of civilization - *Helix aspersa*, *Oxychilus cellarius* and several species of slugs to mention a few. But these are European immigrants and are not pertinent to this discussion.

The future picture does, however, have some bright spots. The western national, state and local parks provide habitats for many snail species. Those living in these areas are definitely not endangered and hopefully never will be. We are only just beginning to wake up to the need to preserve more wild areas for the enjoyment of future generations of people, and public opinion, prodded by an increasing number of conservation-minded folks, seems to be moving in this direction, however slowly. This augurs well for the extension of the great western park systems, the creation of "green belts," and the setting aside of wilderness areas safe from the incursion of loggers, miners, cattle men, resort developers and others of like ilk whose interest in the preservation of our natural resources leaves something to be desired.

Another bright spot for the future well-being of indigenous land snails is the western "lay of the land," with its vast mountainous and desert areas. Much of these are so inaccessible and incapable of "improvement," or the climatic conditions are so adverse, that the so-called advance of man and his works is prevented or at least severely limited and will remain so. Land snails that live in such areas will continue to do so without habitat interference.

Fortunately, also, the ranges of many western land snail species are sufficiently extensive geographically so that the liklihood of wiping them out completely is remote. There is a danger here, however, for future malacological studies dealing with ecology and with species evolution. The possibility of eliminating certain local races of widespread species through habitat destruction is imminent, especially where such races occupy limited areas.

Again, the relatively few collectors especially interested in land mollusks at present are not liable to endanger a species; but this may not be so true in the future. There is an ever-present danger from the over-collecting of some forms having an extremely limited distribution or living in micro-habitats not occurring anywhere else. Danger to such forms can and should be minimized in the interests of science. Land snail collectors can reduce this danger if they will operate with discretion, with a weather eye on the need to allow a race or a colony to perpetuate itself.

RARE AND ENDANGERED WESTERN LAND SNAILS

I can say, at the outset, that at present I know of no western land snail species that is so rare or endangered to the degree that exists, for example, in the case of the California Condor, the California Clapper Rail or the Trumpeter Swan. There may well be such but the west is a big country and includes thousands of square miles where I have not done any appreciable amount of collecting. Thus, I can comment only on those areas and those species with which I have had some familiarity starting in the year 1910, with the hope that others will be able to fill in the gaps.

Perhaps the most practical way to approach the subject is to use Pilsbry's two-volume monograph on the *Land Mollusks of North America* (*North of Mexico*), 1939-1948, published by the Academy of Natural Sciences of Philadelphia, taking the groups, family by family, and commenting on species known to be rare, or that appear to be in some danger of extinction. This, of necessity, will not cover species described since the Pilsbry Monograph was published - one of the gaps mentioned above.

For the sake of brevity in the following list, code letters are used, as follows:

R - Rare occurrence in nature (not because merely hard to collect);
L - Limited or local in geographic distribution;
E - Endangered or possibly endangered for stated reasons.

LIST OF SPECIES

Family HELMINTHOGLYPTIDAE

Monadenia

M. fidelis group. Widespread with many localized subspecies. Safe in redwood parks.

M. f. celeuthia Berry. R - L. Upper Rogue River valley.
M. f. pronotis Berry. R - L. Near Crescent City, Calif.
M. f. leonina Berry. R - L. Along Klamath River, Calif.
M. f. klamathica Berry. R - L. A high dam on the Klamath River could eliminate this and the preceding subspecies.

M. infumata group. Many localized races. Generally safe in redwood parks.

M. i. alamedensis Berry. R - L - E, by industrial development and housing expansion along the eastern shore of San Francisco Bay.

M. mormonum group. Many local races. Generally safe in mountain areas.

M. m. buttoni (Pils.). R - L - E, by construction of both high and low dams causing cañon flooding.
M. m. cala (Pils.). L. Safe in Calaveras Big Tree Park.
M. m. loweana Pils. R - L.
M. m. hirsuta Pils. R - L - E, from possible over-collecting.

M. troglodytes Hanna & Smith. R - L. Recently found living.

M. circumcarinata (Stearns). R - L. Possibly a relict species nearing extinction. Not found living in recent years.

M. hillebrandi (Newc.) & ssp. *yosemitensis* (Lowe). R - L. Safe in Yosemite and Kings River National Parks. A high dam across the Merced River below the Yosemite Park boundary could eliminate a local race.

Helminthoglypta

H. tudiculata series. Fairly widespread. Many local races and subspecies. Generally safe in mountain habitats.

H. t. grippi (Pils.). R - L.

H. t. angelena Berry. L - E, by industrial expansion.

H. cypreophila series. Widespread, and generally safe in mountain habitats.

H. allynsmithi (Pils.). R - L. A high dam across the Merced River Cañon could eliminate this species.

H. hertleini Hanna & Smith. R - L.

H. nickliniana series.

H. californiensis (Lea). L. The typical small form is practically gone from the type locality, a small off-shore islet being destroyed by wave action, but is safe in Pt. Lobos State Park.

H. berryi Hanna. R - L - E. Possibly nearing extinction as a relict species. Could be endangered further by over-collecting.

H. n. awania (Bartsch). R - L. Safe in Pt. Reyes National Seashore.

H. n. bridgesi (Newc.). L - E, by industrial and building expansion.

H. n. contracostae (Pils.). L - E, at the type locality from resort expansion or over-collection. The habitat for the race *arnheimi* on the east side of San Francisco Bay has been completely destroyed by industrial expansion.

H. arrosa series. Widespread and generally not endangered. Many local forms, coastal and inland.

H. a. holderiana (Cooper). L - E, by industrial expansion on the east side of San Francisco Bay.

H. a. miwoka (Bartsch). R - L. Safe in Pt. Reyes National Seashore.

H. a. pomoensis A. G. Smith. R - L. Some danger from logging operations.

H. a. mailliardi Pils. R - L.

H. ayresiana series. Limited to Santa Barbara Channel Islands. E, on San Miguel Id., the type locality, from U.S. Navy operations. The ssp. *sanctaecrucis* Pils. in no present danger on Santa Cruz Id.

H. walkeriana (Hemphill) and ssp. *morroensis* (Hemphill). R - L.

H. dupetithouarsi series.

H. dupetithouarsi (Desh.). An unnamed, dwarf race on an offshore islet (type locality of *H. californiensis*) is probably extinct from wave erosion of its micro-habitat.

H. cuyama Hanna & Smith. R - L.

H. benitoensis Lowe. R - L. Safe in Pinnacles National Monument.

H. sequoicola consors (Berry). L - E, by expansion of farming and industrial operations.

H. cuyamacensis series. Mostly in mountain habitats.

H. c. lowei (Bartsch). R - L.

H. c. avus Bartsch. R - L.

H. c. venturensis (Bartsch). R - L.

H. c. paiutensis Willett. R - L.

H. callistoderma (Pils. & Ferriss). R - L - E, possibly by a high dam across the lower Kern River Cañon.

H. orina Berry. R - L.

H. tularensis series. Mountain habitat. R. Mostly safe in Sequoia National Park.

H. napaea series. L. Mountain habitat. Safe in national parks. (Mohave desert

series). R - L. Several species with desert habitat. Not in danger at present.

H. traski series. Many subspecies and races. Mostly mountain habitat.

H. t. misiona Chace. R - L.

H. t. coelata (Bartsch). R - L.

H. t. coronadoensis (Bartsch). R - L - E, from over-collecting in island habitat.

H. t. pacoimensis Gregg. R - L.

H. t. fieldi Pils. R - L.

H. t. phlyctaena (Bartsch). R - L.

H. t. willetti (Berry). R - L - E, possibly by severe forest fires.

H. t. tejonis Berry. R - L.

H. carpenteri (Newc). R - L. Desert habitat.

H. similans Hanna & Smith. R - L. Desert habitat.

H. petricola series. Several species and subspecies. R - L.

H. stageri (Willett). R - L.

H. inglesi Berry. R - L.

H. lioderma Berry. R - L.

H. ferrissi Pils. R - L. A large race safe in Kings Cañon National Park.

H. proles series. Mountain habitats. Two subspecies. Generally safe in national parks.

H. euomphalodes Berry. R - L.

H. tularica (Bartsch). R? - L. A "lost" species.

Micrarionta. The southern and Lower California species, of which there are many, are confined to the Santa Barbara Channel Islands or to desert mountain habitats. *M. stearnsiana* (Gabb) is a mainland species and there are others in Lower California. Most are limited in distribution. Living specimens of desert species are rare and difficult to collect for the most part. Those that might be endangered at present are:

M. rufocincta (Newc.) and ssp. *beatula* Ckll. E, from resort expansion on Santa Catalina Id.

M. facta (Newc.). E. May be extinct on San Nicolas Id.

M. kelletti (Fbs.). L - E, from possible destruction of its cactus-patch habitat on Santa Catalina Id.

M. tryoni carinata Hemphill. R - E, especially on San Nicolas Id.

Sonorella. Widely distributed, as a genus, but many species, subspecies and local races have extremely limited distributions. Usually occurring in colonies but living specimens often rare and difficult to collect, as they are subterranean. Some forms are no doubt in possible danger from over-collecting or other causes. Dr. Walter B. Miller has studied the group recently and is in a better position than I to indicate species that may be endangered.

Humboldtiana. Mountain snails confined in the U.S. to the Texas border, extending south at least as far as Mexico City. U.S. species seem to be relatively rare but apparently not in danger.

Oreohelix. Mountain snails widespread in the West. Generally colonial and common, with many species, subspecies and local races. As a group, the Oreohelices do not appear to be in any particular danger although some forms having extremely limited distributions may be potentially endangered.

O. avalonensis (Hemphill). E, if not already extinct, the single known colony having been wiped out by the original collector many years ago.

Polygyrella. Fairly wide distribution in relatively unpopulated country.

Ammonitella. A relict genus, possibly on the way to extinction, though common at present, where found.

A. yatesi and ssp. *allyni* Chace. L - E, from possible over-collecting. The subspecies seems safe in a national park.

Polygyroidea. Possibly another relict genus. Mountain habitat.

P. harfordiana (J. G. Cooper). R - L. Safe in Mariposa Big Trees, the type locality, although it appears to be becoming increasingly rare there because of its extremely limited habitat. Also occurs in Merced River Cañon below Yosemite Park, where it could be endangered by a high dam.

Glyptostoma. Several southern California species and subspecies, all except *G. newberryanum* (W. G. B.) being localized and rare.

G. gabrielense Pils. L - E, from industrial development in the Dominguez Hills, near Los Angeles, but probably safe in Elysian Park, Los Angeles.

Family POLYGYRIDAE

Trilobopsis. Generally occurs in a mountainous habitat, in relatively unpopulated areas.

T. loricata series. Several subspecies, all more or less limited in distribution but not thought to be endangered.

T. trachypepla Berry. R - L.

T. roperi series.

T. roperi (Pils.). R - L.

T. tehamana (Pils.). R - L.

T. penitens (Hanna & Rixford). R - L - E, as type locality inundated by Folsom Reservoir. A new locality for this species discovered in 1968, which also may be in trouble from a resort developer.

Triodopsis.

T. devia (Gld.). E, because of industrial expansion in the Seattle area. May not be in danger elsewhere in its range.

T. mullani series. Many subspecies and local races in a mountainous habitat, generally in unpopulated country. In no present danger, as a group.

T. sanburni W.G.B. R - L.

T. populi (Van.). E. A high dam on the Snake River at Hell's Cañon may put this species in danger.

Allogona. Western species in no particular danger. Widespread in Pacific Northwest east of the Cascades in U.S. and Canada.

A. ptychophora solida (Van.). L - E, from a possible high dam at Hell's Cañon.

Vespericola. Many species and subspecies, plus local races, most not being in any present danger although the habitats of some are being restricted.

V. columbiana series.

V. c. depressa (Pils. & Henderson). R - L.

V. hapla (Berry). R - L.

Ashmunella. Mountain snails in Arizona and New Mexico. Many species, subspecies and local races. Generally colonial. I am not familiar with their abundance or rarity at the present time. Most seem not in danger, as a group, although some may be in danger from over-collecting.

Family SAGDIDAE

Thysanophora. Widespread in the Southwest and in Mexico (including Baja California).

Microphysula. Fairly widespread distribution. In no present danger.

Family BULIMULIDAE

Bulimulus. Western species (Pacific Southwest, Mexico and Baja California) occupy mountainous or desert mountain habitats. In no particular danger.

Family UROCOPTIDAE

Holospira. Numerous species in Arizona and New Mexico. Generally colonial in mountainous terrain. I am not familiar with forms that are presently rare, although some have limited distributions. Probably not endangered at present.

Coelocentrum. Several species and subspecies on islands in Gulf of California and in Baja California. Probably not endangered, as most are remote.

Family ACHATINIDAE

Rumina. Introduced into Arizona and California.

Cecilioides. Introduced into California.

Family HAPLOTREMATIDAE

Haplotrema. Numerous western species and subspecies. Smaller forms usually rare.

H. duranti (Newc.). Santa Barbara Channel Ids. only. R - E.

H. catalinense (Hemphill). R - L. Santa Catalina Id. only.

H. keepi (Hemphill). R - L.

H. transfuga (Hemphill). R - L.

H. voyanum (Newc.). R - L. No typical specimens found in recent years. May be extinct.

H. v. humboldtense Pils. R? - L?. Unknown to me. Possibly not related to true *H. voyanum*.

Family ZONITIDAE

Euconulus. Small; widespread. Mountainous habitat. Not in danger.

Oxychilus. Several introduced species. Adapts to civilization.

Retinella. Small mountain snails. Generally rare and seasonal. Probably not in danger.

Pristiloma. Small; seasonal. Numerous western species. Probably not endangered.

P. stearnsi (Bland). R.

P. pilsbryi Vanatta. R.

P. idahoense Pils. R.

P. arcticum (Lehnert). R.

P. a. crateris Pils. R - L.

P. lansingi (Bland). R.

P. johnsoni (Dall). R.

P. nicholsoni H. B. Baker. R - L.

P. shepardae (Hemphill). R - L. Island distribution only.

P. orotis (Berry). R - L.

P. gabrielinum (Berry). R - L.

P. wascoense (Hemphill). R - L.

P. subrupicola (Dall). R.

P. s. spelaeum (Dall). R - L. Not a true cave snail.

Hawaiia. Small; widespread. Not in danger.

Striatura. Small; widespread. Not endangered.

Vitrina. Widespread in mountains at higher elevations. Not in danger.

Megomphix. Shells similar to *Haplotrema*.

M. hemphilli (W. G. B.). R.

M. lutarius H. B. Baker. R - L.

M. californianus A. G. Smith. R - L.

Family ENDODONTIDAE

Anguispira. One common western form in Pacific Northwest and British Columbia. Not in danger.

Discus. Small mountain snails. Not endangered.

D. marmorensis H. B. Baker. R - L.

D.? selenitoides (Pils.). R - L. Safe in Yosemite Park.

Helicodiscus.

H. singleyanus (Pils.). R.

H. eigenmanni arizonensis (Pils. & Ferriss). R.

H. salmonaceus W.G.B. R - L.

Speleodiscoides.

S. spirellum A. G. Smith. R - L. Not a cave snail. Found living for the first time in 1967. May not be an endodontid.

Punctum. Small; generally widespread. Western species not endangered.

Radiodiscus. Small. Mountain habitat. Western species not in danger.

Family SUCCINEIDAE

Oxyloma. Western species probably not endangered.

O. nuttalliana (Lea). R.

O. n. chasmodes Pils. R - L.

O. haydeni kanabensis Pils. R - L.

O. hawkinsi (Baird). R.

Succinea. Western species generally not endangered.

S. rusticana Gld. R.

S. lutella Gld. R. In Arizona and New Mexico.

S. gabbi Tryon. R.

S. californica Fischer & Crosse. R. In Baja California.

S. oregonensis Lea. An unknown species.

Quickella. Western species not worked out taxonomically.

Family VALLONIIDAE

Vallonia. Western species not endangered.

V. gracilicosta Reinhardt. R - L. In western states.

V. albula Sterki. R - L. In western states.

Planogyra.

P. clappi (Pils.). R.

Cionella.

C. lubrica (Müller). R - L. In western states.

Family PUPILLIDAE

Gastrocopta
Chaenaxis
Pupoides
Pupilla
Vertigo
Sterkia

Many western species and subspecies, some with limited ranges (e.g., *Chaenaxis* and *Sterkia*). Not considered to be particularly endangered, especially in mountainous and desert habitats.

Family CARYCHIIDAE

Carychium.

C. exiguum (Say). R - L.

C. occidentale Pils. R.

Family TRUNCATELLIDAE

Truncatella.

T. simpsoni Stearns. R - L.

C. californica Pfeiffer. R - L.

The above list is, as stated earlier, far from complete. It omits any detailed mention of species living in western Canada (especially the northern provinces), Alaska and Arctic North America, whose status is not known to me. Similarly, I am not familiar with the extensive land snail fauna of Mexico (south of the Sonora Desert), or of Central America, where little collecting has been done in recent years. For such areas, much of which is largely unexplored conchologically, it probably can be stated categorically that the species living there are in no particular present danger.

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7. EASTERN MARINE MOLLUSKS

by R. Tucker Abbott

du Pont Chair of Malacology,
Delaware Museum of Natural History
Greenville, Delaware 19807, *U.S.A.*

The survival problems confronting marine species, although somewhat similar to those facing the land and fresh-water forms, are quite different in severity, manner of endangerment and nature of possible remedial measures.

Marine mollusks do not appear to be endangered in the same sense as are many birds, mammals and fresh-water mollusks. In my considered judgement, there are few, if any, marine species of mollusk, anywhere in the world, being led to extinction because of the activities of man. This, however, is mainly because the distribution of every species of marine mollusk is either very extensive over many hundreds of linear miles, or, in the case of a few highly endemic species, at least extended over many hundreds of square miles. Furthermore, bathymetric ranges in sublittoral species give additional protection.

Although no accurate figures are available, and, indeed, there is need for new studies along these lines, I would not hesitate to say that the well-known high mortality rates of marine mollusks are largely due to natural causes. Probably less than 1% of the annual death rate of all marine mollusks is due to the activities of man. Commercial fisheries would probably account for the greatest cause of man's reduction of mollusk populations; pollution and other environmental changes made by builders and engineers would probably come second; and shell collectors would make a very poor third.

From the distributional records being made by several research fisheries' boats and by casual dredging samplings by amateur conchologists and commercial shrimp trawlers, it would appear that there is a population band of *Macrocallista maculata* running from Alabama to central west Florida and from North Carolina to central east Florida, anywhere from 1 to 8 miles in width at depths ranging from 6 to 60 feet. This represents about 6,000 square miles of high density Calico Clam populations. The species, incidentally, extends through the Caribbean to Brazil. One might hazard a guess that about 2 billion bushels of this clam die every 5 years. Old age, fish, "red-tide," cold water, fungal diseases and shifting bottoms probably account for most of these deaths. Of the 2 billion bushels, I doubt if shell collectors account for more than 1,000 bushels, and most of these would be specimens cast ashore after storms. A similar situation exists for the vast majority of the marine mollusks.

Are some marine species being over-collected? Yes. Especially, locally; and especially the larger and edible species. Are they in danger of becoming extinct? No. Is over-collecting bad? Yes, because it reduces the density of the populations in certain areas to the extent that they are no longer available in commercial quantities (in the case of oysters, scallops, clams and edible whelks) or no longer present in sufficient numbers to satisfy the normal, modest requirements of hobby collectors. Among the species that are being over-collected in certain limited areas are *Strombus gigas* (the Pink Conch), *Cassis madagascariensis* (the Helmet Shell), *Pleuroploca gigantea* (the Horse Conch), *Cyrtopleura costata* (the Angel Wing), *Cyphoma gibbosum* (the Flamingo Tongue), *Melongena corona* (the King's Crown) and edible clams, scallops and oysters. Of all these species, the first 3 (*Strombus*, *Cassis* and *Pleuro-*

ploca) are the least able to replace their numbers, and are becoming comparatively uncommon, but certainly not extinct.

In addition to over-collecting, and I refer mainly to that created by commercial fisheries' activities and professional shell gatherers who sell to shell dealers, far-reaching and much more serious consequences can descend upon shore mollusks and, of course, other forms of marine life, by major engineering projects of man or by mass pollution of coastal waters by heavy metals, major heat transfers, massive oil spillage or altered currents. The filling of extensive marsh lands by real estate developers robs the coastal offshore waters of their life-giving source of nutrients. What's bad for a *Melampus* marsh snail is bad for a coastal shelf *Junonia*.

What practical protective measures are possible? Space does not permit me to discuss national pollution and conservation problems. Agencies of the United States government and well over 500 private foundations and organizations, such as the National Wildlife Federation and the Welder Wildlife Foundation, are actively working on these matters.

Over-collecting can be reduced by shellfishery laws and the dissemination of information among shell collectors. I have studied the shellfishery laws of each state, and in 1961 I published a digest of the laws of 24 of the U.S. states and Canadian provinces that have salt-water coasts (*How to Know the American Marine Shells*, Signet Key Book, KT 375, New American Library, Inc., N. Y., p 197-203). In this I said, "The laws were not created to annoy tourists or shell collectors or to interfere with students of marine life. Unfortunately, the regulations vary from state to state, and in many instances they are ambiguous, scientifically inaccurate, and self-contradictory. We recommend 3 general rules for collectors: cooperate with local wardens; ask local fishermen or ocean-front property owners about local restrictions; don't collect live oysters at any time. Beware of Sunday "blue law" restrictions, especially in eastern Canada and New Jersey. You may write to the director of fishery agencies for special collecting permits. Most states will issue them cheerfully without cost."

Many clubs are encouraging the conservation of mollusks. The Sanibel-Captiva club in Florida was the first to initiate a program of local education by publishing posters, flyers and booklets on "Don't Be a Pig." Other clubs have distributed "collecting creeds," urging members to take small samplings, rather than to pick up every specimen seen. Authors of popular articles and books are now urging the general public to collect in moderate numbers. These measures are helpful in local areas. In some good collecting spots you can find a choice specimen only because a thoughtful and courteous collector was there just before your visit.

One of the most successful systems of protecting our wildlife was championed by President Theodore Roosevelt, who began our system of National Parks and Wildlife Preserves. This is an ideal mechanism of ensuring reasonable protection to undersea life in many areas. There are several underwater parks in America, the first being the Key Largo Coral Reef Preserve, opened in Florida in 1960. The Department of Mollusks at the Academy of Natural Sciences has made surveys in such island groups as the Seychelles, Indian Ocean, with a view towards outlining the methods of establishing underwater preserves that will not interfere with the rights and livelihood of the local people. Other governments, as in Malaya, British Honduras and the Bahamas, are now taking active steps to protect sea life for future generations.

Discussion of Dr. Abbott's Paper

by Joseph Rosewater

Division of Mollusks, U.S. National Museum, Washington, D. C. 20560, *U.S.A.*

It is refreshing to learn that in regard to our marine mollusks it is unlikely that any species is endangered due to man's activities. I should like to make the point, however, that it may not always be possible to make a subjective determination on the probability of the extinction of a species. The fossil record tells us that long before the appearance of man millions of once living species had already ceased to exist. We are relatively sure that this is continuing, and in the case of such cryptic animals as mollusks, probably largely undetected.

What causes it? Probably many things, such as unsuccessful competition between species, changes in climate or in other characteristics of the habitat. It may be that there is inherent in each species a sort of evolutionary "time piece" which "runs down" at last. This is an enormous simplification which one day may be elaborated and more fully understood. The "running down," however, could certainly be hastened or delayed by a multiplicity of factors, many of which man may influence especially in the light of his recent population growth.

Persons, such as ourselves, who collect forms of life intensively and specifically may do well to approach the task thoughtfully. It is true that if we did not collect them the individuals would eventually die anyway. But if we collect every visible specimen of a species from a unit area, we may be upsetting the "balance of nature" in that spot. And if we destroy the habitat by turning rocks which we do not replace, etc., we may be sure that we have created havoc in that spot.

What can be done? Dr. Abbott has made what are probably the most effective suggestions to assure us of a continuing source of enjoyment in our hobby and work. Obey local collecting regulations; collect moderately and intelligently; support conservation efforts. To these I would like to add another suggestion which may appear questionable at first but which may be understandable upon reflection: avoid subjective measures which bring about major changes in the environment or species composition, for these have in the past, and almost certainly will in the future, upset evolution.

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8. WESTERN MARINE MOLLUSKS

by A. Myra Keen

Department of Geology, Stanford University,
Stanford, California 94305, *U.S.A.*

Having contacted several collectors who might know of any West Coast mollusks that are both rare and endangered, I am pleasantly surprised to come up with nearly negative findings. It is true that we have rare species. We also have areas and habitats that are threatened. As yet there seem to be few if any species qualifying in both categories.

I had thought that perhaps *Norrisia norrisi*, a trochid snail that feeds on the blades of giant kelp, might be in a precarious state, for the extent of the kelp beds has markedly diminished in southern California; also, commercial harvesting removes much of the annual production. However, Mr. John Fitch reports that although in places where pollution and sea urchins have destroyed the kelp, the snail is rare or missing, around some of the offshore islands and in untainted coastal waters it is still abundant.

The great hazard to marine populations on the Pacific Coast is not so much to certain species as it is to the whole ecosystem, especially in the shallow bays. This West Coast, characterized by a steep continental shelf and slope, has only a few bays, and most of the species that have adapted to the bay environment tend to be widespread in geographic range. If only part of the bays were threatened, the assemblages might be expected to survive in other areas. However, the pressure of human populations and the obsession on the part of developers to fill or radically modify the few bays that are here is cause enough for alarm. Pollution from industrial wastes, from sewer outfalls, and (most hazardous of all) from agricultural pesticide runoff has already had considerable effect on the marine fauna, and as it increases can cause enormous havoc. The voice of the conservationists is being raised, but here, as elsewhere in the country, the cry is yet too feeble to influence the expansionist planners.

Commercial development of shellfish resources on the West Coast has been limited by several factors. Oysters were introduced into San Francisco Bay nearly a century ago from the Atlantic coast, for the native oyster, which had thrived there, is too small for marketing. Within a few years pollution had built up so much that the oysters became unsafe for food. The industry continues, however, in a few other sites along the coast, importations now being of spat from Japan. With the oysters came several Atlantic and Japanese molluscan species, accidentally. Some have flourished -- for example, *Ilyanassa obsoleta* -- but so far as I know none has been a special threat to native species as so often happens with introduced forms. Because it is in the interests of the industry to keep bay waters clean, the industry is, on the whole, on the side of conservation.

A canning industry, based on such West Coast food clams as the razor clam, *Siliqua patula*, burgeoned in the 1920's from Washington to Alaska, but this enterprise soon foundered because the shellfish could not reproduce fast enough to supply the demands the canners were making. Some clam beds have never recovered, but there was a large enough breeding population so that the species have managed to survive.

I shall give a review of the situation for the one intertidal species, a littorinid, that comes close to qualifying as endangered. It could easily be wiped out with only a

slight habitat change. For a time its numbers decreased markedly, and as it has a limited range, its condition was precarious.

The status of *Algamorda newcombiana* (Hemphill, 1876)

For the following notes on the situation of *Algamorda newcombiana* (family: Littorinidae), I am indebted to Mr. Robert Talmadge, who has been making observations on the species for about thirty years.

This small snail is virtually restricted to Humboldt Bay, in northern California. It lives on the lower stems of a marsh succulent, *Salicornia*, or in the muddy substrate immediately below. Its optimal distribution is at or slightly above mean high tide level, so that it is submerged in sea water only a few hours per year and, because of the heavy rainfall of the region, is more apt to be wetted by fresh than by salt water.

In the 1930's, when Mr. Talmadge's studies began, the species was distributed over a stretch of about 10 miles along the bay margins, present wherever there was *Salicornia* but tending to be in uneven clusters of dense populations thinning out laterally. During the 1940's and 1950's several sawmills were actively operating in the area. By 1961 most of the snails were gone, and only a mass of half-burned sawdust could be found blanketing their habitat. Small isolated colonies survived in parts of the bay where the sawdust was less pervasive, but the prospects at this time seemed dim for the species.

Upon my recent inquiry as to status of the snail, Mr. Talmadge revisited the bay in February 1968. He found a few colonies doing well in both the south and the north ends of the bay. Some of the sawdust layer has broken up, and mud is again evident in places. Some of the normal associates such as arthropods and the marsh snail *Phytia* were present again, even where *Algamorda* was not. It would seem, therefore, that habitat recovery is taking place. Several of the sawmills have been abandoned and others have converted to a type of work not producing sawdust. Thus, the menace to estuarine life here is lessening. *Algamorda* may again be able to expand to its former extent, barring further pollution factors. Possibly the re-occupation of its range might be hastened by judicious transplanting as soon as the environment, through decay and flushing away of the sawdust, has again returned to normal.

Discussion of Dr. Keen's Paper

by William K. Emerson

Department of Living Invertebrates,
American Museum of Natural History,
New York, N. Y. 10024, U.S.A.

I concur with Dr. Keen's conclusion that there are apparently no species of west American marine mollusks facing biological extinction. However, as Dr. Keen has pointed out, it is the basic ecosystem of the shallow water bays, especially those of southern California, that is endangered. The severe modification of these bays by man for commercial and recreational purposes requires that one must look to northern Baja California, Mexico to find an essentially undisturbed bay-fauna of the Californian faunal province. San Quintin Bay, which is situated some 150 miles south of San Diego, is an example of such an embayment (Gorsline & Stewart, 1962).

Fortunately, most of the shallow-water, marine inhabitants of the bays of southern California occur as populations living offshore in shallow water at depths that are below effective wave action. A case in point is the Giant Smooth Cockle, *Laevicardium*

elatum (Sowerby), a southern ranging species that was reported living in San Diego Bay at the turn of the century (Kelsey, 1907). Apparently as a result of man-made changes of the environment of the bays of southern California, this species is now restricted along this coast to quiet offshore waters. Populations of this species are now known to occur between Seal Beach and Huntington Beach, off the California coast (Fitch, 1953). Farther south, this cockle, which ranges from San Pedro to Panama, can be found living in the intertidal zone (Keen, 1958).

It appears likely that most of the marine elements of the bays of southern California would be re-populated by the offshore-larvae of the presently missing species. The re-establishment of these species seemingly will occur only when the bays are allowed to return to their former environmental status. Partial success in re-establishing these species by natural faunal succession has apparently been achieved in Mission Bay at San Diego, where the bay environment was modified extensively for recreational purposes, but where certain areas are being retained as natural preserves (Morrison, 1957).

It is, however, the truly estuarine species, which require brackish water and extensive mud flats, that appear at the present time to be in danger of extinction locally. The destruction of the tidal flats by land fill and the changing of the salinity of the water by the channelling of the runoff of freshwater from the few rivers and streams of the area into unnatural flood control systems has largely eliminated some elements of the brackish water fauna in the larger bays. Although the brackish water element constitutes only a small part of the fauna, we must make an effort to conserve this endemic assemblage by retaining some of the existing natural areas of the bays when we undertake to modify them further for the "benefit" of mankind.

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9. BRACKISH WATER MOLLUSKS

by J. P. E. Morrison

Division of Mollusks, United States National Museum, Washington, D. C. 20560, *U.S.A.*

Brackish water mollusks may be divided into 2 groups. Those with the more primitive life histories have a free swimming veliger stage that permits scattering of individuals in each generation to all available and suitable estuarine habitats. The second group has "crawl-away" young. Its species are thereby assured continuation in one-way current-swept localities, but spread of the population is restricted to immediately contiguous habitats.

In North America man continues to unconsciously endanger and to ignorantly exterminate brackish water species every time a marina is "built," "dug," "dredged" or "improved" in an estuary situation. In the same way, today's real-estate developments with land-fills and dredged or blasted canals, designed to increase the number of water-front lots for sale, are deadly to estuarine species. Another modern water "conservation" plan to impound fresh waters in lowland reservoirs by damming estuaries, prevents effective mingling with saline waters, and so narrows or destroys the brackish water habitat.

Brackish water mollusks (with pelagic larvae) such as the Salt Marsh Snail *Melampus bidentatus*, the mactrid clam *Rangia cuneata* and the Virginia Oyster *Crassostrea virginica*, are not now in danger of extinction. Local populations may be extinct, but *Melampus bidentatus* still lives from southeastern Quebec to Yucatan. *Rangia cuneata* is locally abundant from Chesapeake Bay, Maryland to the Laguna Terminos, Campeche. The Virginia Oyster is still harvested commercially from New Brunswick to Campeche.

Some widespread species such as the ovo-viviparous marsh clam *Cyrenoida floridana* and the tiny snail *Hydrobia jacksoni* may be exterminated locally whenever conditions are arbitrarily changed by man. Such local populations could only be replaced by reintroduction from (relict) undisturbed populations in other areas.

There is a complex of hydrobiid gill-breathing snails in North American brackish waters that is headed for extinction even before the species are scientifically described or named. *Littoridinops tenuipes* is the only named species among hundreds which belong to the group. Some have been made extinct by a single hurricane which changed the salinity of the waters in their restricted local habitat. A pair of species are known to have been wiped out of existence when their brackish water "lake" was filled in the construction of one airport facility in Maryland. Others are so localized in range that a single marina development is known to have made a half dozen species extinct. The direct importance of these minute species (with crawl-away young) to man is nil except in that they form part of the food chain. They serve as food for shrimps, crabs and fishes in these brackish waters. With the extinction of even a small fraction of the food chain the production of sea-foods from the estuaries is modified.

Since estuarine and littoral habitats are the greatest proportionate source of sea-foods man must examine critically every "improvement" that modifies and inevitably decreases his own food supply. Note that the Virginia Oyster is today commercially re-seeded or re-planted in many regions in an effort to prevent such a decrease of food resource. In the lagoons of Campeche, the Virginia Oyster has been deliberately replanted into "reefs" for centuries to maintain the harvest.

10. SUMMARY

In spite of differences in mode and degree of endangerment of the mollusks within the regions discussed, some features are common to all. In general those species whose survival is most in jeopardy occur only within small geographical areas which are undergoing urbanization, industrialization or other ecological disruption. Moreover, numbers of species have recently become extinct or are on the threshold of extinction which were not even suspected of being imperiled. A much larger number will soon follow if effective programs for their protection are not soon initiated.

The survival status of large segments of the freshwater molluscan fauna is particularly precarious, especially within the southeast and south-central portions of North America. In all, approximately 185 species and subspecies have been cited as rare and endangered. An additional 9 species, 8 *Dysnomia* (pp 19-20, pl. 1, 2) and 1 *Goniobasis* (*G. catenoides*, p 25), are now almost certainly extinct. These figures do not include the gastropods of the American Interior Basin because their status has not been determined. Scores of Pleuroceridae and many other snails from that region are probably also endangered or recently extinct.

Numerous terrestrial species are imperiled. Some 45 species and subspecies, about half in the East and half in the West, are apparently rare and endangered. A much larger number, particularly in the West, are also rare and/or highly localized. Many of these may soon have to be added to the list of endangered taxa.

Fortunately marine mollusks are relatively secure. Only *Almagorda newcombiana* (p 52) is known to be endangered. Some local populations of the more conspicuous species are being over-collected but since most of these also occur in subtidal or other relatively inaccessible regions, or are widely distributed, the species themselves are still safe.

Brackish-water mollusks, like freshwater mollusks, are vulnerable to pollution and habitat disruption. Widespread species are not in danger but hundreds of highly endemic species, especially Hydrobiidae, are in great danger.

Future challenges to species survival may be even more intense. The recent Santa Barbara disaster has shown that massive pollution from oil may menace whole communities of species. Effects of pesticides and radioactive waste products may be even more pervasive. Critics of the proposed sea-level canal in or near Panama have even predicted that if unrestricted faunal interchange is permitted between the oceans much of the tropical eastern Pacific fauna may be wiped out from competion with Caribbean species possessing superior adaptive features. Fortunately this problem is now under investigation by a number of workers.

Recently Mr. H. D. Athearn has revisited the Clinch River and has found that the rich mollusk fauna there is still in a healthy condition. Miraculously, it was apparently unharmed by the temporary severe pollution in 1967.

The recent deaths of millions of fish in the Clinch River was a most regrettable accident. That accident, however, engendered this *Symposium*. If students are now encouraged to study the endangered mollusks of North America and if heightened general awareness of our obligation to conserve our fauna coupled with suitable remedial action now result, the net effect of that accident will have been supremely beneficial to the preservation of our native molluscan fauna.

A. H. C.