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The Terrestrial Gastropods (Mollusca: Gastropoda) of Plummers Island, Maryland

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Abstract.—A survey of the landsnails inhabiting the 20.5-hectare portion of Chesapeake and Ohio Canal National Historic Park formerly owned by the Washington Biologists' Field Club was conducted. Twelve stations, representing all major habitat types present, were intensively studied, and general collecting was done throughout the area. Twenty-five species of snails and slugs representing 12 families were documented. Survey of the literature and pertinent museum collections documented very little change in the composition of the gastropod community over the past 100 years, despite vegetation community succession of the property from largely open field to mature forest. Of nine species known historically from the study area, only one was not found during this survey. Although the mollusk community was diverse, the number of small species was less than expected. This may be the result of the near absence of a leaf litter/humus layer. The absence of those forest floor layers from the study area may be due to the presence of a large population of the introduced Asiatic earthworm, *Amynthras agrestis.* Regular inundation of flood plain areas along the Potomac River appears to depress or eliminate discrete colonies of land snails.

Key words.—Inventory, land snails, slugs, introduced species, Chesapeake and Ohio Canal National Historical Park, Potomac River, Washington Biologists' Field Club.

Plummers Island, located in the Potomac River, Montgomery County, Maryland (38°58′0″N, 77°10′36″W), was leased by the Washington Biologists' Field Club (WBFC) in 1901. Between then and 1924 the club acquired the 4.8-hectare Island and 15.6 hectares of the adjacent mainland. In 1959 ownership of the WBFC property passed to the National Park Service and the land became part of the Chesapeake and Ohio (C&O) Canal National Historic Park. During its period of ownership, the WBFC managed the property as a natural preserve and research facility, and the Club has continued to maintain a presence on the Island and to support research activity under a special agreement with the National Park Service. As a result of the efforts and interest of WBFC members, Plummers Island and the adjacent mainland property are considered to be among the biologically best-studied areas in North America. Although numerous papers considering various invertebrates from Plummers Island have been published, nothing pertaining to the terrestrial mollusks is available. The present report identifies the species of land dwelling snails and slugs that presently inhabit the area and examines their distribution.

This investigation included Plummers Island and the adjacent mainland portion of the C&O Canal National Historic Park previously owned by the Washington Biologists' Field Club (Fig. 1). Plummers Island lies along the Maryland bank of the Potomac River near Cabin John, about 14.5 km northwest of central Washington, D.C., in Montgomery County, Maryland. The mainland property includes the area between the river and the canal towpath, extending from Rock Run on the east to the Capital Beltway (I-495) on the west. Plummers Island is separated from the mainland by a narrow channel. During periods of low flow it is nearly connected to the mainland by rock outcroppings at several points.

The Plummers Island property is typically mature hardwood forest with a diversified understory and herbaceous layer. There are well-developed primary and secondary flood plains. The flood plains slope steeply to uplands reaching elevations of about 34 m above mean sea level (msl) on the Island and 37 m above msl on the mainland. The geology and morphology of the area are well known (Erwin 1981, Shetler et al. 2006), and Shetler et al. (2006) described the vascular plant community in detail. Bedrock consists of granite gneiss and schist, and those rocks outcrop at numerous locations throughout the

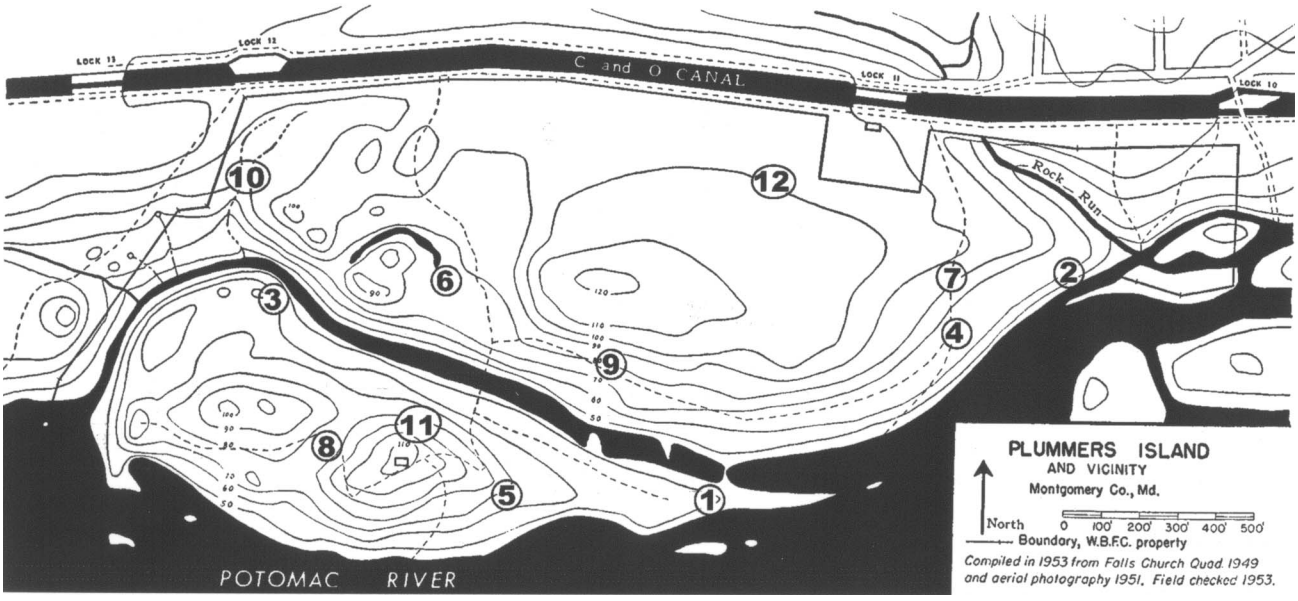

Fig. 1. Map of Plummers Island property, Montgomery County, Maryland. Numbered circles represent approximate location of twelve stations selected for detailed survey during this study. Contour interval is 3.05 m (ten feet).

study area. Although carbonate rocks are absent, calcium levels are high at some localities (Ca+ >3000, Erwin 1981), particularly on floodplains where the alluvial soils include abundant fragments of aquatic mollusk shells. Calcium levels are generally much lower on uplands, ranging as low as Ca+ = 20 (Erwin 1981), with the exception of Station 11 which has been used as a disposal site for oyster shells. Levels there were as high as on flood plains.

Photographs in the archive of the WBFC show that the Island and mainland were mostly cleared of forest in the early part of the 20th century. At that time a sparse growth of cedars (*Juniperus virginiana* L.) was present, with scattered large hardwoods. However, once acquired by the WBFC, reforestation was allowed to occur, except for several upland plots on the mainland. Those areas were managed as agricultural fields, and some were used for gardening as late as World War II. All previous agricultural fields are now uniformly forested. At present, conifers are represented only by a few isolated pines on the mainland upland and a sparse stand of cedars around the cabin on the Island.

Flood plain portions of the study area are regularly inundated. Although water elevation has not been recorded at Plummers Island, the U.S. Geological Survey (USGS) operates a gauge on the Potomac River at Little Falls Dam, approximately 4.9 km downstream. Even though three tributaries discharge into the river between Plummers Island and Little Falls (Cabin John Creek, Rock Run, and Turkey Run) flooding characteristics of the Potomac are such that it can be assumed that an increase in water elevation at Little Falls reflects a comparable increase in water elevation at Plummers Island. The base elevation at Little Falls Dam is 13.5 m (44.4 feet) above msl. Data recorded by the USGS (Bob James, pers. comm.) shows that between April 1931 and April 1993, that base elevation was exceeded by at least 3.05 m (10 feet) on 75 occasions. It was exceeded by at least 6.1 m (20 feet) on four occasions (1936, 1937, 1943, and 1972). The highest water elevation recorded during that period was 8.6 m (28.1 feet) above base, on 19 March 1936. Floods of that magnitude inundate both the primary and secondary flood plains, and extensive areas of adjacent upland habitat. In addition, photographs in the WBFC archives demonstrate that winter floods occasionally have deposited thick layers of broken ice on the flood plain, breaking off and pushing over numerous trees. Such ice scouring is documented photographically for 1912, 1936, and 1948.

Materials, Methods, and Site Description

Plummers Island was surveyed intensively for land snails on 40 visits between April 1994 and August 1996, and sporadic observations continued throughout the fall of 2005. On the first six visits, a general survey of the study area was performed to assess habitat diversity and identify major community types. Twelve stations were selected for intensive survey, and subsequent visits were directed toward those stations. Survey stations were selected to represent typical examples of major habitats characteristic of the study area. Each station included a circular area approximately 10 m in diameter. Stations are identified and described below, and their locations are shown on Fig. 1. Stations are numbered generally in order of increasing elevation. Stations 1, 2, and 3 were sit-

uated within the primary flood plain. Stations 9, 10, 11, and 12 were on upland areas. Station 5 was within the secondary flood plain, and Stations 4, 6, 7, and 8 occupied the transition from secondary flood plain to upland.

Station 1.—Plummers Island. Forested area on primary flood plain at east end of Plummers Island. Elevation approximately 16 to 18 m above msl. Alluvial soils covered with recently deposited sandy alluvium containing numerous aquatic mollusk shell fragments. Sparsely shaded. Substrate bare of leaf litter.

Station 2.—Mainland. Forested area on primary flood plain near mouth of Rock Run. Elevation approximately 17–19 m above msl. Level floodplain area with alluvial soils. Well shaded. Substrate bare of leaf litter.

Station 3.—Plummers Island. Forested area on primary flood plain along channel, including bedrock outcrop at west end. Elevation approximately 16–20 m above msl. Area included floodplain and massive rock outcrop. Well shaded, but abutting canopy gap. Alluvial soils present on floodplain, with dark organic soils present in pockets on outcrops. Substrate bare of leaf litter.

Station 4.—Mainland. Forested area along path between Lock 11 and the river, including transition from secondary flood plain to upland. Elevation approximately 21–25 m above msl. Gently sloping from upland to edge of floodplain. Heavily shaded. Thin layer of leaf litter present over alluvial soils.

Station 5.—Plummers Island. Forested area on secondary flood plain near base of extensive outcrop. Elevation approximately 22–24 meters above msl. Level, sandy alluvial soils with sparse leaf litter. Well shaded.

Station 6.—Mainland. Forested area around vernal pools on mainland, including transition from secondary flood plain to upland. Elevation approximately 24–26 m above msl. Vernal pool area generally level, then sloping steeply to high knoll. Rock outcrops common. Substrate bare alluvial soil around floodplain pools, but layer of leaf litter present on adjacent upland slope. Lightly shaded.

Station 7.—Mainland. Forested flood plain extending along both sides of path to river. Elevation approximately 26–28 m above msl. Well shaded forest along compacted footpath. Heavy mineral soils with thin, patchy layer of leaf litter.

Station 8.—Plummers Island. Forested area on ''saddle'' connecting two prominences on Island. Elevation approximately 27–30 m above msl. Alluvial soils on level area, replaced by rich organic soils on slope leading to massive rock outcrop. Upland slope covered by layer of leaf litter and detritus. Floodplain soil bare of leaf litter. Lightly shaded.

Station 9.—Mainland. Upland forest on steep slope above channel between mainland and Island. Elevation approximately 28–31 m above msl. Large outcrops occur on the lower portion of the slope. Area is well drained and soils tend to be dry. Thick layer of leaf litter. Well shaded mineral soils.

Station 10.—Mainland. Forested upland area south of Lock 12, including intermittent seepage marsh. Elevation approximately 26–29 m above msl. Mineral soils with thick layer of leaf litter. Elevated knoll sloping to lower depression with seepage area draining to river. Rock outcrops common. The swale is the most consistently wet site within the study area.

Station 11.—Plummers Island. Forested area on steep rocky slope below prominence where cabin is located. Site overlooks the mainland and is historic area for disposing of oyster shells. Elevation approximately 25–30 m above msl. Well shaded. Thin layer of dark organic soil over rock outcrop. Thin layer of leaf litter present.

Station 12.—Mainland. Forested upland southwest of lockhouse. Elevation ranged from approximately 32–34 m above msl. This site was an old field in the 1930s and early 1940s. By 1981 succession had led to a community dominated by *Pinus virginiana* Mill. (Erwin 1981), which had been subsequently replaced by *Liriodendron tulipifera* L. by 1984 (Johnston & Winings 1987). The soil is heavy and tends to be dry with little or no leaf litter accumulation.

Collecting was conducted during daylight hours, typically in early to mid-morning. Tree trunks and other standing vegetation were examined for the presence of mollusks. Fallen logs were overturned, and rocks, loose bark, and other places of concealment were inspected, after which they were returned to their original position. Leaf litter and samples of the upper soil layer were sifted through sieves, and the soil samples and samples of lichens and bryophytes, were examined under low magnification. All mollusks present were either identified in the field or collected. Where necessary, dissections were performed to confirm identifications. Certain specimens were submitted to acknowledged authorities for identification or annotation. Vouchers representing all species present have been deposited in the collection of the Carnegie Museum of Natural History. During all visits life history observations were made.

The abundance of each species at individual study stations was estimated based on the number of individuals found on dates when conditions were suitable for mollusk activity (see Table 1). Status was recorded as ''rare'' if a species was found only occasionally and in small numbers; ''uncommon'' if it was present in small numbers (<5 individuals) but found in most surveys; ''common'' if it was found in reasonable numbers (5–10) in each survey; or ''abundant'' if more than 10 individuals were found on each survey date.

Table 1.—Distribution and estimated abundance of land snails at 12 study stations, Plummers Island property, Montgomery County, Maryland. Stations are numbered generally in order of increasing elevation above mean sea level. Status of species is indicated as: (R) rare, found only occasionally and in small numbers; (U) uncommon, present in small numbers (<5 individuals) but found in most surveys; (C) common, found in reasonable numbers (5–10) in each survey; or (A) abundant, more than ten individuals found in each survey when conditions were suitable.

Species	Station											
	1	2	3	4	5	6	7	8	9	10	11	12
Anguispira alternata	R	R	—	C	—	R	C	R	U	C	—	U
Anguispira fergusoni	U	—	—	R	A	—	U	U	—	—	U	—
Arion intermedius	—	R	—	C	U	R	C	R	U	—	U	C
Arion subfuscus	C	C	C	A	A	C	A	C	C	U	C	U
Carychium exile	—	—	—	—	—	—	—	—	—	A	—	—
Deroceras laeve	U	C	—	U	U	R	C	U	R	—	R	U
Gastrocopta contracta	U	—	U	R	A	—	—	U	—	U	—	—
Gastrocopta corticaria	—	—	—	A	U	—	—	—	—	—	—	R
Glyphyalinia indentata	—	—	—	—	—	—	R	—	—	—	R	—
Glyphyalina wheatleyi	—	—	—	—	—	—	—	R	—	—	R	—
Hawaiia minuscula	—	—	—	—	—	—	U	R	—	—	R	—
Helicodiscus parallelus	—	—	—	R	—	—	—	R	—	U	—	—
Limax maximus	—	—	U	—	—	U	—	R	—	C	—	—
Megapallifera mutabilis	—	—	—	C	R	—	C	R	R	—	R	C
Mesodon thyroidus	A	C	U	A	U	U	A	C	C	U	C	U
Novisuccinea ovalis	R	U	U	C	U	—	—	R	U	—	—	—
Philomycus carolinianus	U	U	—	C	R	R	C	C	C	U	U	R
Punctum minutissimum	—	—	—	—	R	—	—	—	—	R	U	—
Stenotrema barbatum	—	—	—	R	R	—	R	R	R	R	—	—
Strobilops aenea	—	—	—	C	—	U	U	U	U	U	—	—
Strobilops labyrinthica	—	—	—	—	—	U	—	A	—	—	—	R
Triodopsis juxtidens	U	R	—	A	C	U	A	C	R	R	C	—
Ventridens ligera	A	C	C	A	A	C	A	C	C	C	C	C
Ventridens suppressus	R	—	—	—	—	—	—	—	—	—	—	—
Xolotrema denotata[1]												
Zonitoides arboreus	U	C	R	A	C	U	A	C	C	C	C	C
Total Number of Species	12	10	7	17	15	12	15	20	13	14	14	11

[1] *Xolotrema denotata* included based on a historic record from ''Plummers Island.'' Because the specific collection locality is unknown, no Station is identified for this species.

Historic records for mollusks from the Plummers Island property were sought in the literature and through online databases or contact with curatorial staffs of the collections at the Museum of Comparative Zoology (MCZ), Harvard University, the National Museum of Natural History (USNM) (Smithsonian Institution), Natural History Society of Maryland, Delaware Museum of Natural History, and the Philadelphia Academy of Sciences.

Results

Although the Plummers Island vicinity has been well studied, previous research neglected terrestrial mollusks. No records from this location are mentioned in any of the regional lists (e.g., Girard 1855, Lehnert 1885, Richards 1934, Grimm 1971), and the only record published prior to this study seems to be a series of *Xolotrema denotata* reported by Vagvolgyi (1968). That record was based on three specimens from Plummers Island, Maryland, with no other data; the specimens now are in the MCZ. According to Kenneth Boss (pers. comm.), those specimens were obtained from D. Thaanum on 28 January 1947. Thaanum lived in Hawaii and probably obtained the snails through exchange. There is no indication of who sent them to him, when they were collected, or who the collector may have been. A search of the MCZ collection for specimens of several other species that occur abundantly at Plummers Island revealed no additional material, suggesting that other Plummers Island records are absent. The historic presence of *X. denotata* at Plummers Island is supported by a report of this species from Fairfax County, Virginia, right across the Potomac River from Montgomery County, Maryland (Hubricht 1985).

The extensive collection of terrestrial mollusks housed at the USNM includes the following records from the Plummers Island property:

Anguispira alternata (USNM 194085, specimen label reads 194058), collected by H. Henshaw, 1905.

Anguispira fergusoni (USNM 194082), collected by H. Henshaw, 1905.

Carychium exile (USNM 365579), collected by H. S. Barber, 25 Sep 1926.

Gastrocopta contracta (USNM 336916), found by H.

S. Barber in old leaves collected ''to feed myriapods,'' 1919.

Helicodiscus parallelus (USNM 336917), found by H. S. Barber in old leaves collected ''to feed myriapods,'' 1919.

Ventridens ligera (USNM 193949), collected by Barber and Schwartz, 17 Aug 1906; (USNM 194052), collected by D. H. Clemons in decaying leaves, 11 Aug 1905.

Ventridens suppressus (USNM 194078), collected by D. H. Clemons in ''decaying leaves,'' 11 Aug 1905.

Zonitoides arboreus (USNM 365577) collected by H. S. Barber, 1926.

The USNM collection also contains two immature shells collected by H. S. Barber on 25 September 1926 identified as *Cochlicopia lubrica* (USNM 365575). Those shells can not be identified with certainty but are not *Cochlicopia.* They may be young *Gastrocopta contracta.* In addition, the original USNM catalogue includes entries for *Haplotrema concavum* (USNM 193880, collected by Mearns, 3 May 1905); *Econulus* (USNM 365576, collected by H. S. Barber, 25 Sep 1926); and *Vertigo* (USNM 365578, collected by H. S. Barber, 25 Sep 1926). However, these specimens could not be found in the collection. Paul Greenhall (pers. comm.) suggested that the most likely explanation is that the specimens subsequently were identified as other taxa and placed elsewhere in the collection. Lacking specimens for verification, I have not included these species as valid records from the study area.

Over ten thousand snails and slugs were examined during this study. Twenty-five species in 12 families were represented. These species are discussed below, and their distribution among survey stations is shown in Table 1. The taxonomy follows Turgeon et al. (1998).

Family Carychiidae

Carychium exile Lea, 1842

This small snail was found at a single station. It occurred only in moist, decaying detritus under fallen bark at the base of a standing dead tree in a swale. The area occupied by this colony was only about 1.5 m in diameter, but hundreds of individuals were observed. This location supports some wetland vegetation and frequently carries running water from late winter or spring through early summer. The preference of *Carychium* for wet places has been noted by Brooks & Kutchka (1937), Burch & Jung (1988), and Leonard (1959).

Family Pupillidae

Gastrocopta contracta (Say, 1822)

This small snail was found at six stations in two distinct habitats. At Stations 1, 4, and 5 it was abundant under fallen branches on sandy soil with little or no leaf litter. At Stations 3, 8, and 10 it occurred in small numbers under branches and fallen or loose bark over organic soils on or adjacent to uplands. On 24 September 1994 a rotted stick approximately 5 cm in diameter was lifted from the ground at Station 5, and the bark on the lower surface separated and remained in contact with the substrate. Numerous *G. contracta* were attached to the stick and a concentration of 112 individuals was found in a depression in the bark approximately 3 cm in diameter.

Gastrocopta corticaria (Say, 1816)

This tiny snail was found at three stations. All occurrences were on trunks of *Fraxinus* or *Carya,* or in ground litter. Norden (2007) noted that *G. corticaria* within the study area was largely an arboreal species living in discrete colonies on the trunks of deciduous trees. One colony of about 50 individuals occupied a recumbent ash that had fallen partially over but continued to grow with most of the trunk parallel to the ground. There, numerous individuals were observed in and around a moist weep hole in the trunk. The second, much larger colony, occupied a bryophyte covered portion of the trunk of a large, recently fallen, walnut tree at a location about 44 feet above the base. Individuals were found on or under bark, and once in leaf litter.

Family Strobilopsidae

Strobilops aenea Pilsbry, 1926

This small snail was found at six stations, where it occurred beneath loose bark or fallen logs. At Stations 8, 9, and 10 the snails were under loose bark of fallen logs lying on dark organic soil along rock outcrops. At Stations 4, 6, and 7 they were beneath logs and loose bark on a sloping hillside with mineral or alluvial soils.

Strobilops labyrinthica (Say, 1817)

This species occurred at three stations, twice with *S. aenea.* At Station 6 both *S. aenea* and *S. labyrinthica* were uncommon, but at Station 8 *S. labyrinthica* was abundant and *S. aenea* uncommon.

Family Succineidae

Novisuccinea ovalis Say, 1817

This species was found at seven stations. At Station 3 snails were found on vegetation during wet

periods, or on the substrate in crevices and along the base of rock outcrops. At the other stations individuals were found on herbaceous vegetation or the soil surface. The largest specimen found measured 22.4 mm in shell length.

Family Philomycidae

Philomycus carolinianus (Bosc, 1802)

This large species was the most common native slug found in the study area. It typically occurred under bark or in damp cavities of standing trees, but was occasionally found under fallen logs. When found on logs, it usually occurred as single individuals, but in cavities (''weep holes'') it frequently occurred in aggregations. Those aggregations were generally small but occasionally numbered more than a dozen individuals. One large group of 27 *P. carolinianus* and 11 *M. mutabilis* was found in a cavity in a large oak that fell near the cabin on the Island. Although these two species frequently were found together, such aggregations never included *Arion subfuscus* or any of the other slugs present in the study area. *Philomycus carolinianus* was not found active during daylight hours, even on wet days.

Megapallifera mutabilis (Hubricht, 1951)

This large native slug was generally a common species within the study area, although it was slightly less abundant that *Philomycus carolinianus.* As with *P. carolinianus, M. mutabilis* frequently were found on standing trees but only rarely on or beneath fallen logs; they were not found in close association with any non-native slug.

Family Arionidae

Arion intermedius (Normand, 1852)

This is the smallest of the five slugs found in the study area. The largest individual observed measured 30 mm in length. Although present at nearly every station, it was never found active, always being located in repose beneath bark, rocks, or logs. Individuals were often found beneath accumulations of castings deposited by earthworms [*Amynthas agrestis* (Gato & Hatai)], occasionally buried several centimeters deep. *Arion intermedius* was observed less frequently during dry periods and was generally less abundant at upland sites than on flood plains. However, at upland Station 12, it occurred abundantly beneath logs and other litter in immature woods adjacent to the towpath.

Records for *A. intermedius* from eastern North America are scattered, and this small species was not reported in many surveys conducted in the first half of this century. However, Chichester & Getz (1969) noted that it was widely distributed in cultivated areas and woodlands in the northeast and suggested that it probably had been present there for a long time. It was first reported from Maryland by Grimm (1971). Although Grimm had records from only four Maryland counties and Baltimore City, this slug is now common throughout much of the state.

Arion subfuscus (Draparnaud, 1805)

This was the most abundant slug observed during this study. It occurred at every station and was recorded as common or abundant at most. Although regularly observed on tree trunks and herbaceous vegetation, *A. subfuscus* was found most frequently beneath logs or bark, or crawling on bare soil of forest trails and the towpath. *Arion subfuscus* climbed readily, and individuals were noted on tree trunks as high as 8 m above the ground. When the soil was damp after periods of rain, this slug was observed in large numbers crawling in the open even during the hottest part of the day. In late September 1995, following a severe drought that included at least 30 days with no measurable precipitation, it was the only mollusk that could be found alive at most stations. At that time, *A. subfuscus* was common beneath logs and bark.

On numerous occasions *A. subfuscus,* occasionally in large clusters, were noted feeding on earthworms or other *Arion* that had been crushed on forest trails or the canal towpath. This slug also frequently was observed feeding on bracket fungi growing on logs or tree trunks, in some instances actually excavating a groove on the under surface large enough for the animal to fit into.

Family Discidae

Anguispira alternata (Say, 1816)

Although *A. alternata* was found frequently within the study area, it was not found in large numbers. It was present at every station on the mainland portion of the study area but was found on the Island only at Stations 1 and 8. Specimens occurred under logs and loose bark, or in crevices of tree trunks. The ten largest individuals ranged from 17.5–21.5 mm in diameter ($\bar{X}$ = 19.9 mm). The smallest individual was a 2.9-mm hatchling found on 31 June 1996. About 40% of the *A. alternata* from the study area exhibited the lower spire and strongly angular periphery characteristic of Pilsbry's form *angulata* (Pilsbry 1948).

Anguispira fergusoni (Bland, 1861)

Anguispira fergusoni was common on Plummers Island, but on the mainland it was found only at Stations 4 and 7. As noted by Hubricht (1985) and Pilsbry (1948), *A. fergusoni* appears to be an inhabitant

of the Atlantic Coastal Plain that has followed flood plains up into the interior of the Piedmont region. This species was found in small numbers at most locations but was abundant at Station 5. There, a colony was present on a 3.0-m long recumbent *F. americana* trunk on the secondary floodplain. One end of the trunk was decaying and pulpy, and most of its length was raised above the substrate. *Anguispira fergusoni* was found in numbers ranging from 8–27 each time this site was surveyed. Snails were noted on the log's surface, in cracks in the wood, and in the pulpy interior of the log. On 18 September 1994 a large fungus (*Polyporus squamosus* Fr.) was noted developing on the trunk, and from then until it deteriorated and fell from the log, *A. alternata* frequently were observed crawling and feeding on its surface. Juvenile individuals often were found on this log, and newly hatched snails approximately 3 mm in diameter appeared in late May or early June. The ten largest individuals ranged from 14.2–17.1 mm in diameter ($\bar{X}$ = 15.5 mm). A series of 20 juveniles taken at Station 5 on 3 June 1995 ranged from 3.1–6.7 mm and averaged 4.8 mm in diameter.

Family Helicodiscidae

Helicodiscus parallelus (Say, 1817)

This small snail was rare or uncommon at three stations. All were on slopes above the flood plain or in areas of transition from secondary flood plain to upland.

Family Punctidae

Punctum minutissimum (I. Lea, 1841)

This diminutive snail was rare to uncommon beneath loose bark and in leaf litter and soil samples at three stations. One was on the secondary flood plain and two were on uplands, on or near bedrock outcrops.

Family Limacidae

Deroceras laeve (Müller, 1774)

Deroceras was widespread within the study area but was recorded as common only at Stations 2 and 7. This slug responded more quickly to changes in precipitation than the other slugs present. It was observed regularly following periods of rain but became less apparent as an area dried out. During periods when there was no measurable rainfall for a week or ten days, *D. laeve* became uncommon and disappeared completely during longer periods of drought. Like *A. intermedius, D. laeve* was found beneath logs and other ground litter, and was never observed under the bark of standing, dead trees.

Limax maximus Linnaeus, 1758

This large European slug has become a common naturalized species around human habitations throughout Maryland. Early in this study, *L. maximus* was found only along the forested fringe bordering the canal towpath and the wet swale running from near Lock 12 to the river. It was first observed on the Island in the summer of 1999 when a single individual was found beneath a log at Station 8. Its appearance there followed two floods that deposited logs and other debris at the northern end of the Island. During the summer of 2000 specimens were found under rocks beneath the faucet of a water barrel at the cabin, and by the summer of 2005 individuals had been found throughout the western third of the Island, and all along the river on the mainland.

Family Zonitidae

Glyphyalinia indentata (Pilsbry, 1946)

This small snail was rare at two stations. At Station 7 one individual was found between the gills of an inky-cap mushroom (*Coprinus* sp.) growing in heavily shaded deciduous forest. The current concept of *G. indentata* actually encompasses a complex of very similar species (Hubricht 1985, T. Pearce, pers. comm.).

Glyphyalinia wheatleyi (Bland, 1883)

Glyphylinia wheatleyi was rare at two stations. Both were on the Island and included rich organic soil along the edges of rock outcroppings.

Hawaiia minuscula (A. Binney, 1840)

Hawaiia was rare to uncommon at three stations where specimens were found beneath the loose bark of fallen logs and in surface litter.

Ventridens ligera (Say, 1821)

Ventridens ligera was the most frequently encountered gastropod within this study area. It was common or abundant at all stations under all weather conditions. Individuals were found most often on the ground or beneath logs, but this snail was also common on herbaceous vegetation and tree trunks. The greatest density was always noted on the primary or secondary floodplain. Stopping anywhere within those portions of the study area and examining the substrate would always reveal *V. ligera.* This snail was frequently observed active during periods of daylight. On 3 June 1995 a large (ca. 13 cm in diameter) grapevine (*Vitis* sp.) was observed to have been cut at a trail on the Island near Station 1. The end of the vine was weeping clear liquid. When the vine was first observed a cluster of 47 adult *V. ligera*

were collected on or within 50 cm of the cut end. When the site was visited again about one hour later, 54 additional *Ventridens* were counted in the same area. The primary floodplain at that location was sparsely vegetated with a substrate of loose, recently deposited sand. Many *V. ligera* within the study area over-winter by simply withdrawing into their shell and lying dormant on the soil surface, beneath a thin layer of leaves and vegetation.

Ventridens suppressus (Say, 1829)

Ventridens suppressus was rare at Station 1, where a single specimen was found beneath a fallen log. Of several hundred small *Ventridens* examined from the study area, all other individuals represented juvenile *V. ligera.*

Zonitoides arboreus (Say, 1816)

Among the smaller snails from the study area, *Z. arboreus* was the most widespread and frequently encountered. It was found at all Stations, and was recorded as common or abundant at nine. *Zonitoides arboreus* typically was found under loose bark, beneath fallen logs, or in surface litter.

Family Polygyridae

Stenotrema barbatum (Clapp, 1904)

Stenotrema barbatum was found at six stations. With one exception it was found infrequently. In most instances adults were found singly, but juveniles often were found in small groups of 3 to 5. Individuals in those groups were always close together and appeared to be aggregated. On 28 January 2006 over 30 adult *S. barbatum* were found under leaves and bark adjacent to a fallen oak on a slope just west of Stations 4 and 7. They seemed randomly distributed over an area of approximately 1.9 m^2. A sample of 16 individuals from that concentration ranged from 8.0 to 9.1 mm in shell diameter ($\bar{X}$ = 8.4 mm). These snails were identified as *S. barbatum* using the characteristics given by Grimm (1971).

Mesodon thyroidus (Say, 1816)

This large snail was one of the most common species. It was found at all stations and was rated as abundant or common at seven. *Mesodon* frequently were observed crawling on the trunks of trees or understory vegetation during daylight hours, and were found actively feeding on the bark of tree trunks following periods of rain. Individuals on tree trunks were noted up to 9 m above the ground. Examination of bark samples exhibiting feeding marks showed that *M. thyroidus* were consuming a thin coating composed of the crustose lichen *Dimerella pineti* [Ach.] Vezda and a variety of non-lichenized algae (J. Lawrey, pers. comm.).

As noted by Pilsbry (1940), most adult *M. thyroidus* possess a well developed parietal tooth, but the tooth may be absent. Of 100 randomly examined adult specimens from Plummers Island all trace of a parietal tooth was absent in 29.

Triodopsis juxtidens (Pilsbry, 1894)

Triodopsis juxtidens was found throughout the study area, with the exception of Stations 3 and 12. Unlike *M. thyroidus* and *V. ligera, T. juxtidens* always were found beneath logs or bark and never crawling in the open during the day.

Discussion

During this study, 25 species of terrestrial gastropods (Table 1) representing 12 families were found on Plummers Island or the adjacent mainland; a historic record of one additional species (*Xolotrema denotata*) was found in the literature based on specimens at the MCZ. Review of available museum records makes it clear that earlier Plummers Island specimens in collections resulted from incidental collections and not comprehensive survey. All of the species now known to occur within the study area have been reported from Montgomery County, Maryland (Grimm 1971, Hubricht 1975, Örstan 1999), except *X. denotata.*

Three of the species occurring at Plummers Island, all slugs (*A. intermedia, A. subfuscus,* and *L. maximus*), represent introductions from Europe (Chichester & Getz 1969). All three occur widely throughout the region in areas that have been disturbed by human activity. Their presence in the study area is not surprising since the C&O Canal would have provided a suitable corridor for dispersal westward from the Washington, D.C. area, and the presence of the residences and associated disturbed areas (i.e., gardens and farm plots) at Locks 10 and 11 would have served as ideal points of introduction.

The flood plain of the Potomac River is dynamic and is inundated by floodwaters on a regular basis. Floods may wash away invertebrates, remove litter and other cover, and deposit or scour away substrate, all of which could impact terrestrial mollusk populations. Examples of this were documented several times during this study. For instance, a very large colony of *G. contracta* was present on the secondary floodplain at Station 5. That colony was nearly destroyed by floods in 1999 and still had not recovered by the end of the activity season of 2005. A discrete colony of *A. alternata* inhabiting a single *Fraxinus* trunk at that same location also nearly disappeared following those floods. A third instance was provided by a colony of *Gastrocopta corticaria* that occupied

the trunk of a *Fraxinus* on the primary floodplain near Station 4. That colony also was destroyed by the 1999 floods. In that instance, the entire tree was uprooted and removed by flood waters.

Following most flood events, the mollusk population was significantly reduced but rebounded and, by the end of the seasonal activity period, had returned to about normal levels of abundance. This was particularly notable for *A. subfuscus, M. thyroidus* and *V. ligera.* Since all three species frequently were observed on tree trunks, some individuals would be expected to survive flooding by moving up into the trees. However, the abundance of these species on floodplains within the study area following flooding makes it likely that significant migration from adjacent upland areas occurred.

It also seems likely that logs and other debris deposited on the floodplain within the study area would strand land snails originating from farther upstream. *Limax maximus,* which was found near the upstream end of the Island following the 1999 floods, likely arrived in that way. Flood dispersal may also explain the historic presence of *X. denotata* at Plummers Island. According to Valvolgyi (1968), *X. denotata* is characteristic of deciduous forests at elevations greater that 500 feet (152 m), higher than elevations within the study area which reach a maximum of 125 feet (38 m) above msl. He further noted that it was found more commonly on the banks of creeks and suggested that populations at lower elevations may have been carried down by streams. Considering the amount of flood debris regularly deposited within the study area, it is likely that the presence of *X. denotata* at Plummers Island prior to 1947 was a short-term introduction of snails carried down from upstream in the Potomac River Valley.

Review of photographs and records maintained by the WBFC show that in the early 1900s the study area was largely cleared of forest, and portions were managed for agriculture. Some parts of the site, for instance the plateau west and south of the lock keepers house at Lock 11 (Fig. 1), were farmed until the late 1940s. The entire area is now deciduous forest. Previous studies of ground beetles (Erwin 1981) and forest breeding birds (Johnston & Winings 1987) showed significant change in community composition since the early 1900s when the property was acquired by the WBFC. However, the lack of sufficient historical data makes it impossible to determine if similar changes have occurred in the terrestrial mollusk community. As noted previously, with a single exception (*X. denotata*), all species collected in the early 1900s were also found during this survey.

Little has been published regarding the microdistribution of terrestrial gastropods in Maryland, most information on local distribution coming from Grimm (1971) and Hubricht (1985) who reported occurrence only by county. Site specific data is given by Hotopp (2002) for ten sites in Garrett County and Örstan (1999) for Black Hills Regional Park in Montgomery County. Comparing data acquired during this study with their published records shows that the suite of species found in the study area contains fewer small (< 3 mm) species than expected.

A number of authors have noted that greater land snail diversity is correlated with forest habitat and its accompanying leaf litter (Burch 1955, Locasciulli & Boag 1987), and Locasciulli & Boag (1987) showed that small forest floor snails in western Alberta were most common where the litter and humus layers were thickest, and that some species were found more frequently in deeper layers. Considering that, it is notable that a typical leaf litter/humus layer is generally absent from most of the study area. A thin layer of fallen deciduous leaves is usually present, but brushing it aside reveals the soil surface; there is no gradation through a humus layer composed of decaying leaves and other organic material.

The reason for the absence of a litter/humus layer, even on most study area uplands (above normal flood level), may be the presence of a dense population of the introduced Asiatic earthworm *Amynthas agrestis.* Research has shown that introduced earthworms can profoundly change the nature of the forest floor in northeastern North America, simplifying the understory plant community and reducing or eliminating the litter and humus layer (Bohlen et al. 2004). Such physical changes have the potential to impact the land snail fauna by reducing food and shelter resources, affecting the water holding capacity of the soil and modifying soil chemistry. Although the work published on the impact of non-native earthworms to date involved glaciated areas in the northeast that did not have native earthworms, Callaham et al. (2002) demonstrated that introduced, aggressive species such as *A. agrestris* also can dominate the earthworm fauna of undisturbed, non-glaciated areas of North America. Maryland is beyond the area affected by Pleistocene glaciation and does have native earthworms (Reynolds 1974), but the lack of other factors to explain the absence of a litter/humus layer in the study area leads me to conclude that the dense population of *Amynthas* may be responsible.

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