BANISTERIA

A JOURNAL DEVOTED TO THE NATURAL HISTORY OF VIRGINIA

John R. Holsinger
(1934-2018)

An obituary of this world renowned biospeleologist, cave conservationist, and freshwater amphipod systematist, who was a pioneering figure in the exploration and study of Virginia caves and their faunas, appears on pages 61-72 of this issue.

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B A N I S T E R I A

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Cover: Biospeleologist John R. Holsinger wading in a New York cave stream, July 1991; photo by Lynn M. Ferguson.

Back cover: *Aletris aurea* Walter (Golden Colicroot); original drawing by John Banister, sent to Bishop D. H. Compton in 1689. Figure 57 in folio in Sir Hans Sloane's MS 4002 in the British Museum. Photocopy courtesy of Joseph and Nesta Ewan.

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Annual Patterns of Production in a Dragonfly Community in Western Virginia[1]

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ABSTRACT

The number of dragonflies emerging from five mountain ponds over a four-year period was highly variable and independent for six species. Levels of adult activity were accurate indicators of relative reproductive input to the individual ponds. There was a general lack of concordance between reproductive input and subsequent adult emergence at a pond for three of four species studied, demonstrating the existence of differential egg or larval survival among ponds and years. Emergence and subsequent adult activity were not correlated for two of four species, indicating the existence of among-pond variability in factors affecting adult distributions. *Plathemis lydia* exhibited spatially and temporally stable populations and significant correlations between reproductive input and emergence, and between emergence and subsequent adult activity.

Keywords: ecology, habitat selection, life history, Odonata, population dynamics, reproductive output, spatial heterogeneity.

INTRODUCTION

It is axiomatic that the sizes of natural populations are determined by combinations of two dynamic forces: 1) recruitment of new individuals through local reproduction, and immigration from other populations; and 2) loss of individuals through mortality and emigration. Both forces may vary considerably over space and time and produce dramatic fluctuations in the sizes and distributions of populations (Andrewartha & Birch, 1954; Birch, 1957). Information on the magnitudes and underlying forces of fluctuations in size are unknown for most natural populations. Such information depends on long-term studies which use dependable census techniques on well-defined populations. Examples of such studies include work by Ehrlich et al. (1975) on butterflies, Dixon (1979) on aphids, Taylor & Taylor (1979) on moths and aphids, and Gill (1978) and Gill et al. (1983) on amphibians.

Dragonflies which breed in discrete habitat patches such as small ponds offer an exceptional opportunity to document the range of spatial and temporal variation in recruitment and mortality of critical life stages. Odonate life histories are characterized by an extended aquatic larval stage and a comparatively short terrestrial adult stage (Corbet, 1962, 1980). The points of transition between these two stages, i.e., emergence (aquatic to terrestrial) and oviposition (terrestrial to aquatic), provide excellent windows through which to view the forces controlling population size. Furthermore, comparison of emergence patterns with oviposition patterns at several ponds illuminates the possible sources of variation in rates of immigration, emigration, and local reproduction. In this paper, we report the patterns of emergence and oviposition of adult dragonflies at five mountain ponds in northwestern Virginia over a four-year period. Species-specific patterns of emergence document the importance of spatial and temporal variation in reproductive suitability of ponds. We focus on oviposition as a measure of reproductive input and a potentially important source of variation in emergence of four species. Differential survival of eggs and larvae represents the only other source of variation in emergence. Patterns of variability in the survival of these

[1]Editor's note: This paper is adapted from Chapter 2 in Halverson (1983); with my approval, no effort was made to update the literature references.

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stages were evaluated by Halverson (1983). Measures of the extent of migration among ponds by adult dragonflies are reported in Halverson (1983).

The specific questions asked in this study were: 1. What are the annual patterns of variability among ponds in dragonfly emergence? 2. Are the patterns similar for different species which utilize the same set of ponds? 3. Does the number of emerging adults correlate with the size of the subsequent breeding population at a pond? and 4. Can the variation in emergence be ascribed to variation in previous reproductive input, or is it necessary to postulate variation in environmental factors affecting the survival of eggs or larvae?

STUDY SITE AND ORGANISMS

Our study was conducted at five woodland ponds in the Shenandoah Mountains, George Washington National Forest, Rockingham County, Virginia, from 1978 through 1981. The ponds were small (5–15 m in diameter), roughly circular, and positioned along mountainous ridges varying in elevation from 1,024 to 1,114 m above sea level. None of the ponds supported fish populations but each was used for breeding by a variety of amphibians. For more detailed descriptions of the surrounding terrain and the fauna of these ponds see Fraser (1976), Gill (1978), Gill et al. (1983), and Halverson (1984). The five ponds used in this study were Pond Ridge Pond (PR), White Oak Flat Pond (WF), Cline's Hacking Pond (CH), Dictum Ridge Pond (DR), and Second Mountain Pond (SM) (Fig. 1). These ponds, along with a similar sixth pond, comprised the only permanent, aquatic habitat within a 6 km radius. Each of the five study ponds was surrounded by a drift fence of window screening 0.5–0.8 m high at a distance of 0.5–2.5 m from the pond edge. These fences were erected and maintained to study amphibian populations (see Berven et al., 1979; Berven, 1982; Gill, 1978; Gill et al., 1983), but also provided convenient supports for emergence of many of the dragonfly species.

The dragonfly communities of the study ponds were composed of six common species which bred at one or more of the ponds in all four years, and an additional six rare or infrequently observed species. The largest of the common species were the Black-tipped Darner, *Aeshna tuberculifera* Walker, and the Shadow Darner, *Aeshna umbrosa* Walker (common names follow DSA, 1996). These species were very similar in both their morphology and life histories: two-year life cycles, oviposition in late summer and fall, an overwintering embryonic diapause, and a 15–17 month larval period (Halverson, 1984). The Common Whitetail, *Plathemis lydia* Drury, and Twelve-spotted Skimmer, *Libellula pulchella* Drury, were moderate-sized dragonflies which also showed morphological and ecological similarities. Both species had a one-year life cycle with a lengthy ovipositional period (mid-May to mid-August), direct embryonic development, a 10–11 month larval period, and asynchronous emergence. The remaining two common dragonflies at the study site were the Ruby Meadowhawk, *Sympetrum rubicundulum* Say, and the American Emerald, *Cordulia shurtleffii* Scudder. The former is a small species which bred from mid-July through August. Its eggs passed through an overwintering embryonic diapause but the life cycle appeared to be univoltine. Much less information is available on the life history of *C. shurtleffii*. Adults emerged early in the spring but persisted through most of the summer. The life cycle of this species may have been univoltine or semivoltine.

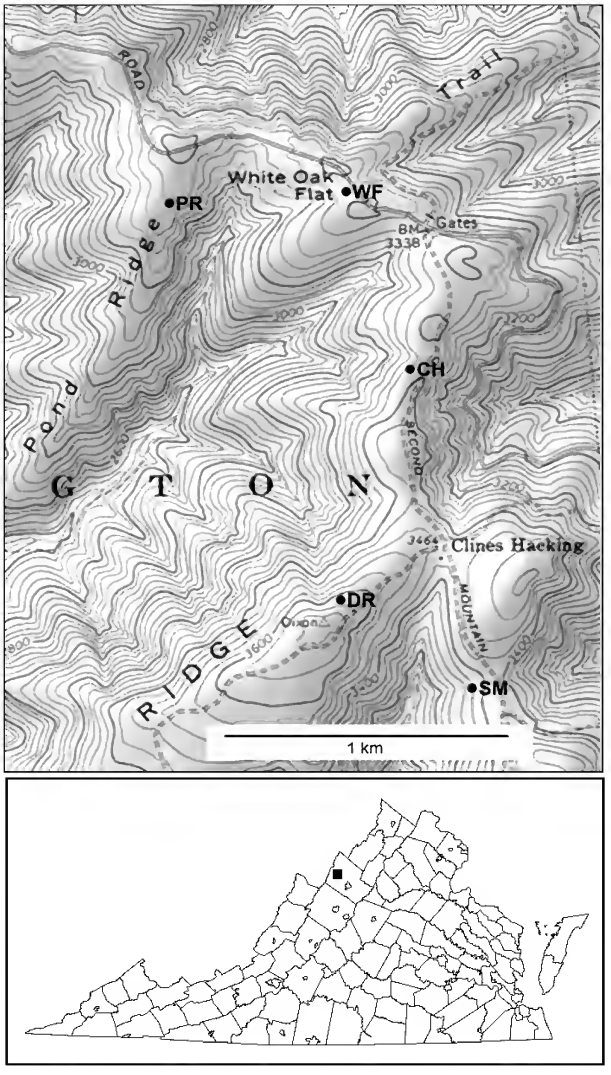

Fig. 1. Map of study ponds and location within Rockingham County, Virginia (square). See text for abbreviations.

We observed six other dragonfly species infrequently as either adults or larvae at the study ponds. Twenty-six Swamp Darners, *Epiaeschna heros* Fabricius, emerged from three ponds (PR, CH, and DR) during 1978, but none was seen at the study site during the subsequent three years. Eleven Common Green Darners, *Anax junius* Drury, emerged from SM and WF ponds in 1980; we observed adults occasionally in 1979 and 1980, but only once each in 1978 and 1981. Our records for Black Saddlebags, *Tramea lacerata* Hagen, were limited to an adult observed at PR pond in 1979 and an exuvia found at the same pond in 1980. The remaining three rare species were seen only as breeding adults, with no evidence of emergence from any of the study ponds. We saw two Blue Dasher (*Pachydiplax longipennis* Burmeister) males at CH pond in 1979 and eight adults (6 males, 2 females) were observed breeding at this pond in 1980. We collected three Dot-tailed Whiteface (*Leucorrhinia intacta* Hagen) males at CH pond in 1980 and a Painted Skimmer (*Libellula semifasciata* Burmeister) male was sighted at PR and SM ponds in 1979.

METHODS

We collected exuviae at one- to two-week intervals during the emergence season in all four years by carefully searching the fences and enclosed vegetation at each pond. Generally, collections were taken from all five ponds on the same day, but collections spanned as many as three days on rare occasions. Collected exuviae were sorted to species and counted in the laboratory.

In 1980 and 1981, we marked 142 fresh exuviae *in situ* at two ponds, with small spots of enamel paint. These exuviae were then censused at one- to four-day intervals in order to determine the natural rate of loss of exuviae, and hence the sampling efficiency of our weekly exuvial collections. We assigned exuviae to one of two groups on the basis of morphology and emergence site, and representatives of each of these groups were marked and censused during three different portions of the emergence season. One group included large exuviae of the family Aeshnidae (*A. tuberculifera* and *A. umbrosa*), which tended to occur on reed stems or other emergent vegetation at heights of 2 to 90 cm above the pond surface. The second group included moderate-sized dragonfly exuviae (Family Corduliidae, *C. shurtleffii*) and Family Libellulidae, *L. pulchella* and *P. lydia*), which tended to occur lower in the vegetation (<30 cm) but over a wider range of horizontal distances from the pond (5-150 cm). We used the three seasonal samples as replicates to estimate variation in loss rate independently for the two morphological groupings.

We monitored adult activity of both species of *Aeshna, P. lydia,* and *L. pulchella* at the study ponds in 1979 and 1980 during a series of 30 min observation periods. Our observations were conducted at all five ponds on 19 days in 1979 and on 23 days in 1980. Ponds were surveyed between 1000 h and 1700 h; our observations spanned the entire breeding season in both years. During each minute of an observation period, we recorded the numbers of males and females of each species at the pond. We defined adult activity level for a given species as the total number of dragonfly minutes accumulated during the 30 min observation period. Mean activity levels during the flight season were calculated for each species at each pond in both years. The flight season for a species in any year was defined as the period between the first and last observations of a breeding adult in the study area.

Reproductive input to each pond was also evaluated directly for *A. tuberculifera* in 1978, 1979, and 1980. These data were obtainable because over 90% of oviposition by this species at the study ponds occurred in stems of the rush *Juncus effusus* L. (Halverson, 1984). At the end of the breeding season (late September or October) in all three years, we carefully examined all stems of *J. effusus* at SM and DR, and approximately 20–30% of the stems at CH, WF, and PR. We recorded the number of characteristic oviposition marks left by female *A. tuberculifera* for each clump of *J. effusus* examined. At CH, WF, and PR ponds, where 20–27 clumps of *J. effusus* of nearly equal size existed, five or six clumps were chosen randomly for exhaustive sampling. We estimated reproductive inputs at these ponds by multiplying the mean number of ovipositional marks per clump by the number of clumps at the pond.

These direct estimates of oviposition by *A. tuberculifera* during 1979 and 1980 were compared with mean adult activity for those years using Spearman rank correlations in order to verify that adult activity measurements accurately reflected reproductive input. Spearman rank correlations were also used to investigate relationships between adult activity and emergence in the same year, and between adult activity (or reproductive input) and subsequent emergence number (i.e., the number of exuviae collected one year later for *P. lydia* and *L. pulchella* or the number collected two years later for *A. tuberculifera* and *A. umbrosa*).

RESULTS

The loss rate of marked exuviae was significantly greater for the corduliid-libellulid group than for the aeshnid group (Fig. 2). Differences among the three

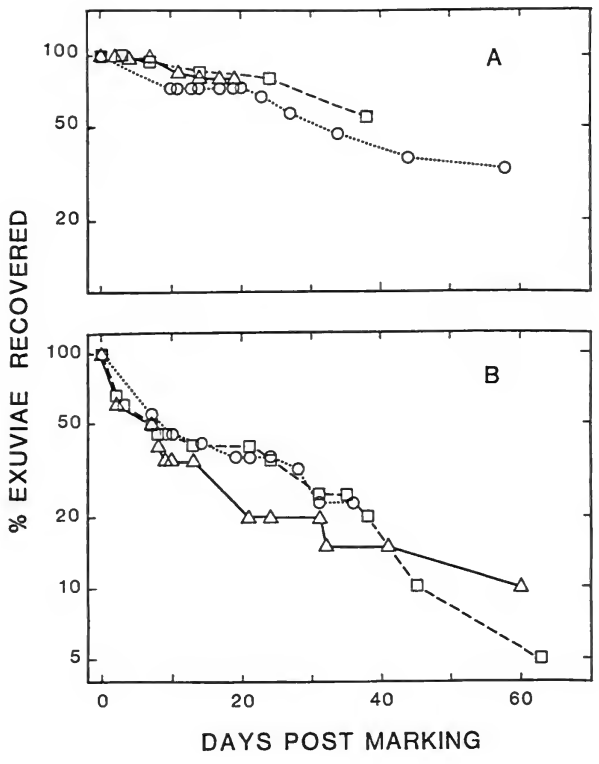

Fig. 2. Loss rate of exuviae of the aeshnid group (A) and the corduliid-libellulid group (B). Each of the three separate cohorts of exuviae monitored at different periods of time are represented by a different symbol (see methods).

seasonal samples within each group were small. Estimates of the mean sampling efficiency of weekly exuvial collections (i.e., percent of total exuviae discovered) were 89% for the aeshnid group and 49% for the corduliid-libellulid group.

Spatial variability in adult production was conspicuous for all six species (Fig. 3). Within any given year, some ponds were more productive than others. Only one species (*A. umbrosa*) emerged from all ponds in a single year, and even in this case there was an order of magnitude difference in numbers of exuviae collected at the most productive and the least productive ponds. Ponds which were the most productive for one species were not necessarily the most productive for all species. For example, while CH produced the most *S. rubicundulum* it produced relatively few exuviae of the other species.

Dramatic annual fluctuations were also apparent for five of the six species. Many species appeared and disappeared irregularly at ponds (e.g., *A. tuberculifera* at CH pond, *L. pulchella* at WF pond). Even at ponds which consistently produced exuviae over the four years, the numbers collected frequently shifted by an order of magnitude between successive years (e.g., *A. umbrosa* or *A. tuberculifera* at WF pond). Independence among ponds in annual patterns of variation was the rule for these species. The eleven-fold increase in the number of *A. umbrosa* exuviae collected at WF (from 1979 to 1980), for instance, was accompanied by a decrease in numbers of this species at the other four ponds, including an apparent extinction at DR. The irregular appearance and disappearance of other species at the various ponds also demonstrates independence among ponds in the effects of annual fluctuations.

Plathemis lydia exhibited greater spatial predictability and less temporal variation in emergence than any of the other species at these ponds. No *P. lydia* exuviae were ever discovered at DR or CH during the study, but they were present in every year at SM and WF. Low temporal variation for *P. lydia* is illustrated by a comparison of variation around the mean emergence population size for the three species which emerged at WF in all four years. The coefficient of variation for the number of exuviae collected was considerably lower for *P. lydia* (34.8) than for *A. tuberculifera* (99.6) or *A. umbrosa* (105.9). In spite of the relative predictability for this species, the different trends in population size at SM (steady increase), WF (rise and fall), and PR (decline to extinction) indicate a level of independence among ponds similar to that found for the other species.

Adult activity levels varied for all species both among ponds and between years (Table 1). Mean adult activity levels were positively correlated with the number of adults emerging at a pond earlier in the same year for *P. lydia* and *L. pulchella*, but not for either *Aeshna* species (Table 2). However, only *P. lydia* yielded a significantly positive correlation between reproductive input one year, and number of exuviae (representing their offspring) collected as a cohort either one or two years later (depending on the life cycle of the study species) (Table 2). For *A. tuberculifera*, there was also a highly significant positive correlation between the number of oviposition marks at a pond and mean adult activity level (Fig. 4).

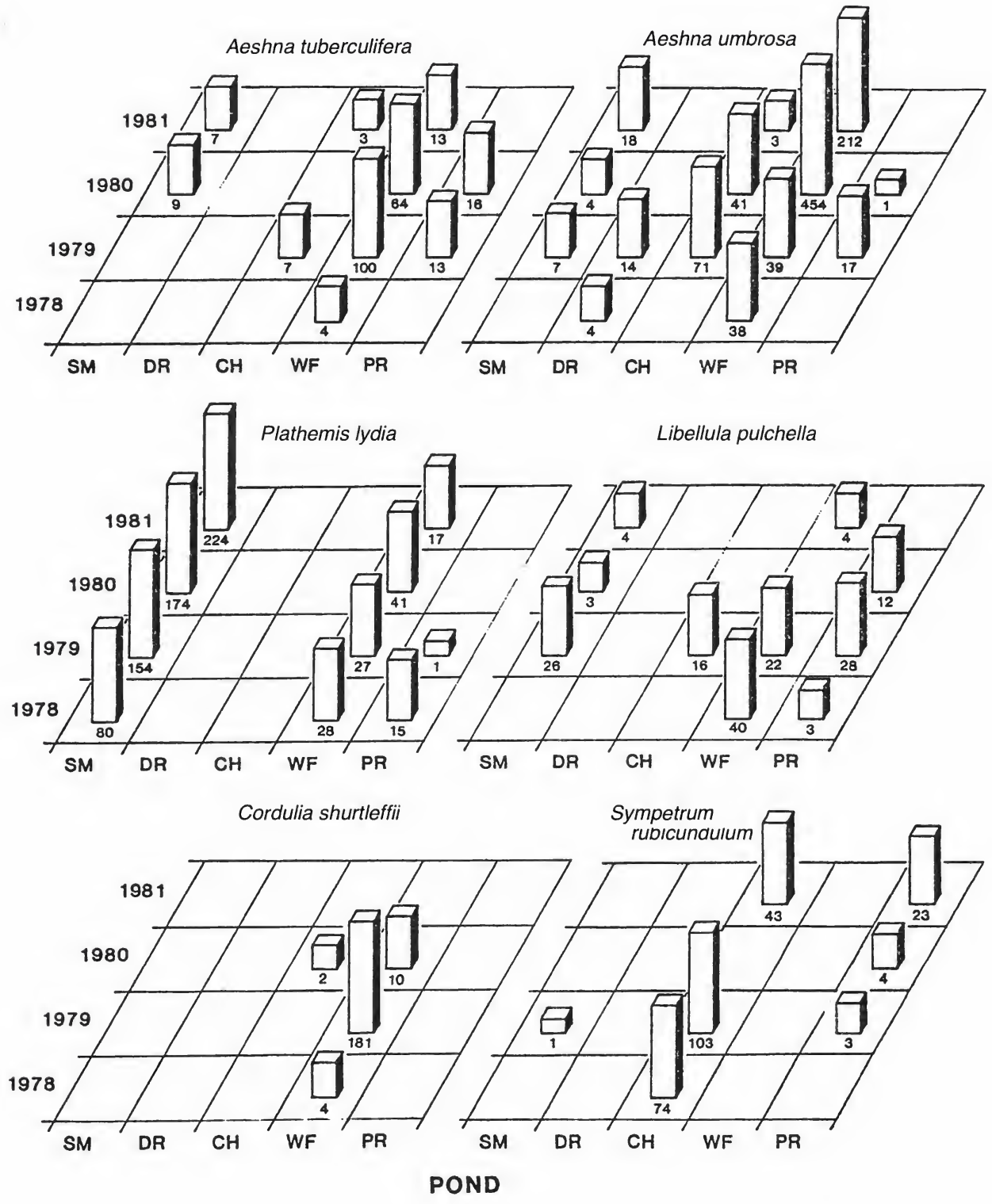

Fig. 3. Annual emergence records for six species of dragonflies at each pond during the four-year study. The height of each block represents the number of exuviae collected on a logarithmic scale; actual numbers collected appear under each block.

Table 1. Adult activity for each pond in 1979 and 1980. Activity is listed as the mean number of dragonfly minutes per 30 min observation period. Number of oviposition marks is also given for *Aeshna tuberculifera* (estimated numbers are indicated by an asterisk).

		Aeshna tuberculifera				
Year	Pond	Adult Activity	Oviposition Marks	*Aeshna umbrosa*	*Plathemis lydia*	*Libellula pulchella*
1979	SM	0.2	256	0.0	134.5	4.4
	DR	0.0	0	0.0	1.2	0.0
	CH	8.0	4375*	0.8	16.0	4.3
	WF	6.0	3723*	0.6	78.2	5.0
	PR	19.4	9196*	2.0	34.8	7.0
1980	SM	9.8	2262	7.6	56.2	5.9
	DR	0.0	673	4.8	0.2	0.0
	CH	6.6	2654*	1.0	8.4	2.5
	WF	25.6	34056*	15.3	61.5	0.1
	PR	0.0	61*	0.6	7.3	3.6

Table 2. Spearman rank correlation coefficients for the relationship between the number of exuviae collected and (1) previous reproductive input, or (2) subsequent adult activity.

Correlation between	*Aeshna tuberculifera*			*Aeshna umbrosa*			*Plathemis lydia*			*Libellula pulchella*		
number emerging and:	N	rs	p	N	rs	p	N	rs	p	N	rs	p
Previous reproductive input	10	.21	NS	10	-.10	NS	10	.81	<.01	10	.54	NS
Subsequent adult activity	10	.44	NS	10	.18	NS	10	.85	<.01	10	.83	<.01

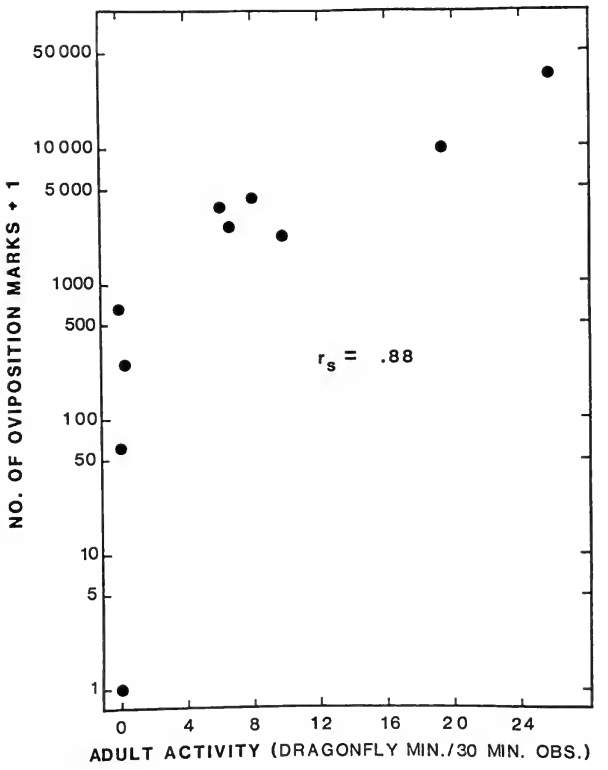

Fig. 4. Correlation between adult activity measurements and direct measures of reproductive input to ponds for *Aeshna tuberculifera.*

DISCUSSION

Patterns of Heterogeneity in Adult Production

Environmental heterogeneity clearly affected populations of all six dragonfly species investigated in this study. There were striking differences in adult production among ponds for all species and among years within ponds for all but *P. lydia.* In addition, annual fluctuations affected ponds independently, adding an important dimension to the heterogeneity of this system. Not only did ponds behave independently, but the various species also showed independent patterns of variability under the same set of environmental circumstances. The different responses by species as closely related as *A. tuberculifera* and *A. umbrosa* emphasizes the difficulty of relating arbitrary measurements of physical, chemical, or biotic factors in the environment to variation in environmental quality for a given species.

This independence among species also demonstrates the improbability that the observed variation was the result of systematic sampling biases. Although weekly exuvial collections underestimated actual adult production at ponds (and did so to varying degrees for the two family groups), this bias could not have produced the large spatial and temporal variations observed. For instance, the absence of *L. pulchella* exuviae from 1980 WF samples cannot be explained by a low sampling efficiency at this pond in that year because *P. lydia* exuviae were found in their greatest abundance at WF during the same period. Similarly, the low number of *A. tuberculifera* exuviae at CH in 1979 contrasts with a high number of *A. umbrosa* exuviae at that pond in the same year. Similar arguments can be constructed for differences in the relative abundances of *C. shurtleffii* or *S. rubicundulum.*

A number of workers have reported significant spatial or temporal variations in dragonfly population size (Moore, 1964; Kurata, 1971; Lutz & McMahan, 1973) but none has examined these two components of variability simultaneously. For example, relative temporal stability of odonate populations such as was found for *P. lydia* in this study, has been reported for other species from studies of individual ponds, but these do not provide information on spatial heterogeneity among ponds (Macan, 1977; Ubukata, 1981).

Patterns of Heterogeneity in Adult Activity

There was extreme variation in adult activity among ponds for all species. For *P. lydia* and *L. pulchella*, this variation was related to the number of adults emerging at a pond, and deceptively suggests a functional relationship between the emergence population and the breeding population at a given pond. However, this correlation is not causative. Long-distance dispersal of adults, which is presumed to occur in odonates in general (Jacobs, 1955; Corbet 1962, 1980; Moore, 1964), has been demonstrated specifically in this system (Halverson, 1983). Such dispersal necessarily disassociates the adult breeding population from the emerging population at a pond. We interpret the observed variation in adult activity among ponds as representing behavioral responses of adults to varying environmental conditions at each pond. Some ponds attracted adults which accumulated there and elevated adult activity levels (e.g., *P. lydia* at SM), while other ponds failed to attract adults (e.g., DR). Consistent attraction of adults over several years to particular ponds which were also highly productive, resulted in the correlation of adult activity and emergence for *P. lydia* and *L. pulchella.*

Mean adult activity at a pond was a very accurate indicator of relative reproductive input at least for *A. tuberculifera.* This was demonstrated by the highly significant positive correlation between activity and the

number of oviposition marks at a pond (Fig. 3). Furthermore, mean adult activity should have been a less accurate measure of reproductive input for *A. tuberculifera* than for the other three species because a significant portion of oviposition by *A. tuberculifera* was performed by solitary females near dusk (Halverson, 1984), a time of day when adult activity was difficult to monitor. In contrast, nearly all oviposition by the other species (particularly *P. lydia* and *L. pulchella*) occurred during the middle of the day (Campanella & Wolf, 1974; Pezalla, 1979; T. G. Halverson, pers. obs.). Thus, we are confident that mean adult activity level provided a very accurate indicator of relative reproductive input for the species in this study.

Causes of Variation in Adult Production

Variation in production of adult dragonflies may result from variation in the number of eggs which are deposited in a pond, or from variation in the survival of those eggs or resulting larvae. Our data indicate that both factors were important in causing the differential patterns of emergence in this system.

In spite of the fact that variation in adult activity was observed for all species, this variation did not provide a general explanation for variation in the production of adults. Correlations between adult activity (= reproductive input) and subsequent emergence were generally low and not statistically significant for three of the four species examined. These results indicate that other environmental factors (i.e., those affecting survival of eggs and larvae in the ponds), must have been important in determining patterns of adult production in these species. The high correlation between reproductive input and subsequent emergence which was found for *P. lydia*, on the other hand, implies that most of the observed variation in emergence for this species can be explained by differential reproductive input. Nevertheless, direct observation and experimental evidence has shown that these same ponds were, in fact, variable in their ability to support larvae of *P. lydia* as well as the other three species (Halverson, 1983).

CONCLUSIONS

The number of dragonflies emerging from the five study ponds was highly variable and independent over the four-year period. Only *P. lydia* showed spatial and temporal predictability in emergence and adult activity. Variation in population size was the result of factors acting independently at both the aquatic and terrestrial stages of the dragonfly life cycle. We contend that variation in egg and larval survival is the major factor affecting emergence population size in this system, while behavioral responses of adults, leading to immigration and emigration, are the major cause of variations in the size of breeding populations. The dynamics of the dragonfly populations at the individual ponds can be explained by these parameters of individual recruitment and loss.

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Natural History of Amphibians and Reptiles of the Cohoke Mill Creek Watershed in Virginia

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ABSTRACT

Cohoke Mill Creek in King William County, Virginia was selected in the early 1990s as a reservoir site to serve the water needs of the growing human population in the City of Newport News. It would have flooded 890 ha of the watershed. At the request of the company overseeing the environmental assessment, we conducted field research during 1994 to document the herpetofauna in terrestrial and wetland habitats. We searched 12 study sites scattered throughout the watershed using multiple techniques and found 23 species of amphibians (14 anurans, 9 salamanders) and 20 species of reptiles (8 turtles, 4 lizards, 8 snakes). We provide an annotated checklist that summarizes our observations on habitat occurrence, activity times, body sizes, weights by sex, clutch size, hatchling emergence times, and prey. Two forested wetlands (seasonally flooded and semi-permanently flooded) contained the highest herpetofaunal diversity of all the sampled wetland types. The herpetofaunal diversity of the Cohoke Mill Creek watershed is typical of the Coastal Plain fauna in the Virginia portion of the mid-Atlantic region. Museum specimens provided the first voucher documentation for amphibians and reptiles in this heretofore unsurveyed watershed.

Keywords: amphibians, Cohoke Mill Creek watershed, mid-Atlantic, reptiles, wetlands.

INTRODUCTION

The Coastal Plain of Virginia has received a great deal of attention from field herpetologists since E.D. Cope (1895) caught a Rainbow Snake (*Farancia erytrogramma*) on the banks of the Pamunkey River in King William County in 1895. Yet despite efforts to document the distributional patterns of the amphibians and reptiles of the region (e.g., Reed, 1957; Mitchell, 1994; Mitchell & Reay, 1999; Greenlee, 2001; Grimm, 2004), the Middle and Upper peninsulas remain to be thoroughly surveyed. Notably, however, the Virginia Herpetological Society has been filling gaps in various parts of the state through their annual/biannual field trips (e.g., Steele, 2006; Watson, 2008, 2013; Perry, 2013; Gibson, 2015). One such under-surveyed area is King William County, for which miscellaneous locality records have accumulated over the past century from incidental collections (e.g., Cope, 1895; Dunn, 1936; Steele & Kleopfer, 2005; Harrell et al., 2009), but distribution maps in Mitchell & Reay (1999) and those

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on the Virginia Herpetological Society website (http://www.virginiaherpetologicalsociety.com/) reveal that the species checklist for the county is incomplete. This situation is especially true for the Cohoke Mill Creek watershed which had never been surveyed. The amphibian and reptile fauna may be represented by as many as 28 amphibians and 33 reptiles (Mitchell & Reay, 1999; Powell et al., 2016).

Cohoke Mill Creek watershed was selected in the early 1990s for a new water supply reservoir to serve the growing human population in the City of Newport News. The reservoir would have flooded 890 ha of the watershed, with wetlands comprising 212 ha of those flooded. Ultimately, however, the reservoir was not built due to public opposition and because the city determined that its needs would be met in the projected time period by existing water sources. Pre-construction surveys for several taxonomic groups were conducted in the 1990s during the environmental assessment. The herpetological survey was contracted to the senior author by a private environmental company. Our survey of the amphibian and reptile fauna had the following objectives: (1) determine whether listed endangered and threatened species occurred in the area, (2) obtain as complete a species list as possible in the time allowed in the portion of the watershed that would have been impacted by the reservoir, and (3) to collect museum voucher specimens and as much natural history information as possible in this heretofore unexplored area of Virginia.

MATERIALS AND METHODS

Study Sites

Cohoke Mill Creek lies between U.S. Rt. 30 and Co. Rt. 633 in the Coastal Plain in southeastern King William County. The study area extended from the Cohoke Mill Pond dam to the upper reach of the watershed east of Co. Rt. 633 near Whites Shop. At the time of the survey, the floodplain of the mainstem and its tributaries were extensively covered with hardwoods, scrub/shrub wetlands with emergent macrophytes, and beaver ponds spaced irregularly along the stream. The entire floodplain has remained in this condition with only moderate alteration (timber harvest) through 2018 as evidenced by images on Google Earth (accessed 12 December 2018). We identified a variety of other wetlands in the watershed, including farm ponds, man-made dikes, and ephemeral pools. Two primary activities have occurred in the watershed: agriculture and logging of hardwoods and pines. Elevation in the creek is 17 m above sea level (ASL) at its upper end and 4.5 m ASL at the lower end near Cohoke Mill Pond. The highest elevation in the study area was 47 m ASL. The floodplain in the watershed has until recently remained undisturbed by timber harvesting and other human encroachment for over 200 years (Wass & Wright *in* Fowler & Herschner, 1989). A plant ecology study in 1984–1985 determined that six species of trees dominated the overstory: green ash (*Fraxinus pennsylvanica*), black gum (*Nyssa sylvatica*), ironwood (*Carpinus caroliniana*), red maple (*Acer rubrum*), tulip poplar (*Liriodendron tulipifera*), and sweetbay magnolia (*Magnolia virginiana*). Arrowwood viburnum (*Viburnum dentatum*) dominated the understory (Fowler & Herschner, 1989).

We conducted field research during three periods in 1994: 29 April–1 May, 10–12 June, and 8–10 July at 12 sites selected from USGS 7.5' topographic maps (New Kent quad) and aerial photographs. These sites were located throughout the watershed to provide broad geographic coverage and ensure that we investigated each wetland type in the area. We visited 11 of the 12 study sites and eliminated two (6, 12) because they were difficult to access.

Site 1. 37.585353N, -76.944536W. This was the site of the proposed reservoir dam on the mainstem of Cohoke Mill Creek. This portion of the creek contained extensive emergent and scrub/shrub wetlands dominated by woody vegetation < 6 m tall. The overstory consisted of smooth alder (*Alnus serrulata*), buttonbush (*Cephalanthus occidentalis*), swamp rose (*Rosa palustris*), black willow (*Salix nigra*), and highbush blueberry (*Vaccinium corymbosum*). The herbaceous layer had sedges (*Carex* spp.), spotted jewelweed (*Impatiens capensis*), rushes (*Juncus* spp.), and arrow arum (*Peltandra virginica*). Seasonally flooded forested wetlands occurred within an unnamed tributary that feeds into this area from the east. Mixed hardwoods included red maple, river birch (*Betula nigra*), American beech (*Fagus grandifolia*), sweet gum (*Liquidambar styraciflua*), sycamore (*Platanus occidentalis*), ironwood, flowering dogwood (*Cornus florida*), and American holly (*Ilex opaca*). Loblolly pine (*Pinus taeda*) stands occurred on both sides of the creek.

Site 2. 37.606703N, -76.918522W. Two open-water, man-made ponds with turbid water and silted substrate comprised this site but had no emergent plants. A tributary connected to the ponds contained emergent wetland plants. Several seepages were associated with this area. Re-growths following timber harvesting consisted of mixed hardwoods (e.g., sweet gum, tulip poplar, and Virginia pine [*Pinus virginiana*]) and surrounded both ponds. Emergent wetlands included sedges, spotted jewelweed, rushes, arrow arum, and

broad-leaved cattail (*Typha latifolia*).

Site 3. 37.966679N, -76.944755W. This area consisted primarily of large ponds created by a man-made dike enhanced by beaver activity. Most of the ponds were shallow with silt bottoms. Emergent grasses lined the margins and occurred in the shallow areas. Most of the surrounding slopes harbored loblolly pine stands and some mixed hardwoods (e.g., sweet gum, tulip poplar, black gum).

Site 4. 37.612503N, -76.939549W. This is an open-water farm pond on a small tributary created by a man-made dike. The pond undoubtedly receives large amounts of nutrient runoff from agricultural fields. It appeared to be constantly turbid with a silt bottom. Little aquatic vegetation occurred here except along one of the small tributaries. A seasonally flooded forested wetland occurred below the dike in the riparian zone with red maple, river birch, sweet gum, and black gum trees. Planted stands of loblolly pine bordered this wetland on each side.

Site 5. 37.627808N, -76.961514W. This area on the mainstem of Cohoke Mill Creek was characterized by a large expanse of emergent wetlands that graded into scrub/shrub wetlands to the north. Characteristic wetland plants included sedges, spotted jewelweed, rushes, arrow arum, broadleaf cattail, and swamp rose. The small tributaries feeding into the mainstem from the east and west contained seasonally flooded forested wetlands. One large tributary had semi-permanently flooded forested wetlands. Mixed hardwood stands (e.g., sweet gum, tulip poplar, black gum) with some Virginia and loblolly pine occurred on both slopes above the creek.

Sites 7 and 8 (combined). 37.636106N, -76.960332W. These two areas were in tandem along a large tributary of Cohoke Mill Creek in the eastern portion of the watershed. Open water wetlands created by beaver, emergent wetlands, and scrub/shrub wetlands characterized these areas. Seasonally flooded, forested wetlands occurred along the tributaries that fed these areas from the south. Mixed hardwoods occurred on the slopes above these areas and recently timbered areas bordered these stands. Hardwoods included red maple, river birch, American beech, sweet gum, tulip poplar, black gum, sycamore, and willow oak (*Quercus phellos*).

Site 9. 37.634095N, -76.970698W. An open water, man-made pond dominated this site, although a patch of seasonally flooded forested wetlands occurred immediately upstream. The overstory tree species included red maple, river birch, sweet gum, black gum, and willow oak. Other vegetation consisted of alder, buttonbush, swamp rose, black willow, common elderberry (*Sambucus canadensis*), and highbush blueberry. The herbaceous layer had sedges, spotted jewelweed, arrow arum, and broadleaf cattail. We searched several ephemeral pools that had no vegetation in a nearby rutted dirt road. The northern slope supported a cutover hardwood forest and the southern slope contained a mix of hardwoods and pines.

Site 10. 37.664212N, -76.983429W. This site lies in the upper portion of the mainstem of Cohoke Mill Creek. The banks bordering the creek were considerably steeper than downstream. The area contained a complex of open water wetlands created by beaver dams, emergent wetlands, scrub/shrub wetlands, and seasonally flooded forested wetlands. Emergent and scrub wetlands supported alder, sweet pepperbush (*Clethra alnifolia*), spicebush (*Lindera benzoin*), buttonbush, swamp rose, black willow, highbush blueberry, sedges, spotted jewelweed, rushes, arrow arum, and broadleaf cattail. Extensive hardwood stands of red maple, river birch, American beech, sweet gum, tulip poplar, ironwood, flowering dogwood, and American holly occurred on the slopes. The creek remained flooded throughout the year due to the presence of beaver dams.

Site 11. 37.513101N, -76.974875W. Emergent wetlands and scrub/shrub wetlands maintained by a large beaver pond dominated the mainstem portion of this site. Emergent wetlands were dominated by herbaceous vegetation and had various hydrologic regimes. Plant species included sedges, spotted jewelweed, rushes, arrow arum, broadleaf cattail, smartweeds (*Polygonum* spp.), and bulrushes (*Scirpus* spp.). The main tributary in this area contained a seasonally flooded forested wetland. Tree species included red maple, river birch, sweet gum, black gum, swamp chestnut oak (*Quercus michauxii*), water oak (*Quercus nigra*), and willow oak. The timber was recently removed on the eastern side of this area and the western side had been clearcut several years previously and consisted of a young loblolly pine stand at the time of the study.

Site 12. 37.655431N, -76.998237W. Two shallow woodland ponds and pools with no cover occurred alongside Co. Rt. 679 at this site. All contained water during our first visit in April, but were dry by June. One of these ephemeral pools occurred in a corner of an agricultural field and extended into the adjacent woods. A dark tannin water pond was completely within a stand of mixed hardwoods.

Site 13. 37.559172N, -76.953490W. An open water wetland created by a man-made dike dominated this site. Agricultural fields bordered this pond to the west and a stand of hardwoods (e.g., sweet gum, tulip poplar) and loblolly and Virginia pine bordered it to the east. Grasses and a thin band of emergent vegetation and alder trees lined the margin.

Site 14. 37.652073N, -76.985750W. This site occurred along the largest confluence of Cohoke Mill Creek and a large unnamed tributary that fed the creek from the northwest. An open water beaver pond dominated the mainstem. The tributary contained a large expanse of seasonally flooded forested wetlands. A large seepage area occurred along the hillside that bordered the western margin of this forested wetland. The surrounding area had been logged in the past and consisted of stands of loblolly pine at the time of the study. Some of the stands on the slopes supported mixed hardwoods. Tree species included red maple, river birch, sweet gum, black gum, green ash, swamp chestnut oak, water oak, and willow oak.

Field Methods

Fieldwork consisted of diurnal visual encounter surveys, dip netting (D-ring net with a fine mesh bag) for amphibian adults and larvae in wetlands, setting minnow traps for larval salamanders, tadpoles and aquatic snakes, nocturnal collection of road-killed individuals, and nocturnal road transects to record locations of calling frogs. For aquatic turtles, we set box traps with two funnel openings made of 2.5 cm chicken wire (Iverson, 1979). Traps were set in shallow water with captured turtles able to reach the surface to breathe and were checked daily. We routinely recorded snout-vent length (SVL) and tail length (TL) of lizards and snakes to the nearest millimeter (mm). We measured straight-line maximum carapace length (CL) and straight-line maximum plastron length (PL) to the nearest 0.1 mm with dial calipers on all turtles captured or to the nearest mm with tree calipers for *Chelydra serpentina*. We obtained weights with portable Pesola® scales to the nearest gram (g), except for *C. serpentina* to the nearest 10 g. We did not measure most of the amphibians. We deposited voucher specimens in the herpetology division of the National Museum of Natural History (USNM). Common names follow Crother (2017) except for *Rana* (subgenus *Lithobates*) and *Bufo* (subgenus *Anaxyrus*) following Smith & Chiszar (2006), Pauley et al. (2009), Yuan et al. (2016), and Hillis (2019).

RESULTS

Annotated Species List

Species distributions in the watershed are summarized by site in Table 1.

Anurans

Acris crepitans (Eastern Cricket Frog) - Cricket frogs were abundant in forested wetlands and around the margins of all other wetland types and calling on all survey dates in April, June, and July. They also occurred in ephemeral pools in agricultural areas where emergent grasses were present. USNM 514840–514868 (adults).

Bufo americanus (American Toad) – *Bufo americanus* was uncommon except during the April-May field trip when several were encountered in one ephemeral pool. USNM 514834–514839 (adults).

Bufo fowleri (Fowler's Toad) – These toads were abundant around the margins of ephemeral pools, ponds, and wetlands with emergent vegetation. We heard vocalizations on 28–29 April and 8 July. Metamorphosed toadlets were found in a grassy flats area at Site 3 on 12 June. USNM 514764–514833 (adults), 515210–515211 (larvae).

Gastrophryne carolinensis (Eastern Narrow-mouthed Toad) – We found adult females under a board at the edge of a pasture above an open water, man-made pond and in a rain puddle on the edge of VA Rt. 30 at its junction with Co. Rt. 626. One 36 mm SVL female was found in a debris pile at this site. It is only 2 mm shy of the record size for the species (Powell et al., 2016). USNM 514908 (adult).

Hyla chrysoscelis (Cope's Gray Treefrog) – This species was abundant throughout the Cohoke Mill Creek watershed in or near ponds and ephemeral pools. Males called each day during our surveys. USNM 515869–514882 (adults), 515210–515211 (larvae).

Hyla cinerea (Green Treefrog) – This species was abundant throughout all wetland types except for ephemeral pools. We found large populations in all of the wetlands associated with the mainstem of Cohoke Mill Creek. Calling dates were 29 April, 10–12 June, and 8–9 July. USNM 514883–514895 (adults).

Hyla femoralis (Pine Woods Treefrog) – We found tadpoles of this species in an ephemeral pool in an area approximately 2 km east of Site 11 that had been logged and planted with loblolly pine. We captured two tadpoles in a small, water-filled pit in an old field and mixed pine-hardwood habitat. USNM 515215–515216 (larvae).

Pseudacris crucifer (Spring Peeper) – *Pseudacris crucifer* was abundant in all wetland types throughout the Cohoke Mill Creek watershed. We heard choruses on 29 April. USNM 514896–514907 (adults).

Pseudacris feriarum (Upland Chorus Frog) – This species was rarely found during our survey, largely because it calls earlier than most frogs in Virginia (February-March). One was calling from an ephemeral pool on 29 April. No specimens were collected.

Rana catesbeiana (American Bullfrog) – Adults and juveniles were abundant throughout the Cohoke Mill Creek system. We heard calling males on 29 April, 10–12 June and 8–9 July. USNM 514914–514944 (adults and juveniles), 515223–51524 (larvae).

Rana clamitans (Green Frog) – Adults and juveniles were abundant in all wetland types in the Cohoke Mill Creek system. We heard a large chorus on 29 April. USNM 514945–514985 (adults and juveniles), 515225–515246 (larvae).

Rana palustris (Pickerel Frog) – Unlike the other two ranids in the Cohoke Mill Creek watershed, this species was not found in ephemeral pools, although it was common in forested wetlands. We heard their calls on all of our survey dates. USNM 514986–515010 (adults and juveniles), 515247–515253 (larvae).

Rana sphenocephala (Coastal Plains Leopard Frog) – Although we infrequently encountered this early spring-breeder during our survey, we recorded it in all wetland types. Most records were of isolated calling males on 29 April. We collected one metamorph (USNM 515011).

Scaphiopus holbrookii (Eastern Spadefoot) – We found this secretive species active on paved roads only after a heavy rain on 9 July, but did not detect breeding congregations. USNM 514909–514913 (adults).

Salamanders

Ambystoma opacum (Marbled Salamander) – We found larvae of this species only in two ephemeral pools adjacent to Co. Rt. 679. One was near metamorphosis on 29 April. We found no adults during spring and summer field trips. USNM 515178–515179 (larvae).

Eurycea cirrigera (Southern Two-lined Salamander) – We found adults and larvae of this species in association with seepage areas in forested wetlands, emergent marshes, and scrub-shrub wetlands. We found one clutch of unpigmented eggs under a log. We collected larvae on 29–30 April, 10–12 June, and 9 and 22 July. USNM 515012–515035 (adults), 515180–515191 (larvae), 515586 (eggs).

Eurycea guttolineata (Three-lined Salamander) – This salamander occurred exclusively in seepage areas in forested wetlands where it appeared to be common. We collected adults on 30 April and 10 June. USNM 515036–515038.

Hemidactylium scutatum (Four-toed Salamander) – Adults, eggs, and larvae of this species occurred only in seepages in Site 11. We found five egg clutches in sphagnum on 30 April, three of which were attended by females. One clutch of four eggs hatched on 10 May in the laboratory. USNM 515039–515040 (adults), 515192 (larvae), 515587 (hatching larvae).

Notophthalmus viridescens (Red-spotted Newt) – Adults occurred in all wetland types, but we found larvae only in a turbid ephemeral pool in an old clearcut (12 June and 9 and 11 July). We found efts only in terrestrial woodlands. USNM 515050–515060 (adults and efts), 515193–515196 (larvae).

Plethodon cylindraceus (White-spotted Slimy Salamander) – We found this salamander only in mature hardwood forests and collected three adults on 30 April and 10–11 June. USNM 515041–515043.

Pseudotriton montanus (Eastern Mud Salamander) – We collected one adult on 9 July in a seepage area and discovered larvae in seepages on 10 June and 9–10 July. USNM 515044 (adult), 515198–515202 (larvae).

Pseudotriton ruber (Northern Red Salamander) – We found this species in seepages in the forested wetlands in Site 11 and in seepage habitats between the two ponds in Site 2. We collected adults 11–12 June and 10 July and two larvae on 11 June; one was preserved. USNM 515045–515049 (adults), 515197 (larva).

Siren intermedia (Eastern Lesser Siren) – We caught a 163 mm TL adult in a backwater pool at Site 5 and four larvae (52, 54, 57, and 64 mm TL) on 9 July at the edge of a beaver pond. USNM 515061 (adult), 515204–515205 (larvae).

Table 1. Amphibian and reptile distribution at study sites in the Cohoke Mill Creek watershed, King William County, Virginia.

	Study Sites										
Species	1	2	3	4	5	7/8	9	10	11	13	14
Frogs											
Acris crepitans	X	X	X		X	X		X	X	X	X
Bufo americanus					X			X	X		X
Bufo fowleri	X	X	X	X	X	X		X	X	X	X
Gastrophryne carolinensis		X									
Hyla chrysoscelis	X	X	X	X	X	X		X	X	X	X
Hyla cinerea	X	X	X	X	X	X		X	X	X	X
Hyla femoralis									X		
Pseudacris crucifer	X		X		X		X	X	X		
Pseudacris triseriata	X	X	X	X	X	X		X	X	X	X
Rana catesbeiana	X	X	X		X	X		X	X	X	X
Rana clamitans	X	X	X	X	X	X		X	X	X	X
Rana palustris	X	X	X	X	X	X		X		X	X
Rana sphenocephala	X		X		X				X		
*Scaphiopus holbrookii**											
Salamanders											
*Ambystoma opacum**											
Eurycea cirrigera	X	X						X			X
Eurycea guttolineata						X		X			
Hemidactylium scutatum								X			
Notophthalmus viridescens	X	X							X	X	
Plethodon cylindraceus						X		X	X		X
Pseudotriton montanus									X		X
Pseudotriton ruber		X							X		
Siren intermedia	X				X						
Turtles											
Chelydra serpentina	X	X	X		X			X		X	
Chrysemys picta	X	X	X		X			X	X	X	
Clemmys guttata								X			
Kinosternon baurii					X						
Kinosternon subrubrum											X
Pseudemys rubriventris	X	X	X		X	X		X		X	X
Sternotherus odoratus	X	X	X		X			X		X	X
Terrapene carolina	X				X	X		X			X
Lizards											
Aspidoscelis sexlineatus					X	X					
Plestiodon fasciatus		X			X			X			X
Sceloporus undulatus					X			X		X	
Scincella lateralis					X						
Snakes											
*Agkistrodon contortrix**											
Carphophis amoenus	X			X	X			X			X
Coluber constrictor	X				X	X		X			
Heterodon platirhinos									X		
*Lampropeltis rhombomaculata**											
Nerodia sipedon	X	X	X		X	X			X		
Opheodrys aestivus	X	X	X		X	X			X		
Pantherophis alleghaniensis	X				X	X		X			
Thamnophis sirtalis					X	X					

*Species found extralimital to the study area.

Turtles

Chelydra serpentina (Snapping Turtle) – We collected nine males and eight females during the 30 April–1 May and 11–12 June sampling periods. Most were released. A 245 mm CL, 181 mm PL, 2.8 kg female in the second survey was gravid. Morphometrics of Snapping Turtle adults and four other turtle species are summarized in Table 2. USNM 515116 (adult).

Chrysemys picta (Eastern Painted Turtle) – This was the most abundant freshwater turtle in Cohoke Mill Creek. We found a female (140.9 mm CL, 132.2 mm PL, 390 g) nesting at Site 5 on 29 April. We caught a hatchling (31 mm CL, 26.1 mm PL, 5.2 g) on 30 April just after it emerged from overwintering in the nest. Adult morphometrics are summarized in Table 2. USNM 515145–515151 (adults).

Clemmys guttata (Spotted Turtle) – We found a non-gravid adult female (114 mm CL, 101 mm PL, 209 g) at Site 11 on 11 June. USNM 515152 (adult).

Kinosternon baurii (Striped Mud Turtle) – This understudied species was discovered only in Site 5 in emergent wetlands. Female CL, PL, and mass were larger than that for males (Table 2). This location is near the northern edge of its range (Lamb & Lovich, 1990; Powell et al., 2016). USNM 515117–515124 (adults), 515255 skeleton).

Kinosternon subrubrum (Southeastern Mud Turtle) – A female collected on 10 June at Site 14 had numerous leeches (*Placobdella* sp.). We were unable to detect oviductal eggs by palping one potentially gravid female (106.1 mm CL, 92.7 mm PL, 201 g) found on 12 June in an area used extensively by turtles for nesting. USNM 515125–515133 (adults).

Pseudemys rubriventris (Northern Red-bellied Cooter) – This is a common species in open water wetlands of Cohoke Mill Creek. On 29 April we found a hatchling (36.5 mm CL, 33.6 mm PL, 9.9 g) that had recently emerged from its overwintering nest. This date is comparable to a known emergence date of 10 April 2008 in New Kent County (Mitchell et al., 2009). Three juveniles (74.9–88.5 mm CL, 69.8–83.0 mm PL, 81–122 g) were judged from growth annuli to be in their second year of growth. The largest adult was a male measuring 264.5 mm CL and 247.5 mm PL. USNM 515153–515156 (adults and juveniles), 515256 (skeleton).

Sternotherus odoratus (Eastern Musk Turtle) – We observed and captured many individuals of this species in open water, permanent wetlands in the Cohoke Mill Creek watershed. Morphometrics of adults are summarized in Table 2. USNM 515134–515144 (adults).

Table 2. Comparative morphometrics for five species of freshwater turtles (adults) from aquatic habitats in Cohoke Mill Creek watershed, King William County, Virginia. CL and PL are in mm and mass is in g. Means are followed by ± one standard deviation with minimum, maximum, and sample size (*n*).

	Males			Females		
Species	CL	PL	Mass	CL	PL	Mass
Chelydra serpentina	325.0±46.5 233–392, n = 9	224.2±27.2 172–250, n = 9	7028.8±2657.1 2680–10,000, n = 8	275.4±28.6 236–321, n = 8	204.1±18.6 181–239, n = 8	4868.87±1516.3 2800–7300, n = 8
Chrysemys picta	126.2±11.9 93.3–147.1, n = 45	116.3±10.2 86.5–133.6, n = 45	246.4±57.4 124–352, n = 43	143.1±11.7 118.4–160.1, n = 13	135.2±11.0 112.7–149.3, n =13	392.4±97.0 219–536, n = 13
Kinosternon baurii	80.3±13.1 71.2–95.3, n = 3	69.7±11.6 61–82, n = 3	94.5±46.4 64.5–148, n = 3	89.8 81.9–97.0, n = 2	79.3 70.3–88.2, n = 2	132 90–174, n = 2
Kinosternon subrubrum	100.7±10.3 78.6–109.0, n = 8	84.4±6.6 69.9–89.9, n = 8	177.2±57.8 72–230, n = 8	95.7±9.8 76.1–106.0, n = 7	82.5±9.7 69.2–92.7, n = 7	127.2±50.9 79.0–201.0, n = 5
Sternotherus odoratus	92.4±1.5 53.4–119.8, n = 41	63.3±10.0 43.3–78.0, n = 41	119.7±54.2 32.5–225, n = 39	82.4±8.5 67.4–106.5, n = 59	62.1±5.9 49.9–77.0, n = 59	88.5±26.1 48–172, n = 55

Terrapene carolina (Woodland Box Turtle) – We observed this species in all forested wetlands. We found two males with identical carapace lengths (132.9 mm) and weights (500 g) on 12 July. Two females captured on 1 May and 10 July were 117.0–119.7 mm CL, 113.7–121.5 mm PL, and 280–410 g, respectively. We found a juvenile on 10 June at site 5 that had been killed by a lawn mower. USNM 515157–515161 (adults), 515257–515258 (skeletons).

Lizards

Aspidoscelis sexlineata (Eastern Six-lined Racerunner) – Our only observation of this lizard was on Co. Rt. 626 near Site 5 on 9 July as it ran across the road between open fields.

Plestiodon fasciatus (Common Five-lined Skink) – We found most of these lizards in association with decaying logs in forested wetlands. We found three on a fallen log in a scrub/shrub wetland at Site 11. Three females (65 mm SVL, 5.6 g; 66 mm SVL, 5.4 g; 70 mm SVL, 7.0 g) were tending egg clutches in decaying logs on 8 July; an unattended clutch was also found in the same log. Clutch size was 6–9 ($n = 4$). We caught five juveniles with blue tails measuring 40–53 mm SVL and weighing 1.7–3.2 g on 1 May and 10 June that were probably hatchlings from the previous year. Males were 63–73 mm SVL and 5.9–9.3 g. USNM 515067–515078 (adults and juveniles).

Sceloporus undulatus (Eastern Fence Lizard) – We found one adult male on a fallen log in a scrub/shrub wetland at Site 11. The largest male we measured was 69 mm SVL and 10.2 g and the largest female was 67 mm SVL and 10.8 g; both were collected on 11 June. A 44 mm SVL, 3.1 g juvenile caught on 10 June was likely a hatchling from the previous year. USNM 515062–515066.

Scincella lateralis (Little Brown Skink) – This small lizard was observed only at Site 7/8 in a seasonally flooded forested wetland. No specimens were collected.

Snakes

Agkistrodon contortrix (Eastern Copperhead) – This is the only venomous snake known for King William County (Mitchell, 1994). Our only record was an adult female (856 mm SVL, 984 mm TL, 438 g) found during a rainstorm adjacent to a hedge row in an agricultural field on Co. Rt. 632, 0.3 km W of Lanesville. USNM 515079.

Carphophis amoenus (Eastern Wormsnake) – We collected this species in logs and under bark in forested wetlands and terrestrial habitats. The largest male was 212 mm SVL and 7.6 g and the largest female was 266 mm SVL and 11.0 g; both were collected on 11 June. USNM 515080–515093.

Coluber constrictor (Northern Black Racer) – We observed one juvenile in a riparian area associated with forested wetlands. We found a road-killed male (921 mm SVL, 1217 mm TL) on 12 June. The largest racer we encountered was a male (1102 mm SVL, 1342 mm TL, 418 g) found on 30 April. USNM 515094–515095 (adults).

Heterodon platirhinos (Eastern Hog-nosed Snake) – We found a single adult female (705 mm SVL, 833 mm TL, 240 g) on the edge of a forested wetland at Site 11 on 9 July. USNM 515103.

Lampropeltis rhombomaculata (Northern Mole Kingsnake) – We found one road-killed juvenile (392 mm SVL, 462 mm TL) on Co. Rt. 633 in mixed hardwood and pine habitat on 12 June. It was found outside the survey area; however, we expect this species occupies the upper portions of the watershed. USNM 515104.

Nerodia sipedon (Northern Watersnake) – This is a common snake in Cohoke Mill Creek wetlands and occupies all wetland types. We found the largest male (501 mm SVL, 674 mm TL, 102 g) on 8 July; the largest female (770 mm SVL, 952 mm TL [partial tail], 462 g) on 29 April. The smallest, a subadult female, was 193 mm SVL, 251 mm TL, and 6.2 g. A 198 mm SVL and 7.7 g juvenile regurgitated an *Ambystoma opacum* larva on 29 April. Another juvenile (235 mm SVL, 11 g) regurgitated the rear legs of a small *Rana clamitans* on 8 July. USNM 515105–515112 (adults and juveniles).

Opheodrys aestivus (Northern Rough Greensnake) – We found a single juvenile (153 mm SVL, 2.1 g) in emergent wetlands in Site 5 on 29 April. USNM 515113.

Pantherophis alleghaniensis (Eastern Ratsnake) – We found this species in mixed hardwoods and in a pine plantation. The two largest snakes were both road-killed males (1106 mm SVL, 1357 mm TL; 1326 mm SVL, 1606 mm TL) found on 11 and 12 June, respectively. The sole female (965 mm SVL, 1091 mm TL, 275 g) was captured in grassland at an old farm building on 10 June. USNM 515096–515102 (adults).

Thamnophis sirtalis (Eastern Gartersnake) – Both specimens collected during this survey occurred in terrestrial habitats, one on Co. Rt. 626 near Site 5 and another in a mixed hardwood-pine stand in Site 7/8. The largest was a fresh road-killed female (710 mm SVL, 890 mm TL) found on 12 June. Another adult female (548 mm SVL, 694 mm TL, 8.1 g) was found on 30 April in site 8/9. USNM 515114–515115.

DISCUSSION

Information on some aspects of the natural history of amphibians and reptiles in Virginia is lacking for nearly all species, including prey (Mitchell, 1994; Dodd, 2013), as well as life history trait variation, such as clutch size, egg size, size at metamorphosis or at hatching. Although many areas of Virginia are represented by museum specimens, just as many more have no formal vouchers of any species. Our collections provide the first such vouchers for the Cohoke Mill Creek watershed.

The herpetofaunal diversity of the Cohoke Mill Creek watershed is typical of the Coastal Plain fauna in the Virginia portion of the mid-Atlantic region. We found no state or federally listed species in the Cohoke Mill Creek watershed. The watershed is near historic occurrences of several rare species, including the state endangered *Ambystoma tigrinum* and the state threatened *Ambystoma mabeei* and *Hyla gratiosa* (Mitchell, 1991; VDGIF, 2019). We did not encounter a number of species that could occur in the Cohoke Mill Creek watershed, including four species of salamanders (*Ambystoma maculatum*, *Amphiuma means*, *Desmognathus fuscus*, *Plethodon cinereus*), three lizards (*Plestiodon inexpectatus*, *P. laticeps*, *Ophisaurus attenuatus*), and 11 snakes (*Cemophora coccinea*, *Diadophis punctatus*, *Pantherophis guttatus*, *Farancia erytrogramma*, *Lampropeltis getula*, *L. triangulum*, *Storeria dekayi*, *S. occipitomaculata*, *Thamnophis sauritus*, *Haldea striatula*, *V. valeriae*). We found all frog and turtle species that were expected for the area.

Complete inventories of amphibians and reptiles require using multiple techniques throughout the activity seasons of these animals (Mitchell et al., 1993; Heyer et al., 1994; Foster, 2012). Amphibians breed at different times of the year, such as late-winter/early spring and spring/summer, and many of them are secretive outside of the breeding season. Survey periods of short duration (e.g., several weeks) will usually miss several species. Mitchell et al. (1994) demonstrated that the composition of amphibian, reptile, and small mammal communities studied in two 6-week periods in Quantico Marine Corps Base, Prince William County, Virginia differed dramatically between sampling periods.

Our perception of the herpetofaunal diversity in the Cohoke Mill Creek watershed is based on three short-term survey periods. However, long-term studies using multiple capture techniques conducted over an extended period of time would yield a more accurate picture of species richness, including adding more species than we were able to document (Gibbons et al., 1997). Buhlmann et al. (1994) demonstrated that even with the use of an intensive, 24-h trapping technique (drift fences with pitfall traps) used over several months, the capture of a final rare species in a Virginia Coastal Plain habitat took an additional 19 weeks. Thus, in order to complete the inventory of the herpetofauna of Cohoke Mill Creek, this project would have required numerous additional field trips over many years. Even then, the species likely to be added would be secretive and common taxa, not rare or listed species. Accumulation of natural histories and life history traits in the watershed would also take considerable extra effort.

Construction of the reservoir in Cohoke Mill Creek might have resulted in extirpation of several species due to loss of a variety of wetland habitats. The overall effect of construction of the proposed Newport News reservoir would have contributed to the continued decline in diversity of the watershed's amphibian and reptile fauna and cause additional loss of biodiversity in Virginia's already modified Coastal Plain. Unless the Cohoke Mill Creek watershed is again proposed for a reservoir project, the diversity of amphibians and reptiles in the watershed should remain intact for the foreseeable future.

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Carpenter and Leopard Moths of Virginia (Lepidoptera: Cossoidea: Cossidae, Dudgeoneidae)

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ABSTRACT

Seven species of the moth families Cossidae (n = 6) and Dudgeoneidae (n = 1) are reported for Virginia based on recent field work, museum specimens, literature records, and photographs. Four species, including *Givira anna* (Dyar), *G. francesca* (Dyar), *Inguromorpha basalis* (Walker), and *Zeuzeura pyrina* (Linnaeus), are recorded from Virginia for the first time. County and city records and capture dates are reported for all species.

Keywords: *Givira anna*, *Givira francesca*, *Inguromorpha basalis*, *Zeuzeura pyrina*, new state records, distribution, phenology.

INTRODUCTION

This paper is the first installment of what is projected to be a series of papers documenting our current knowledge of the moth fauna of Virginia. Cossidae is a small family containing nearly 1,000 species in 151 genera (van Nieukerken et al., 2011), mostly in tropical regions. Approximately 50 species are reported from North America (Hodges et al., 1983), mostly from the western United States. Cossids are among the largest "microlepidoptera," with wingspans ranging up to 8.5 cm (Covell, 1984). The larger species are robust and heavy-bodied (e.g., *Prionoxystus robiniae*). Many species are mottled gray with black markings on the wings, and females are typically larger than males. The larvae bore into branches or trunks of living shrubs or trees, sometimes resulting in considerable damage, and require up to 4 years to mature (Covell, 1984). The subfamily Cossulinae was recently transferred from Cossidae to Dudgeoneidae; the latter includes 57 species assigned to six genera (Mutanen et al., 2010; van Nieukerken et al., 2011).

The most recent monograph on the Nearctic cossid fauna (sensu lato) is the century-old treatment by Barnes & McDunnough (1911), but Covell (1984) and Solomon (1995) provided useful species accounts for most of the species discussed in this paper. Collectively, Beadle & Leckie (2012) and Leckie & Beadle (2018) contain brief accounts for all of the species discussed below. Illustrations of adults can also be found on several websites (e.g., Moth Photographers Group [hereafter MPG], Butterflies and Moths of North America [BAMONA], BugGuide [BG], iNaturalist [iNat]). The purpose of this paper is to summarize our current knowledge on the distribution and phenology of the families Cossidae and Dudgeoneidae in Virginia.

METHODS

Staff of the Virginia Department of Conservation and Recreation, Division of Natural Heritage (VDCR-DNH), including the author since 1992, have been sampling the moth fauna of the state for the past three decades, relying primarily on ultraviolet light traps, with more limited use of mercury vapor lights, sugar baiting, Malaise traps, diurnal netting, and other methods. Virtually no larval sampling has been conducted. Although these efforts have focused primarily on macromoths, thousands of micromoth specimens have been collected and pinned, particularly during the past two decades. Most specimens of Cossidae and Dudgeoneidae have been retained from these sampling events and constitute the majority of the material that I examined for this study.

Most specimens collected by VDCR-DNH staff and collaborators are deposited in the National Museum of Natural History (NMNH), Smithsonian Institution,

Washington, DC, and the Virginia Museum of Natural History (VMNH), Martinsville, VA, or retained in a reference collection at the agency's headquarters in Richmond, VA. Specimens collected in national parks (e.g., Shenandoah National Park, Blue Ridge Parkway, George Washington Memorial Parkway) have been returned to the respective parks in compliance with U.S. National Park Service policy.

I also visited the following collections to search for Virginia specimens: National Museum of Natural History, Smithsonian Institution, Washington, DC; American Museum of Natural History (AMNH), New York, NY; Carnegie Museum of Natural History (CMNH), Pittsburgh, PA; Academy of Natural Sciences of Drexel University (ANSP), Philadelphia, PA; McGuire Center for Lepidoptera and Biodiversity (MGCL), Florida Museum of Natural History, Gainesville, FL; Cornell University (CUIC), Ithaca, NY; University of Kentucky (UK), Lexington, KY; University of Connecticut (UConn), Storrs, CT; University of Kansas (KU), Lawrence, KS; University of Maryland (UMD), College Park, MD; West Virginia University (WVU), Morgantown, WV; Virginia Museum of Natural History, Martinsville, VA; Virginia Polytechnic Institute and State University (VPISU), Blacksburg, VA; Virginia Commonwealth University (VCU), Richmond, VA; Virginia Military Institute (VMI), Lexington, VA; Radford University (RU), Radford, VA; and Shenandoah National Park (SHEN), Luray, VA. The private collections of Susan Felker (Floyd, VA) and the late William Grooms (Ashburn, VA), both currently in the possession of VDCR-DNH, also were examined. Paul Dennehy (Danville, PA) and Kelly Richers (Bakersfield, CA) provided records from their private collections, and Brent Steury checked the national park service's database for records from the George Washington Memorial Parkway (GWMP).

I also reviewed published and unpublished literature sources (including the annual Season Summary published by The Lepidopterists' Society and regional reports in the Southern Lepidopterists' News) and selected internet websites (including LepNet, MPG, BAMONA, BugGuide, iNaturalist, iDigBio, SCAN, Maryland Biodiversity Project, North Carolina Biodiversity Project, and the Society of Kentucky Lepidopterists [Covell et al., 2018]), as well as other readily available photographs, some of which were sent directly to me, for relevant records. Photographic records are listed below only if a voucher specimen is not known to exist from the corresponding county or city.

ANNOTATED CHECKLIST

Six species (one non-native) of Cossidae and one species of Dudgeoneidae are documented from Virginia. It is possible that one additional species of Cossidae may inhabit the state. Covell (1984) illustrated the adults of five of the confirmed species and included a brief species account for each. I have cited the appropriate plate number in his field guide for each species below. The checklist numbers of Hodges et al. (1983) precede the species' names in the list below. Common names (in brackets) follow those used by Covell (1984) or Solomon (1995). Detailed collection data are provided only if few specimens or localities are documented for Virginia.

Family Cossidae

Subfamily Hypoptinae

2659 *Inguromorpha basalis* (Walker)
[Black-lined Carpenterworm Moth]
NEW STATE RECORD
Covell: 60(18)

Covell (1984) listed the range of this species as southeastern New Jersey to Florida, west to Missouri and Arkansas and noted that it is common southward. The hostplant is unknown. Schweitzer (1979) recorded this species from the New Jersey pine barrens, and Covell (1999) provided records from three localities in Kentucky, where the species is uncommon. Brou (2017c) suggested that Louisiana populations of *I. basalis* have three annual broods, with a combined flight season extending from April to September.

I am aware of only two Virginia records for *I. basalis*, both of which were obtained by VDCR-DNH staff at the same locality in the southeastern corner of the state (Fig. 1): City of Virginia Beach, First Landing State Park, 25 May 2006, A.C. Chazal and A.V. Evans (2), 9 June 2014, E.C. Orcutt (1). Both collections were made at the ecotone between live oak (*Quercus virginiana* Miller) upland forest and bald cypress (*Taxodium distichum* [L.] Richard) interdunal swamp habitat. More information is needed on the distribution and status of *I. basalis* in Virginia to determine if it warrants conservation attention in the state. The lone known locality is a state park, most of which is in a relatively natural condition.

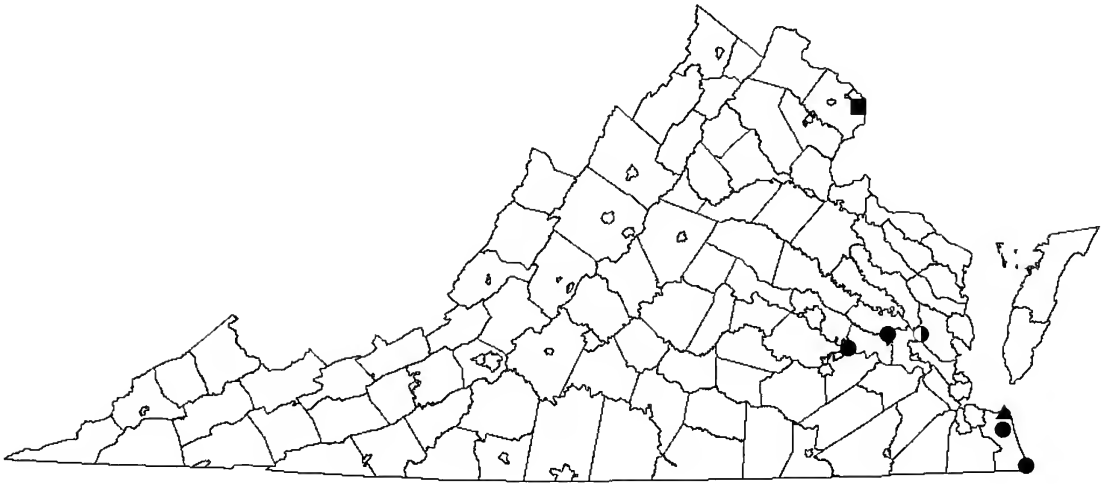

Fig. 1. Distribution of *Inguromorpha basalis* (triangle; voucher specimens), *Cossula magnifica* (triangle and dots = voucher specimens, half-filled circle = photograph), and *Zeuzera pyrina* (square; photographs) in Virginia. *Cossula magnifica* and *Z. pyrina* reach their northern and southern documented range limits, respectively, in Virginia.

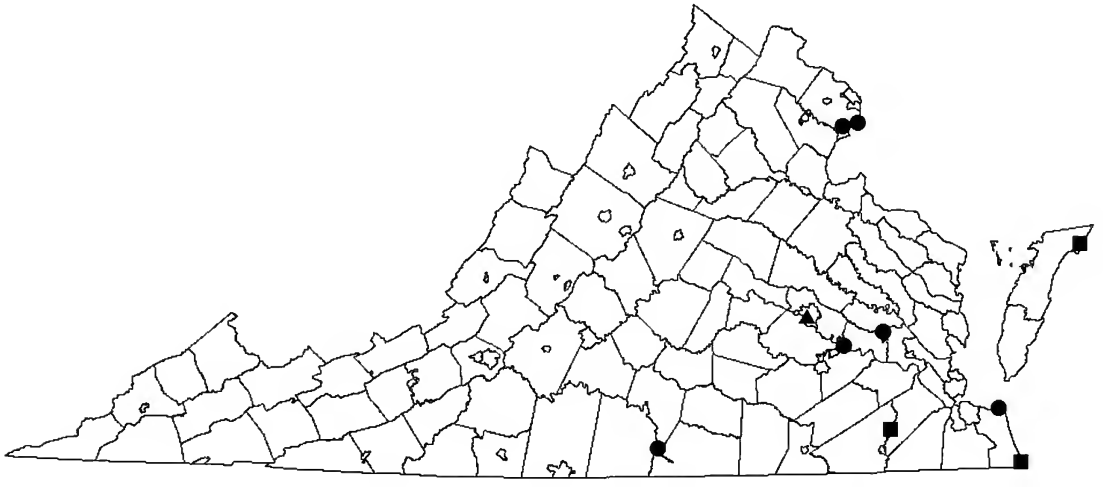

Fig. 2. Distribution of *Givira anna* (dots) and *G. francesca* (squares) in Virginia. Both species were documented at the locality (City of Richmond residential yard) indicated by a triangle.

2668 *Givira anna* (Dyar)
[Anna Carpenterworm Moth]
NEW STATE RECORD
Covell: 60(15)

Covell (1984) listed the range of this infrequently collected species as southeastern New Jersey to Florida, west to Missouri and Arkansas, and noted that it is locally common in the Deep South, and the larvae bore into pine trunks. Schweitzer (1979) recorded *G. anna* from the New Jersey pine barrens. Brou (2017a) suggested that Louisiana populations have three annual broods, with a combined flight season extending from March to mid-September. There are few known Virginia records of *G. anna* as detailed below, all from the eastern part of the state (Fig. 2).

Museum specimens examined: New Kent Co., 1 mi SE Lanexa, 29 July 1953, N.D. Richmond (CMNH, 1).

VDCR-DNH records: Charles City Co., Virginia Commonwealth University's Rice Environmental Education Center, 2 km SE jct. VA Rt. 5 and Co. Rt. 156, 27 June 2009, S.M. Roble and T.P. Roble (1) [also

photographed at this site on 7 June 2014 by M. Morris (BugGuide)]. Halifax Co., Kerr Reservoir, Hogan Creek Wildlife Management Area, 3 June 1998, A.C. Chazal and C.S. Hobson (1). Fairfax Co., George Washington Memorial Parkway, 1 km SE jct. Fort Hunt Road and Vernon View Drive, 30 May 2002, K.L. Derge (1); Fairfax Co., Fort Belvoir, Area T-17, 12 July 2012, C. Hobson, J. Pilcicki and T. Smith (1). City of Virginia Beach, First Landing State Park, 16 June 2007, S.M. Roble (2), 11 June 2009, A.V. Evans (2), 4 June 2014, S.M. Roble and E.C. Orcutt (1), 9 June 2014, E.C. Orcutt (1), 7 July 2014, E.C. Orcutt (2).

Photo records: City of Richmond, West 45th Street (residential yard), 6 June 2016, A. Belden (Fig. 3; image also posted on BAMONA).

Virginia flight dates: 30 May–29 July

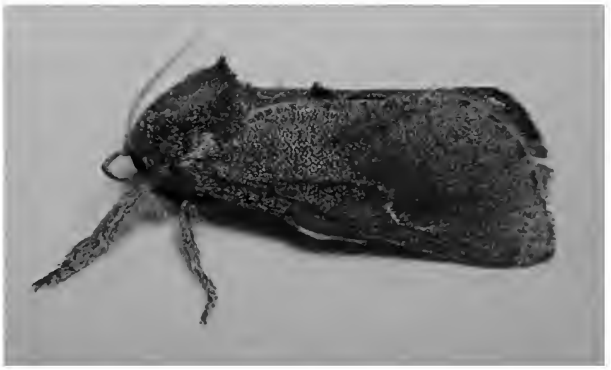

Fig. 3. *Givira anna* adult observed at mercury vapor light in the City of Richmond on 6 June 2016 (photograph by Allen Belden).

2671 *Givira francesca* (Dyar)
[No common name]
NEW STATE RECORD
[Not in Covell]

Givira francesca is superficially similar to, but considerably smaller than, *G. anna*. Brou (2017b) suggested that Louisiana populations have four annual broods, with a combined flight season extending from April to October, reaching peak abundance in late June. February is the only month for which *G. francesca* records are lacking from Florida (Heppner, 2003). The arboreal ant *Crematogaster ashmeadi* uses the abandoned larval burrows of *G. francesca* as refuges (Tschinkel, 2002).

This species was not treated by Covell (1984), but Heppner (2003) reported that its range includes Florida, Georgia, Alabama, and Mississippi. Virginia is near the northern distributional limit of *G. francesca*, apparently exceeded only by a recent record (2015) from Dorchester County, Maryland (BugGuide; Maryland Biodiversity Project). All known Virginia records are from the eastern part of the state (Fig. 2), with both species of *Givira* documented from an urban residential yard in the City of Richmond (A. Belden, pers. comm.).

I did not find any museum specimens of *G. francesca*, but have collected this species at the following localities in southeastern Virginia: Accomack Co., Assateague Island, Chincoteague National Wildlife Refuge, 24 June 1998, A.C. Chazal and S.M. Roble (1). Isle of Wight Co., Blackwater Ecological Preserve, 4 mi S Zuni, 1 July 1994, S.M. Roble (1). City of Virginia Beach, False Cape State Park, 3–4 August 2005, S.M. Roble and G.W. Wahl III (4), 7 September 2005, S.M. Roble (1). I am aware of only one other specimen record from Virginia: City of Richmond, West 45th Street (residential yard), 21 August 2018, A. Belden (Fig. 4; image also posted on BAMONA).

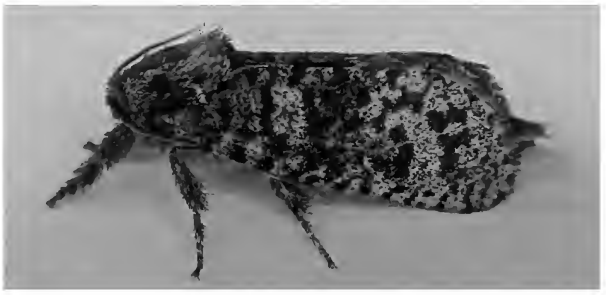

Fig. 4. *Givira francesca* specimen collected at mercury vapor light in the City of Richmond on 21 August 2018 (photograph by Allen Belden).

Virginia flight dates: 24 June–7 September

Comments: Due to the limited number of Virginia records, *G. francesca* is currently placed on the VDCR-DNH Animal Watchlist (Roble, 2016).

Subfamily Cossinae

2675 *Acossus centerensis* (Lintner)
[Poplar Carpenterworm Moth]
[Not in Covell]

This is a northern species that bores into poplars, reportedly preferring quaking aspen (Bailey, 1883). Its known range extends south to New York and New Jersey (Solomon, 1995). Since several native poplars are

present in some northern Virginia counties (Weakley et al., 2012; VBA, 2018), it is possible that *A. centerensis* occurs in that part of the state, but there are no confirmed records for Virginia or Maryland (Glaser et al., ms; Maryland Biodiversity Project).

2693 *Prionoxystus robiniae* (Peck)
[Carpenterworm Moth]
Covell: 7(6, 9)

This is a widespread North American species, the larvae of which bore into the wood of ash, chestnut, locust, oak, poplar, willow, and other trees (Covell, 1984). Oaks of the red oak group are the primary foodplant in the eastern and southern United States (Drooz, 1985). The damage caused by larvae decreases the value of hardwood timber (for illustrations of larval tunnels see Solomon [1995] and Cranshaw [2004]). Solomon & Hay (1974) prepared an annotated bibliography for this species, which is the most-studied cossid due to its economic importance.

Prionoxystus robiniae is the largest cossid in Virginia, with females considerably larger than males (female wingspans are up to 60% larger than males in Louisiana; Brou, 2009). The gray and black mottled pattern of adults is highly cryptic when they rest on tree trunks (Solomon, 1995). Color images of adults, larvae, pupae, and larval galleries are presented by Cranshaw (2004). Solomon (1995) summarized the life history of this species and provided black and white images of an adult, eggs, larva, larval gallery, pupal case, frass, a bark scar, and damage caused by larvae to trees and lumber.

The available records listed below indicate that *P. robiniae* is the most common and widespread cossid in Virginia (Fig. 5).

Literature records: Albemarle (oak damage; USDA, 1954a), Culpeper (sight record: Pavulaan, 2001), Fairfax (Brown, 2008; NMNH), Montgomery (Girault, 1913), and Rappahannock (Manderino et al., 2014 [Appendix S2]) counties; cities of Falls Church (Rohwer, 1916; description of a parasitic wasp of *P. robiniae* in chestnut [*Castanea*]), Hampton (oak damage; USDA, 1954b), Lynchburg (oak damage; USDA, 1954b), and Virginia Beach (Bastian, 2011; "fairly common").

Specimen records (by county or city only): Arlington (NMNH), Augusta (VDCR-DNH), Bedford (VDCR-DNH, VPISU), Caroline (VDCR-DNH), Dickenson (VDCR-DNH), Fairfax (GWMP, NMNH, VDCR-DNH), Floyd (S. Felker collection), Franklin (VDCR-DNH), Giles (VDCR-DNH, VPISU; Garriock & Caldwell, 2010), Gloucester (VCU), Hanover (VDCR-DNH), Isle of Wight (VDCR-DNH), King and Queen (VDCR-DNH), Lee (VDCR-DNH), Loudoun (W.R. Grooms collection), Montgomery (MGCL, NMNH, VPISU), New Kent (CMNH), Nottoway (VPISU), Page (SHEN), Patrick (VDCR-DNH), Prince William (KU, VDCR-DNH), Pulaski (VDCR-DNH), Richmond (VPISU), Roanoke (VPISU), Rockbridge (VMI, VPISU), Rockingham (K. Richers collection), Stafford (NMNH, VDCR-DNH), Surry (VDCR-DNH), Sussex (VDCR-DNH), Tazewell (VDCR-DNH), and Warren (CMNH, MGCL) counties and the cities of Fall Church (NMNH) and Virginia Beach (NMNH, VDCR-DNH).

Photo records (by county or city only): Bath (BAMONA), Buckingham (BAMONA, iNat), Carroll (iNat), Charles City (BG, iNat), Chesterfield (BAMONA, iNat), Greene (BG), James City (iNat), Louisa (BG), Nelson (iNat), Northampton (iNat), Northumberland (BAMONA), Pittsylvania (iNat), Powhatan (J. Reilly), and Spotsylvania (iNat) counties, and the cities of Fredericksburg (BG), Richmond (BAMONA), and Williamsburg (BG, iNat).

Virginia flight dates: 22 April–27 September

2694 *Prionoxystus macmurtrei* (Guérin-Méneville)
[Little Carpenterworm Moth]
Covell: 7(7)

The range of this species extends from Quebec to Florida, west to Minnesota and Texas (Covell, 1984). The larvae bore into the wood of ash, maple, and oak (Covell, 1984). Solomon (1995) summarized the life history of this species and provided black and white images of adults, larvae in tunnels, and a pupal case. Forbes (1923) remarked that *P. macmurtrei* is "Rare in collections. Widespread but apparently quite local in distribution…" This same pattern seems to hold for Virginia, where the few known records are widely scattered, especially in the eastern portion of the state (Fig. 6). The documented flight period is much shorter than that of *P. robiniae*.

Published Virginia records: I did not find any published records that specifically document this species from Virginia, but given its widespread distribution in eastern North America, I presume that such references exist.

Museum records: Fairfax Co., Great Falls Park, 9 May

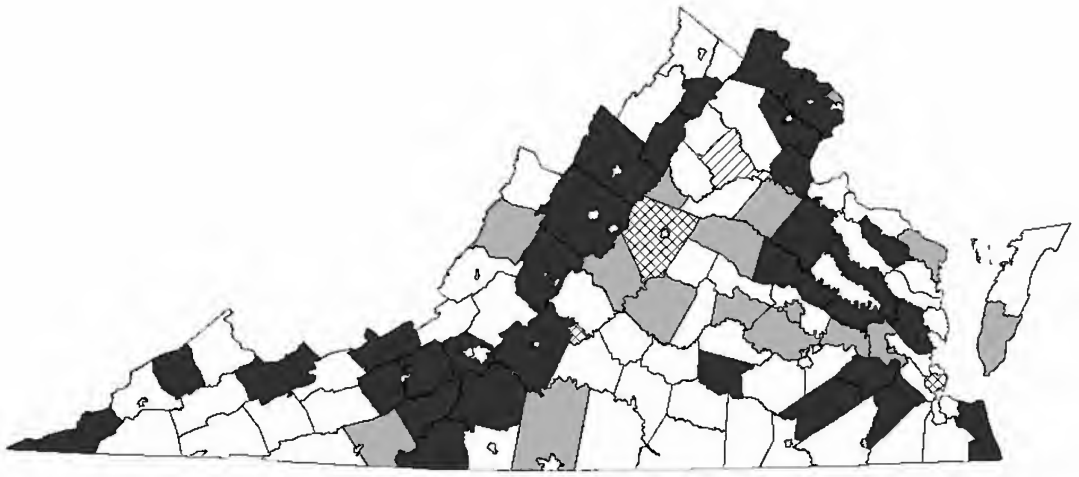

Fig. 5. County and city distribution of *Prionoxystus robiniae* in Virginia (dark shading = voucher specimens, light shading = photographs, diagonal hatching = published sight record; cross hatching = reports of tree damage).

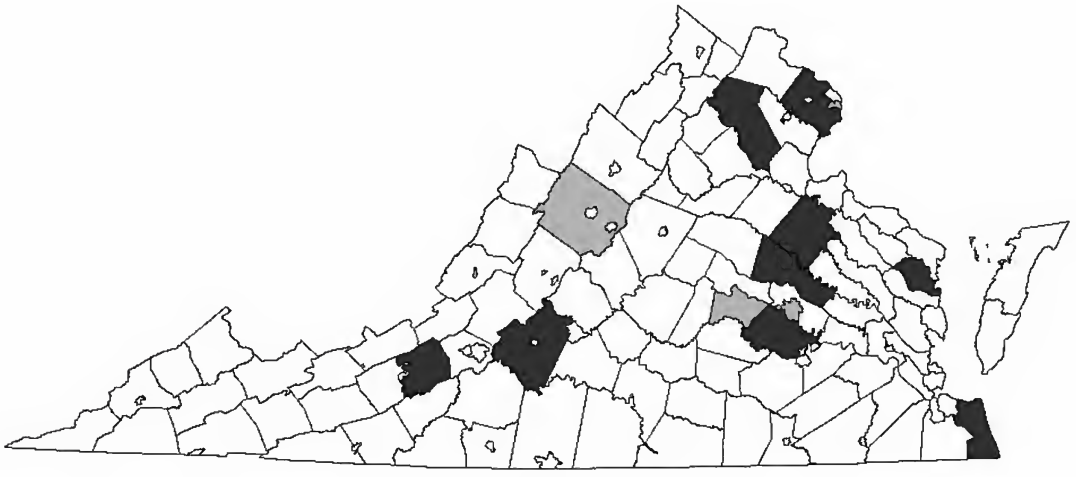

Fig.6. County and city distribution of *Prionoxystus macmurtrei* in Virginia (dark shading = voucher specimens, light shading = photographs).

2005, J. Glaser (GWMP, 1). Giles Co., Newport, 19 May 1977, B.C. Kondratieff (VPISU, 1). Montgomery Co., [probably Blacksburg vicinity], 21 May 1914, [E. A. Smyth] (NMNH, 1); same but no date [ca. 1900, E. A. Smyth] (NMNH, 2); Blacksburg, 30 May 1955, R.S. Tulloss (VPISU, 1); same locality, 7 May 1959, D. Burnett (VPISU, 1); Brush Mountain, 9 June 1963, C.V. Covell (MGCL, 1). City of Falls Church, 31 May 1916, J. N. Knull (NMNH, 1).

Private collections: Lancaster Co., 0.5 mi NE Kilmarnock, 22 May 2013, P. Dennehy (photo of specimen is BAMONA record 927857).

VDCR-DNH records: Bedford Co., Blue Ridge Parkway, Peaks of Otter Recreation Area, Sharptop Mountain, 13 June 2001, J.C. Ludwig (1). Caroline Co., Fort A.P. Hill Military Reservation, Meadow Creek below Jordan Crossing Pond, 26 May 2009, O.S. Flint and S.M. Roble (1). Chesterfield Co., Scotford Road, ca. 1.2 km SE jct. Rt 175 and 679, 24 April 2004, S.M. Roble (1); same data but 24 April 2011 (1); same data but 6 June 2015 (1). Fairfax Co., Fort Belvoir Military Reservation, 24 May 2012, C.S. Hobson and J. Pilcicki (1). Fauquier Co., Bull Run Mountain Natural Area Preserve, High Point, 4 May 2006, K.H. Bass and M.J. Kieffer (1). Hanover Co., 2 km W Vontay, 5 May 1997,

J.C. Ludwig (1). City of Virginia Beach, First Landing State Park, 4 May 2006, M.E. Dougherty and A.V. Evans (1).

Photo records: Augusta Co. (BG), Powhatan Co. (J. Reilly), City of Alexandria (BG), City of Richmond (BAMONA).

Virginia flight dates: 4 April–13 June

Subfamily Zeuzerinae

2700 *Zeuzera pyrina* (Linnaeus)
[Leopard Moth]
NEW STATE RECORD
[Not figured in Covell, but mentioned in text]

This European species was introduced into the northeastern United States sometime before 1879 (Anonymous, 1904). As of the early 1980s, its range extended from Maine to Pennsylvania (Covell, 1984). There are subsequent records from Maryland (Glaser et al., ms; Maryland Biodiversity Project) and Kentucky (Covell, 1999). Photographic records on the BAMONA and iNaturalist websites indicate a current range that extends from New England west to Ontario and south to northern Virginia. The range expansion of *Z. pyrina* in North America has been slow due to the poor flight capabilities of adult females (Solomon, 1995). The larvae bore into elm, maple, and more than 100 other trees and shrubs (Solomon, 1995). They have a 2-year life cycle (Covell, 1984).

Color images of this species can be found in Cranshaw (2004), Beadle & Leckie (2012), and several websites (e.g., MPG, BAMONA, BugGuide, iNaturalist). Solomon (1995) summarized the life history of this species and provided black and white images of adults, eggs, larvae, pupae, and larval tunnels. The black and white pattern of *Z. pyrina* superficially resembles that of the Giant Leopard Moth, *Hypercompe scribonia* (Stoll), a species of tiger moth (Erebidae: Arctiinae).

I did not find any voucher specimens from Virginia, but there are four recent photographic records available online (BAMONA, BG, iNat), all from the City of Alexandria, a suburb of the District of Columbia (Fig. 1). These records apparently constitute the first documentation of *Z. pyrina* in the state, nearly a century and a half after its introduction into the Northeast. Dates of observation are 30 May 2013, 17 May 2017, 24 May 2018, and 3 July 2018, suggesting a recent arrival to Virginia.

Family Dudgeoneidae Berger, 1958

Subfamily Cossulinae

2674 *Cossula magnifica* (Strecker)
[Pecan Carpenterworm Moth]
Covell: 7(4)

Covell (1984) gave the range of this species as coastal North Carolina to southern Florida and west to Mississippi, whereas Boethel et al. (1980) and Brou (2007) provided records from Louisiana, and Solomon (1995) stated that its range extends south to Texas, Mexico, and Guatemala. Covell (1984) noted that *C. magnifica* is locally common and the larvae bore into the wood of oak, hickory, pecan, and persimmon.

Drooz (1985), Solomon & Payne (1986), and Solomon (1995) summarized the life history of this species and provided black and white images of an adult, larva, larval holes and galleries, frass, and damage caused by larvae to lumber. Color images of a larva, larval tunnels, and an entrance hole with frass are provided by Cranshaw (2004).

The first Virginia specimen of *C. magnifica* was collected more than 60 years ago, but the species was not reported from the state until Bastian (2011) described it as "rare" in his little known, self-published book on the natural history of Virginia Beach. No supporting information was provided by the author, who shared his unpublished photograph of *C. magnifica* with me. In fact, this species is common in Virginia Beach, where more than 60 specimens have been collected by VDCR-DNH staff. Its range extends farther north and inland to at least Charles City, New Kent, and Gloucester counties (Fig. 1). There are no Maryland records of *C. magnifica* (Glaser et al., ms; Maryland Biodiversity Project), but this species is widely distributed in the Coastal Plain and Piedmont regions of North Carolina, with surprisingly few records from the coastal counties of that state (North Carolina Biodiversity Project).

Museum specimens examined: New Kent Co., 1 mi SE Lanexa, 1–6 July 1956, N.D. Richmond (CMNH, 1). City of Virginia Beach: Oceana [Naval Air Station], 21 and 25 June 1973, W.A. Allen (VPISU, 2); Cape Henry, Seashore [now First Landing] State Park, 10 June 1974, D. Davis and M. Davis (NMNH, 7).

VDCR-DNH records: Charles City Co., Virginia Commonwealth University's Rice Environmental Education Center, 2 km SE jct. VA Rt. 5 and Co. Rt. 156, 12–13 June 2004, S.M. Roble et al., Bioblitz survey (1),

27 June 2009, S.M. Roble and T.P. Roble (3). City of Virginia Beach, False Cape State Park, 5–6 July 2005, S.M. Roble (21), 2 August 2005, S.M. Roble and G.W. Wahl III (1), 3 August 2005, S.M. Roble (1). City of Virginia Beach, First Landing State Park, 20–21 June 2006, A.C. Chazal and P. Bedell (28), 16 June 2007, S.M. Roble and B.M. Roble (6), 10–11 June 2009, A.V. Evans (3), 4 June 2014, S.M. Roble and E.C. Orcutt (1), 10 June 2014, E.C. Orcutt (1), same but 24 June 2014 (1), same but 1 July 2014 (3).

Photo records: Gloucester Co., Pinetta, 4 July 2006 (T. Kain). City of Virginia Beach ("Hampton Roads area"), 1 June 2012 (BG).

Virginia flight dates: 1 June–3 August.

Covell (1984) listed the flight season of *C. magnifica* rangewide as March to June, whereas Brou (2007) reported that captures (n = 517) at his study site in Louisiana ranged from mid-April to late July, with the vast majority taken during May and the first half of June.

DISCUSSION

The total of seven species in the families Cossidae and Dudgeoneidae reported from Virginia is comparable to that recorded from Kentucky (5 species; Covell, 1999), Maryland (5 species; Glaser et al., ms; Maryland Biodiversity Project), and North Carolina (6 species; North Carolina Biodiversity Project). Except for the genus *Prionoxystus*, there are few known records of Cossidae from Virginia. However, *Cossula magnifica* (Dudgeoneidae) is relatively common in sandy coastal habitats in the City of Virginia Beach (e.g., False Cape and First Landing state parks) where persimmon grows.

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Euteliidae of Virginia (Lepidoptera: Noctuoidea)

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ABSTRACT

Seven widespread, eastern North American species of the moth family Euteliidae are reported for Virginia based on recent field work, museum specimens, literature records, and photographs. County and city records and capture dates are reported for all species. The euteliid fauna of Virginia is identical to that of Kentucky, Maryland, and Ohio; North Carolina and West Virginia share six of the seven species recorded from Virginia.

Keywords: distribution, *Eutelia*, *Marathyssa*, moths, *Paectes*, phenology.

INTRODUCTION

This is the second installment in what is projected to be a series of papers documenting our current knowledge of the composition, distribution, phenology, and conservation status of the moth fauna of Virginia. The first contribution dealt with the superfamily Cossoidea (Roble, 2018), and this one treats the family Euteliidae.

Euteliidae is a small family of "macromoths" with its greatest diversity in the tropics. Formerly considered a subfamily of Noctuidae, it was recently elevated to family status (Zahiri et al., 2010). Worldwide, the family includes 29 genera and 520 described species (van Nieukerken et al., 2011). The fauna of North America north of Mexico is depauperate, represented by only 18 species (Lafontaine & Schmidt, 2010), including seven widespread Eastern species (Wagner et al., 2011), all of which occur in Virginia. The larvae of most Eastern euteliids feed on poison ivy (*Toxicodendron radicans* [L.] Kuntze), sumac (*Rhus* spp.) or sweetgum (*Liquidambar styraciflua* L.).

METHODS

Staff of the Virginia Department of Conservation and Recreation, Division of Natural Heritage (VDCR-DNH), including the author since 1992, have been surveying the moth fauna of the state for the past three decades to determine its composition, distribution, and conservation status. Sampling has primarily relied on ultraviolet light traps, with more limited use of mercury vapor lights, sugar baiting, Malaise traps, diurnal netting, and other methods. Virtually no larval sampling has been conducted. Specimens of Euteliidae have been retained from virtually all of these sampling events and constitute the majority of the material that I examined for this study. I also visited the following collections to search for Virginia specimens: National Museum of Natural History (NMNH), Smithsonian Institution, Washington, DC; American Museum of Natural History, New York, NY (AMNH); Carnegie Museum of Natural History (CMNH), Pittsburgh, PA; Academy of Natural Sciences of Drexel University (ANSP), Philadelphia, PA; McGuire Center for Lepidoptera and Biodiversity (MGCL), Florida Museum of Natural History, Gainesville, FL; University of Kentucky (UK), Lexington, KY; University of Connecticut (UConn), Storrs, CT; University of Kansas (KU), Lawrence, KS; University of Maryland (UMD), College Park, MD; West Virginia University (WVU), Morgantown, WV; Virginia Museum of Natural History (VMNH), Martinsville, VA; Virginia Polytechnic Institute and State University (VPISU), Blacksburg, VA; Virginia Commonwealth University (VCU), Richmond, VA; Virginia Military Institute (VMI), Lexington, VA; and Radford University (RU), Radford, VA. The private collections of Susan Felker (Floyd, VA) and the late William Grooms (Ashburn, VA), both currently in the possession of VDCR-DNH, also were examined. Kelly

Richers (Bakersfield, CA) provided records from his private collection. Most specimens collected by VDCR-DNH staff and collaborators have been deposited in the National Museum of Natural History, Smithsonian Institution, Washington, DC, and the Virginia Museum of Natural History, Martinsville, VA, or retained in a reference collection at the agency's headquarters in Richmond, VA. Specimens collected in national parks (e.g., Shenandoah National Park, Blue Ridge Parkway, George Washington Memorial Parkway) have been returned to the respective parks in compliance with U.S. National Park Service policy.

I also reviewed published and unpublished literature sources, including the annual Season Summary published by The Lepidopterists' Society and regional reports in the Southern Lepidopterists' News, for Virginia records relevant to this paper. I searched various internet websites, including LepNet, SCAN, Yale Peabody Museum, Moth Photographers Group, Butterflies and Moths of North America, BugGuide, iNaturalist, iDigBio, Maryland Biodiversity Project, North Carolina Biodiversity Project, and the Society of Kentucky Lepidopterists (Covell et al., 2018) for records. I have included two online museum records from the University of California-Davis (UCD) obtained from SCAN, but did not examine those specimens. I also reviewed readily available photographs on other websites as well as some that were shown or sent to me.

ANNOTATED CHECKLIST

Seven species of Euteliidae are documented from Virginia. Covell (1984) provided an illustration and brief species account for all but one of these species (*Paectes abrostolella*), whereas Beadle & Leckie (2012) and Leckie & Beadle (2018) included all seven species in their field guides. Photographs of the adults of all species also can be found on several internet websites (e.g., Moth Photographers Group, Butterflies and Moths of North America, BugGuide). The checklist numbers of Lafontaine & Schmidt (2010) and Hodges et al. (1983), respectively, precede the species' names in the following list. Numbers with decimal points represent taxonomic changes subsequent to the Hodges et al. (1983) list. Common names (in brackets) are taken from Covell (1984) and Beadle & Leckie (2012). Photographic records are listed below only if a voucher specimen is not known to exist from the corresponding county or city. The range maps in Beadle & Leckie (2012) were not considered authoritative for the purpose of determining county or state records.

931103/8955 *Marathyssa inficita* (Walker) Map 1
[Dark Marathyssa]

Published Virginia records: Fairfax (Steury et al., 2007) and Hanover (Ludwig, 2000, 2009) counties; City of Virginia Beach (Bastian, 2011). I presume this species was recorded from the state in older references, but did not locate any of these.

VDCR-DNH records (41 specimens): Brunswick, Chesterfield, Dinwiddie, Halifax, Hanover, Isle of Wight, James City, Montgomery, New Kent, Nottoway, Prince William, Russell, Scott, Sussex, and York counties, and the cities of Suffolk and Virginia Beach.

Other Virginia records: Fairfax (NMNH, 3), Floyd (VPISU, 1), Franklin (UK, 1), and Rockingham (K. Richers collection, 2) counties and the cities of Newport News (UCD, 1), Virginia Beach (NMNH, 1), and Williamsburg (UCD, 1).

Photo records: Powhatan Co. (J. Reilly).

Virginia flight dates: 10 May–28 August

Hostplants: Staghorn sumac (Forbes, 1954; Covell, 1984); also poison ivy (Beadle & Leckie, 2012).

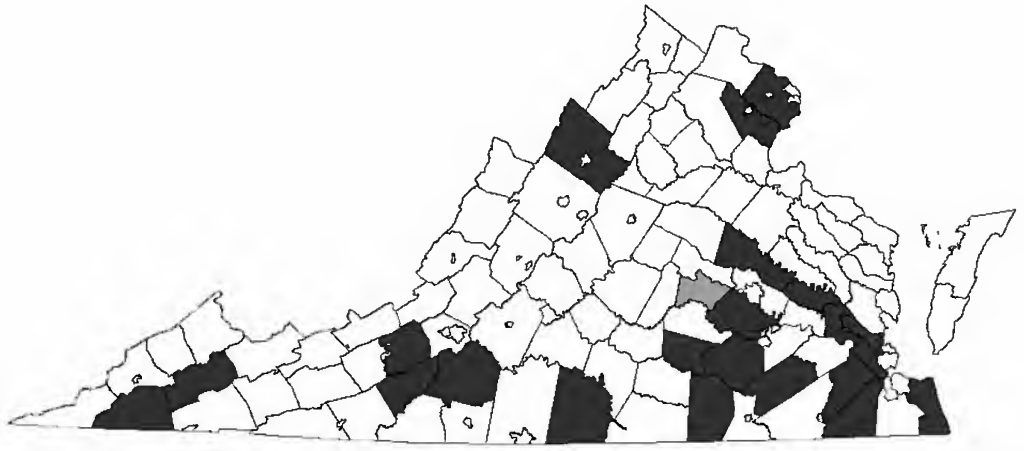
Comments: This widespread eastern North American species is common in Virginia. Males have serrate antennae in contrast to the bipectinate antennae present in all of the following species.

931104/8956 *Marathyssa basalis* Walker Map 2
[Light Marathyssa]

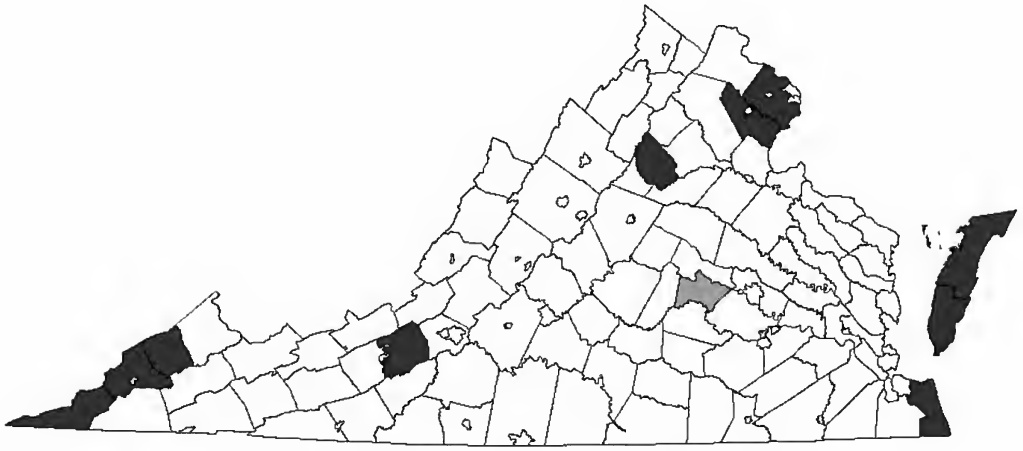
Published Virginia records: I have not seen any published source that specifically records this widespread eastern North American species from Virginia except Bastian (2011), who described it as "occasional" in his little known, self-published book on the natural history of Virginia Beach. I presume this species was recorded from the state in some older references also.

VDCR-DNH records (17 specimens): Dickenson, Fairfax, Lee, Madison, Northampton, Prince William, and Wise counties and City of Virginia Beach.

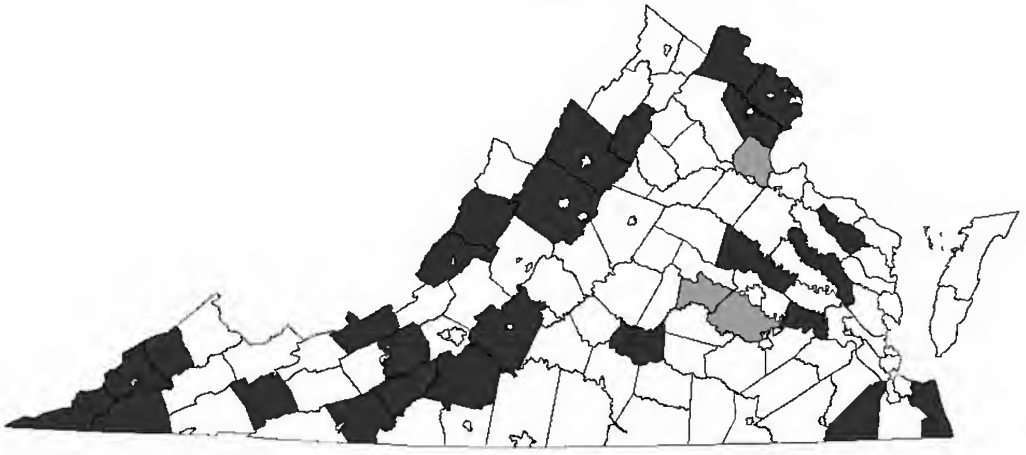
Other Virginia records: Fairfax (NMNH, 4) and Montgomery (NMNH, 1; VPISU, 1) counties.



Map 1. County and city distribution of *Marathyssa inficita* in Virginia (dark shading = voucher specimens, light shading = photographs).



Map 2. County and city distribution of *Marathyssa basalis* in Virginia (dark shading = voucher specimens, light shading = photographs).



Map 3. County and city distribution of *Paectes oculatrix* in Virginia (dark shading = voucher specimens, light shading = photographs).

Photo records: Powhatan Co. (J. Reilly).

Virginia flight dates: 16 April–16 June

Hostplant: poison ivy (Forbes, 1954; Covell, 1984).

Comments: This is another widespread eastern North American species that is somewhat less common than the preceding species (Covell, 1984). *Marathyssa basalis* is less frequently collected in Virginia and has a shorter flight period than *M. inficita*. Forbes (1954) characterized the former species as "rare."

931106/8957 *Paectes oculatrix* (Guenée) Map 3
[Eyed Paectes]

Published Virginia records: Augusta (Butler et al., 2001), Bath (Skinner, 1921), Fairfax (Steury et al., 2007: Brown, 2008), and Hanover (Ludwig, 2000, 2009) counties; City of Virginia Beach (Bastian, 2011).

VDCR-DNH records (69 specimens): Alleghany, Bath, Bedford, Carroll, Charles City, Dickenson, Fairfax, Floyd, Franklin, Hanover, Lee, Page, Prince William, Richmond, Rockingham, Scott, Smyth, and Wise counties and the cities of Suffolk and Virginia Beach.

Other Virginia records: Arlington (NMNH, 1), Fairfax (NMNH, 4), Giles (VPISU, 1), Loudoun (NMNH, 2; W.R. Grooms collection, 5), Montgomery (NMNH, 3), and Prince Edward (NMNH, 1) counties; City of Suffolk (AMNH, 1).

Photo records: Chesterfield (P. Bedell, iNaturalist), Powhatan (J. Reilly), and Stafford (J. Shuman, BugGuide) counties.

Virginia flight dates: 18 April–2 September

Hostplants: Poison ivy (Forbes, 1954; Covell, 1984); also reared on poison sumac (Wagner, 2005; Wagner et al., 2011).

Comments: This is another widespread eastern North American species that may be locally common (Covell, 1984). It has a broad distribution in Virginia, but there are no confirmed records from the Eastern Shore to my knowledge, despite the abundance of poison ivy. Jones (1928–1939) recorded it from the north end of the Delmarva Peninsula in New Castle County and Wilmington, Delaware.

931107/8959 *Paectes pygmaea* Hübner Map 4
[Pygmy Paectes]

Published Virginia records: Augusta (Butler et al., 2001) and Hanover (Ludwig, 2000, 2001, 2002, 2009) counties; City of Virginia Beach (Bastian, 2011).

VDCR-DNH records (34 specimens): Alleghany, Amherst, Botetourt, Dickenson, Dinwiddie, Fauquier, Halifax, Hanover, James City, King and Queen, Nelson, Prince William, Scott, Southampton, and Wise counties; City of Suffolk.

Other Virginia records: Fairfax Co. (NMNH, 2), City of Suffolk (D.F. Schweitzer collection, 1; specimen currently at VDCR-DNH).

Photo records: Powhatan Co. (J. Reilly).

Virginia flight dates: 2 May–17 August

Hostplant: Reared on winged sumac, *Rhus copallinum* L. (Wagner, 2005). There are older reports from sweetgum (Forbes, 1954; Covell, 1984), but Wagner (2005) and J.B. Sullivan (pers. comm.) provided contradictory evidence in favor of winged sumac.

Comments: This is a common, widespread species in eastern North America (Covell, 1984). Records are lacking from the Eastern Shore of Virginia.

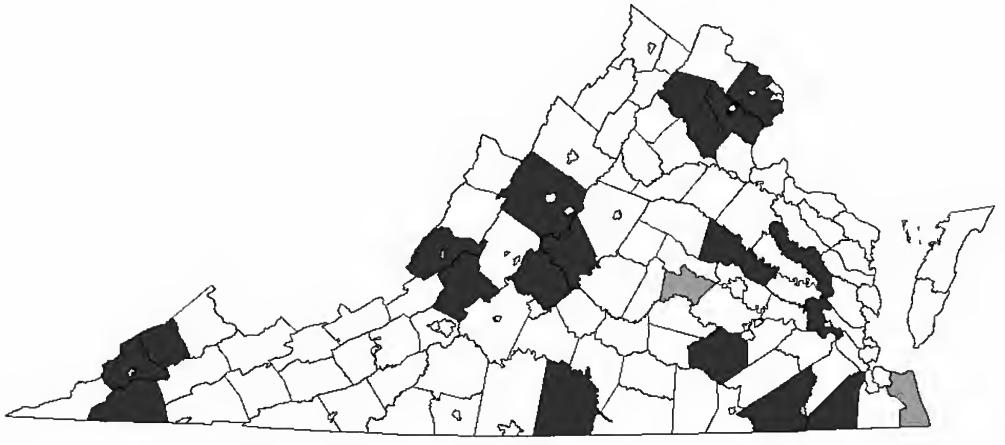
931108/8959.1 *Paectes abrostolella* (Walker) Map 5
[Barrens Paectes]

Published Virginia records: Lee Co. (Metzler et al., 2005; based on the records listed below).

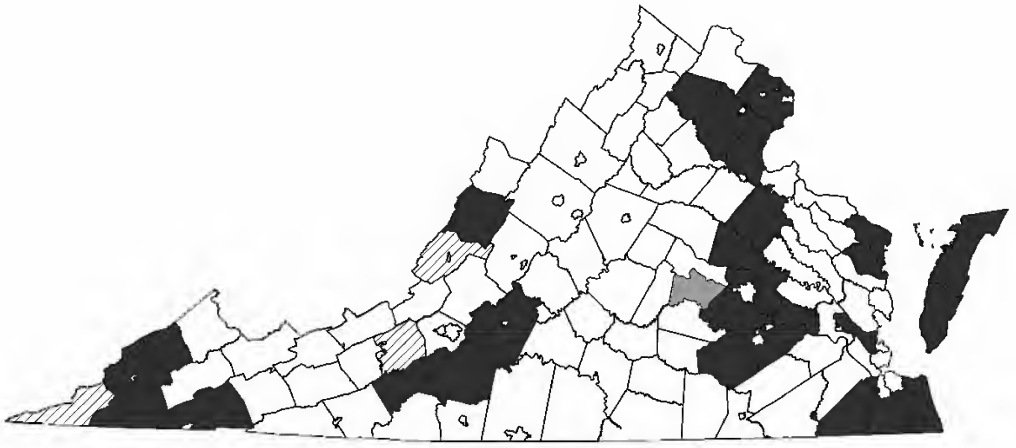
VDCR-DNH records (17 specimens): Alleghany Co., Johnsons Creek Natural Area Preserve, 9 May 2001, S.M. Roble and A.C. Chazal (1). Lee Co., The Cedars Natural Area Preserve, 4 km WSW Jonesville, 5–6 May 1999, S.M. Roble, A.C. Chazal, and C.S. Hobson (2); same but Dry Creek tract, 10 km W Jonesville, 6 May 1999, S.M. Roble, A.C. Chazal, and C.S. Hobson (12); same but off Co. Rt. 622 near Natural Bridge, 22 July 2004, C.S Hobson, A.C. Chazal, and M.E. Bradford (1). Montgomery Co., Sweet Spring Hollow, 1 May 2003, J.C. Ludwig and I.T. Wilson (1).

Other Virginia records: None

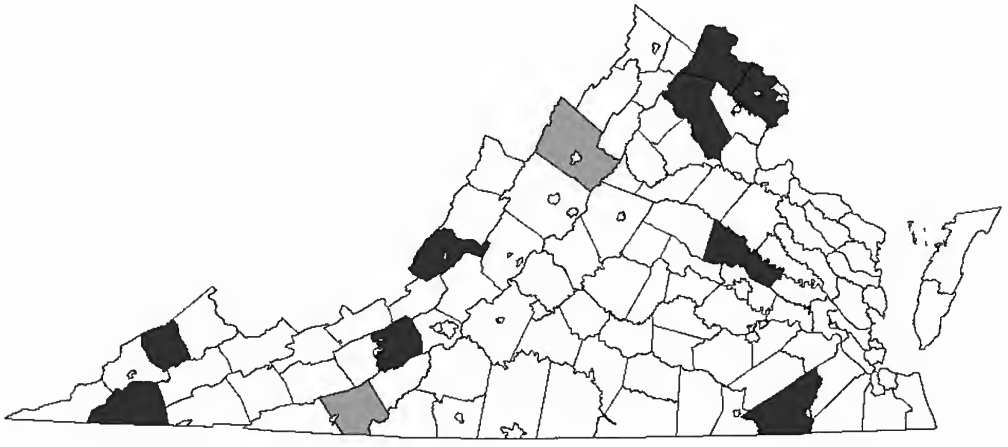
Virginia flight dates: 1 May–22 July



Map 4. County and city distribution of *Paectes pygmaea* in Virginia (dark shading = voucher specimens, light shading = photographs).



Map 5. County and city distribution of *Paectes abrostoloides* (dark shading = voucher specimens, light shading = photographs) and *P. abrostolella* (diagonal hatching; voucher specimens) in Virginia.



Map 6. County and city distribution of *Eutelia pulcherrimus* in Virginia (dark shading = voucher specimens, light shading = photographs).

Hostplant: Wagner et al. (2011) suspected the hostplant is fragrant sumac (*Rhus aromatica* Aiton), which has been confirmed for Ontario populations and is likely true throughout the range of *P. abrostolella* in eastern North America (B.C. Schmidt, pers. comm.).

Comments: Metzler & Franclemont (1991) resurrected this predominantly western species from the synonymy of *P. pygmaea* and reported that it ranges east to Ohio and Kentucky, occurring in remnant prairies in the East. Metzler et al. (2005) plotted records east to the coast in New York, Maryland (Chesapeake Bay region), and Florida (records for latter state are based on misidentifications, B.C. Schmidt, pers. comm.). The lone Virginia record on their map was based on VDCR-DNH collections (cited above) made at three nearby sites in Lee County in the extreme southwestern corner of the state. "The Cedars" region of Lee County is underlain by Ordovician dolomite; the Dry Creek barrens site is characterized by numerous grassy openings surrounded by rich deciduous forest (Ludwig, 1999). *Rhus aromatica* is common in this habitat and is the presumed hostplant of the *P. abrostolella* population, although this has not been confirmed.

The Kentucky and Tennessee records for *P. abrostolella* are quite distant from the Virginia sites, with those for the former state being clustered in four adjoining counties near the Ohio border (Covell, 1999; Metzler et al., 2005). This species has not yet been documented in North Carolina (North Carolina Biodiversity Project) or West Virginia (Butler & Strazanac, 2014; MPG range map).

Paectes abrostolella is a rare species in Virginia and of conservation concern in the state (Roble, 2016). It appears to be associated with barrens habitats, some of which may require active management such as prescribed burning to maintain the proper habitat conditions. All of the currently known populations of *P. abrostolella* in Virginia occur on state natural area preserves.

931111/8962 *Paectes abrostoloides* (Guenée) Map 5
[Large Paectes]

Published Virginia records: Fairfax (Steury et al., 2007), Hanover (Ludwig, 2000, 2002, 2009), and Henrico (Belden & Derge, 2003) counties; City of Virginia Beach (Bastian, 2011).

VDCR-DNH records (115 specimens): Accomack, Bath, Bedford, Caroline, Charles City, Chesterfield, Dickenson, Dinwiddie, Fairfax, Fauquier, Franklin, Hanover, Henrico, Northampton, Northumberland, Prince George, Prince William, Scott, Stafford, Washington, Wise, and York counties and the cities of Chesapeake, Suffolk, and Virginia Beach.

Other Virginia records: Arlington (NMNH, 3), Fairfax (NMNH, 4), Floyd (S. Felker collection, 1), and Northampton (NMNH, 1) counties and the cities of Franklin (NMNH, 1) and Suffolk (AMNH, 1; NMNH, 2; VPISU, 5).

Photo records: Powhatan Co. (J. Reilly).

Virginia flight dates: 2 April–7 November

Hostplant: Sweetgum (Forbes, 1954; Covell, 1984), but also found in areas lacking this plant (J.B. Sullivan, pers. comm.), thus suggesting use of an alternate hostplant.

Comments: This common, widespread species of eastern North America (Covell, 1984) is common in Virginia and has the longest flight period of any euteliid in the state.

931118/8968 *Eutelia pulcherrimus* (Grote) Map 6
[Beautiful Eutelia]

Published Virginia records: Fairfax (Steury et al., 2007) and Hanover (Ludwig, 2009) counties.

VDCR-DNH records (10 specimens): Alleghany, Dickenson, Fauquier, Hanover, Scott, and Southampton counties.

Other Virginia records: Loudoun (W.R. Grooms collection, 1) and Montgomery (VPISU, 1) counties.

Photo records: Carroll Co. (W. Cook); Rockingham Co. (J. Reilly).

Virginia flight dates: 19 April-8 June

Hostplants: Poison sumac (Forbes, 1954; Covell, 1984).

Comments: This beautifully marked species is collected infrequently in Virginia. It is widely distributed, but uncommon and local in eastern North America (Covell, 1984). It is regarded as "moderately common" in Kentucky (Covell, 1999). Poison sumac is uncommon in the Coastal Plain physiographic province of Virginia, and rare in the Piedmont and mountain regions (VBA, 2018), which, in addition to its early flight season (when sampling has been less frequent), probably accounts for the relatively few records of *E. pulcherrimus*.

DISCUSSION

Seven species of the noctuoid moth family Euteliidae have been documented from Virginia. The same seven widespread species inhabit Kentucky (Covell, 1999), Maryland (Glaser et al., ms; Maryland Biodiversity Project), and Ohio (Rings et al., 1992). The North Carolina fauna also includes seven species, with six of them (all but *P. abrostolella*) shared with Virginia. There is also one record of *P. nubifera* Hampson, a Deep South and Middle American species, from the North Carolina Piedmont (North Carolina Biodiversity Project). The same six species occur in West Virginia (Butler & Strazanac, 2014). Barring the future discovery of undetected sibling species, or perhaps a stray occurrence of *P. nubifera*, no additional members of the family Euteliidae are expected to occur in Virginia.

ACKNOWLEDGMENTS

Numerous VDCR-DNH staff, especially Anne Chazal, Chris Hobson, Chris Ludwig, Megan Ayers, Ellison Orcutt, Maureen Dougherty, Art Evans, Kathy Gipe (nee Derge), Amber Foster, and Tom Smith, have contributed to the agency's efforts to document and assess the moth fauna of Virginia during the past three decades. This work has been supported directly and indirectly by numerous grants from multiple sources, as well as the citizens of Virginia.

For facilitating my visits and/or granting permission to examine specimens in their care, I thank Michael Pogue, Paul Goldstein, John Brown, and the late Douglas Ferguson (NMNH), Eric Quinter (AMNH), John Rawlins and Robert Davidson (CMNH), Jon Gelhaus and Jason Weintraub (ANSP), Charles Covell and Andrew Warren (MGCL), Eric Chapman (UK), David Wagner and Jane O'Donnell (UConn), Zachary Falin (KU), Charles Mitter (UMD), John Strazanac (WVU), the late Richard Hoffman and Kal Ivanov (VMNH), Eric Day and Paul Marek (VPISU), Karen Kester (VCU), Paul Moosman (VMI), and Karen Powers (RU). Kelly Richers provided records from his private collection and Susan Felker and William Grooms (via Robert Lyon) donated their collections to VDCR-DNH. James Reilly shared his photographic records.

Christopher Heckscher, David Wagner, and Dale Schweitzer collectively made me aware of Jones' (1928–1939) unpublished manuscript on Delmarva Lepidoptera and graciously provided a photocopy of it. Dale also identified or verified some of the VDCR-DNH specimens cited above. The late John Glaser provided a copy of his unpublished manuscript on the moth fauna of Maryland.

Finally, I thank John Brown, Bo Sullivan, Steve Hall, Don Lafontaine, Chris Schmidt, Charlie Covell, Eric Quinter, and Dale Schweitzer for reviewing the manuscript and providing helpful comments.

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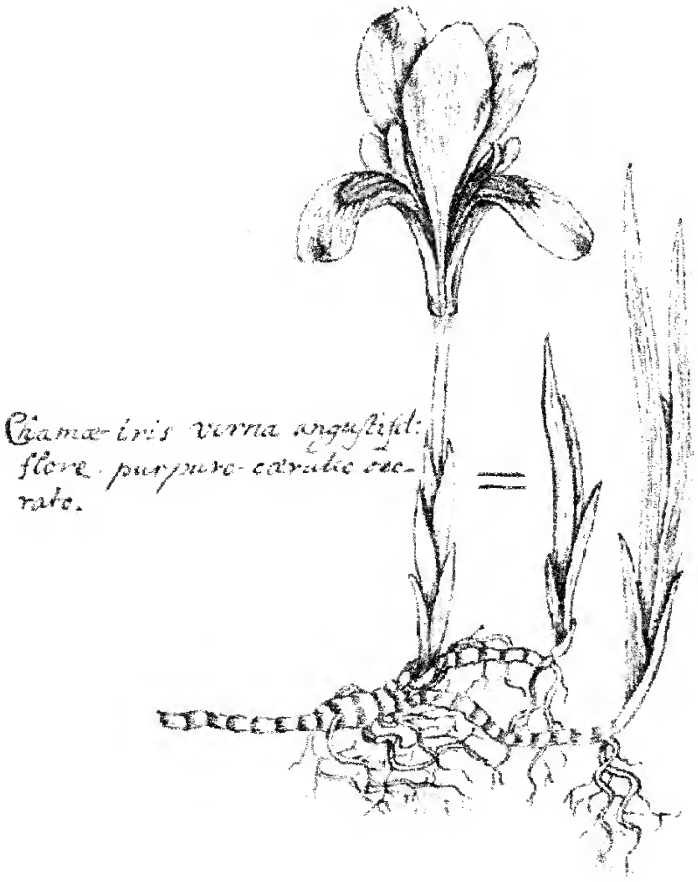

Iris verna Linnaeus (Dwarf Iris)

Original drawing by John Banister; sent to Bishop D. H. Compton in 1689.
Figure 48 in folio in Sir Hans Sloane's MS 4002 in the British Museum.
Photocopy courtesy of Joseph and Nesta Ewan.

Banisteria, Number 51, pages 42-51

First Virginia Records of Four Exotic Noctuoid Moths, with Additional Records for Two Other Introduced Species (Lepidoptera)

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ABSTRACT

The noctuoid moths *Dinumma deponens* Walker (Family Erebidae), *Amphipyra tragopoginis* (Clerck), *Niphonyx segregata* (Butler), and *Omphaloscelis lunosa* (Haworth) (Family Noctuidae), all native to the Old World, are reported from Virginia (USA) for the first time. Additional Virginia records are provided for two other introduced noctuoids, *Rusicada privata* (Walker) and *Noctua pronuba* (L.), both of which were previously reported from the state.

Keywords: *Amphipyra tragopoginis*, *Dinumma deponens*, *Niphonyx segregata*, *Noctua pronuba*, *Omphaloscelis lunosa*, *Rusicada privata*, exotic species, new records, Erebidae, Noctuidae.

INTRODUCTION

The actual and potential adverse impacts of exotic (non-native) species on native species, communities, and ecosystems has received much attention from ecologists, land managers, and others in recent decades (e.g., see reviews by D'Antonio & Chambers, 2006; Sax & Gaines, 2008; Traveset & Richardson, 2014; Gallien & Carboni, 2017; González-Suárez & González-Moreno, 2017). Invasive exotic insects can negatively affect native biodiversity through various interactions such as herbivory, predation, competition, disease transmission, and pollination disruption, in some instances even impacting ecosystem processes through cascading effects (Kenis et al., 2008).

Only about a dozen (1%) of the approximately 1,200 species of macromoths documented in Virginia are exotic species (Roble, unpub. data). The best known of these is the gypsy moth, *Lymantria dispar* (L.), a major defoliator of deciduous forests that was accidentally introduced to eastern North America from Europe in 1868 or 1869 (Elkinton & Liebhold, 1990). Vast amounts of time, money, pesticides, and biocontrol measures have been devoted to reducing populations of this species, which was first detected in northern Virginia around 1980 (Virginia Tech, 2018). It has continued to spread southward in the Appalachians, the leading edge of its ever-expanding range currently extending to Tazewell and Wythe counties in southwestern Virginia (VDACS, 2018). Numerous isolated outbreaks, often the result of unintentional transport of egg masses attached to vehicles, have also been documented in the state. Currently, only far southwestern Virginia and several other counties bordering North Carolina in western Virginia fall outside of the state's gypsy moth quarantine zone delineated by the Virginia Department of Agriculture and Consumer Services (VDACS, 2018).

In contrast, little attention has been paid to most of the other exotic macromoths, several of which are recent arrivals to the state. Zahiri et al. (2017; supplemental Table S3) prepared a list of 35 noctuoid moths that are believed to be non-native inhabitants of North America. Schmidt et al. (2018) recently added another species (*Omphaloscelis lunosa* [Haworth]) to the North American fauna that belongs on that list (see below). Ten of these species occur in Virginia (Table 1), four of which are reported herein from the state for the first time. I also provide additional Virginia records for two other introduced noctuoids. Two of the newly reported species were first documented in the state, and apparently North America in one case, by amateur naturalists.

The following acronyms refer to specimen collections: National Museum of Natural History (NMNH), Smithsonian Institution, Washington, DC; Virginia Polytechnic Institute and State University

(VPISU), Blacksburg, Virginia; Virginia Museum of Natural History (VMNH), Martinsville, Virginia; and Virginia Department of Conservation and Recreation, Division of Natural Heritage (VDCR-DNH), Richmond, Virginia. Most specimens collected by VDCR-DNH staff and collaborators are deposited in NMNH, VMNH or a reference collection at the agency's headquarters in Richmond. Specimens collected in national parks (e.g., Shenandoah National Park, Blue Ridge Parkway) have been returned to the respective parks in compliance with U.S. National Park Service policy. The common names listed for each species below were taken from various sources, including Wagner et al. (2011) and the Moth Photographers Group (MPG), Butterflies and Moths of North America (BAMONA), and BugGuide websites. The checklist numbers of Lafontaine & Schmidt (2010) and Hodges et al. (1983), respectively, precede the species' names. Decimal numbers signify additions to their original lists.

FAMILY EREBIDAE

930611.1/8554.5 *Dinumma deponens* Walker, 1858
[No common name]

The first documented U.S. record of this Asian species was obtained in 2012 in northern Georgia; within a year it had been recorded from five southeastern states, including Alabama, Georgia, North Carolina, South Carolina, and Tennessee (Adams et al., 2013). The local hostplant is mimosa tree [= silk tree] (*Albizia julibrissin* Durazz.), a widely planted ornamental in eastern United States that is classified as an invasive species in some states. Photographs submitted to several websites, including BugGuide, BAMONA, and MPG, collectively document *D. deponens* from 15 states ranging from New Jersey, New York, and Ohio south to Florida, Alabama, and Louisiana, indicating a rapid expansion of its range in North America in less than a decade. I am aware of nine Virginia records dating to 2015, most of which were obtained by amateur naturalists, consisting of one voucher specimen and seven photographic records. Most of the records are from the Greater Richmond metropolitan area (Fig. 1).

Specimen record: Chesterfield Co., Scotford Road [inside shed], 1.2 km SE jct. Rt 175 and 679, 260´, 19 March 2017, S.M. Roble (VDCR-DNH, 1).

Photographic records: Chesterfield Co., "4th floor of an office bldg in an office park" [Boulders Parkway area], 14 and 17 September 2015, M. Coker (BAMONA record 1065301; photographs of two apparently different moths). Chesterfield Co., [Silverleaf Terrace], 12 September 2016, P. Bedell (BugGuide photo 1291805;

Table 1. Non-native species of noctuoid moths known to occur in Virginia.

Family	Species	First Virginia record
Erebidae	*Lymantria dispar* (L.)	ca. 1980
Erebidae	*Rusicada privata* (Walker)	Forbes (1954)
Erebidae	*Dinumma deponens* Walker	2015 (this paper)
Nolidae	*Garella nilotica* (Rogenhofer) [1]	? (widespread in North America)
Noctuidae	*Trichoplusia ni* (Hübner) [1]	? (widespread in North America)
Noctuidae	*Niphonyx segregata* (Butler)	2008 (this paper)
Noctuidae	*Amphipyra tragopoginis* (Clerck)	1998 (this paper)
Noctuidae	*Spodoptera exigua* (Hübner)	? (widespread in North America)
Noctuidae	*Noctua pronuba* (L.)	1997 (Roble et al., 1999; this paper)
Noctuidae	*Omphaloscelis lunosa* (Haworth)	2013 (this paper)

[1] Old and New World populations may represent different species (J.D. Lafontaine, pers. comm.), in which case this species would be considered native in Virginia.

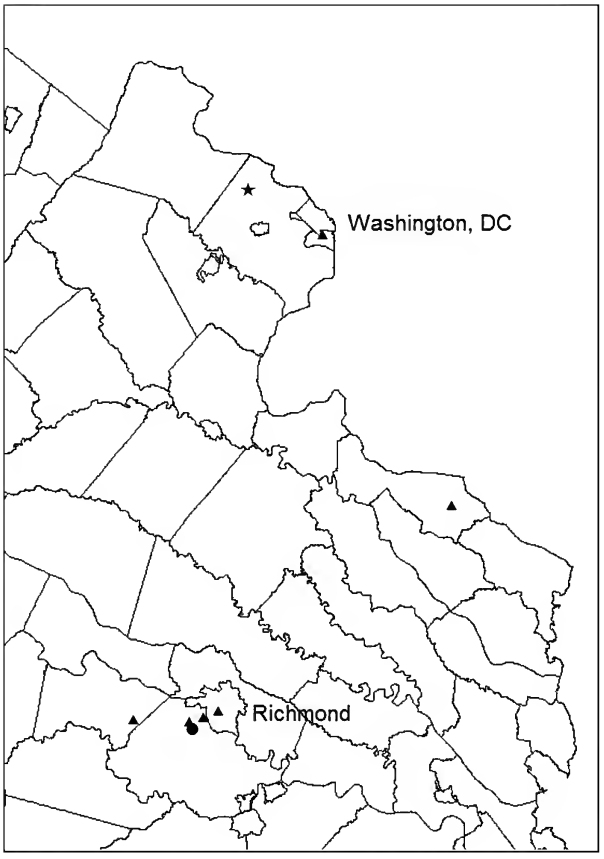

Fig. 1. Distribution of *Dinumma deponens* (dot = voucher specimen, triangles = photographs) and *Omphaloscelis lunosa* (star = photographs) in eastern Virginia.

BAMONA record 1102060; iNaturalist record 4102056). Powhatan Co., Rt. 634, Swift Creek, 22 April 2019, J. Reilly. Westmoreland Co., [Hague], 3 June 2018 and 20 October 2018, K.C. Bergdoll (iNaturalist records 13087692 and 17674308). City of Alexandria, Beverley Drive, 5 September 2018, R. Lohamm (iNaturalist record 16336234). City of Richmond, [West 45th Street], 10 July 2017, A. Belden (BAMONA record 1125364; see also Figs. 2A-2B).

FAMILY NOCTUIDAE

931545/9639 *Amphipyra tragopoginis* (Clerck, 1759) [Mouse Moth]

Forbes (1954) suggested that there was some uncertainty regarding whether this small, brown nondescript moth is a Holarctic species or if it was introduced to North America from Eurasia, but Zahiri et al. (2017) subsequently included *A. tragopoginis* in their list of exotic noctuoids in North America. Its absence from high latitude habitats in North America that typically harbor Holarctic species, combined with its historical presence near areas of human habitation, strongly support the conclusion that *A. tragopoginis* was introduced to this continent (Mikkola et al., 1991). Forbes (1954) summarized the North American range of this general feeder as "Newfoundland and southern Canada south to Pennsylvania, west to the Mississippi; sometimes rather common; British Columbia." Subsequent records are now available from Maryland (Glaser et al., ms, 3 counties; NMNH, 8 specimens [oldest 1987]), West Virginia (MPG, 2 counties; iNaturalist, Pendleton Co., C. Lehman, 2011; NMNH, 5 specimens [all 2011]), North Carolina (iNaturalist and North Carolina Biodiversity Project; 5 counties, first record 1998), and Virginia (first record 1998; see below). The recent nature of all of these records at the southern end of its range in the Appalachians suggests that *A. tragopoginis* is continuing to expand its range in North America. Alternatively, these records could merely reflect increased survey and observational efforts south of Pennsylvania in recent decades.

I did not find any museum or literature records of *A. tragopoginis* from Virginia, nor any recent online photographic records (e.g., BAMONA, BugGuide, iNaturalist, MPG). However, statewide sampling by VDCR-DNH staff and collaborators during the past three decades has resulted in the collection of the following 14 voucher specimens from eight sites (Fig. 3) in the Blue Ridge and Ridge and Valley physiographic provinces of western Virginia that fill the gap in the range between Maryland and North Carolina.

Bath Co., Warm Springs Mountain, Bald Knob, 7 July 1999, J.C. Ludwig (3); same locality but 3 August 1999, J.C. Ludwig and S.M. Roble (1). Bedford Co., Blue Ridge Parkway, Peaks of Otter Recreation Area, Sharp Top Mountain, 28 June 2001, J. Basinger (1). Floyd Co., Buffalo Mountain, 30 June 2000, S.M. Roble (2); 2.5 km W of Willis, 22 June 2004, S.M. Roble (2). Grayson Co., Grayson Highlands State Park, Massie Gap, headwaters of Quebec Branch, "Sullivan Swamp", 30 June 2011, S.M. Roble (1); Jefferson National Forest, Whitetop Mountain, 22 July 2014, S.M. Roble (1). Page Co., Shenandoah National Park, Blackrock [Big Meadows area], 14 July 2005, A.C. Chazal and R.D. Knisley (1). Wythe Co., Sand Mountain, 23 July 1998, S.M. Roble, C.S. Hobson, and B. Charles (2).

Seven of the eight sites are on mountaintops (elevational range 1097–1646 m [3600–5400′]), mostly in deciduous forests, but they include a pitch pine-scrub oak barren, mafic glade, mountain bog, and red spruce forest. The remaining site is a sedge-dominated seepage wetland (823 m [2700′]).

932615.1/9956.1 *Omphaloscelis lunosa* (Haworth, 1809)
[Lunar Underwing]

The first U.S. report of this common but variable western European species that closely resembles the native North American species *Sericaglaea signata* (French) (Variable Sallow) originated from eastern Maryland in 2015 (Schmidt & Lafontaine, 2018). It is currently known from two counties in that state, the oldest record having been obtained in 2014 (Maryland Biodiversity Project). In addition to their similar appearance, both species are active in the fall, which may have led to initial misidentification or unresolved identification of some BugGuide photo submissions. However, recent reexamination of these images by BugGuide editors and reviewers (T. Reichard and H. McGuinness) has revealed the existence of several *O. lunosa* images from Fairfax County, Virginia that predate the Maryland records (BugGuide). This species has been photographed (Fig. 2C) annually at a private residence in Reston (date range September 28–October 20; T. Calkins, pers. comm.) from 2013–2018, with an image obtained on 12 October 2013 apparently constituting the earliest documentation of *O. lunosa* in North America (BugGuide). No other Virginia records of this species are currently known (Fig. 1), but I anticipate that *O. lunosa* will continue to expand its range in the metropolitan District of Columbia region and beyond in the coming decades. Nature enthusiasts will likely contribute the majority of new distributional records documenting this phenomenon via their submissions to websites such as BugGuide, BAMONA, and iNaturalist.

932716/9558.1 *Niphonyx segregata* (Butler, 1878)
[Hops Angleshade]

To date, there have been few references to this Asian species in the literature on North American moths (e.g., Lafontaine & Schmidt, 2010). A hop feeder, it is endemic to eastern Asia, including the Russian Far East, the Korean Peninsula, Japan, China, and Taiwan (BOLD systems). It is believed to have been introduced into the northeastern U.S. in the 1990s, where the first record was obtained on Long Island, New York (Lafontaine & Schmidt, 2010). Photographs submitted to BugGuide, BAMONA, MPG, and the North Carolina Biodiversity Project collectively document *N. segregata* from 10 states ranging from Massachusetts and New York south to North Carolina.

The earliest documentation of *N. segregata* in Virginia is based on a specimen that I collected along the James River in the spring of 2008. Currently, there are at least 13 specimen records from the Commonwealth, all but one obtained by VDCR-DNH staff and collaborators: Buckingham Co., James River at New Canton boat landing, Co. Rt. 670, 27 May 2011, S.M. Roble (NMNH, 1; VDCR-DNH, 1). Cumberland Co., James River at Columbia boat landing, Co. Rt. 690, 22 May 2012, S.M. Roble and A.C. Chazal (VDCR-DNH, 1). Fairfax Co., Fort Belvoir, Area F-1 near Pohick Creek, 9 August 2012, C.S. Hobson and J. Pilcicki (1); same but Area T9 (1). Goochland Co., James River at West View boat landing, Co. Rt. 643, 30 May 2008, S.M. Roble (NMNH, 1); same but 11 May 2011 (NMNH, 1); same but 28 May 2011 (NMNH, 2; VDCR-DNH, 1); same but 22 May 2012, S.M. Roble and A.C. Chazal (NMNH, 1), same but 16 August 2013, S.M. Roble (VDCR-DNH, 2). *Niphonyx segregata* has also been collected along the Mattaponi River: King and Queen Co., 0.5 mi NE Aylett, 8 June 2013, P. Dennehy (P. Dennehy collection, 1).

I am also aware of the following photographic records obtained in Virginia: Augusta Co., Verona, 6 August 2014, M. Morris (BugGuide photo 974448; see also Fig. 2D). Buckingham Co., Warren Ferry Road, 10 July 2018, J. Gallagher (iNaturalist record 14406451). Henrico Co., Glen Allen, 23 August 2017, K. Richardson (iNaturalist record 7616032). City of Richmond, James River [James River Park, "The Wetlands"], on Japanese hops, 2 August 2016, A. Belden (BAMONA record 1093704). City of Richmond, James River Park [Pony Pasture, photographed on Japanese hops], 21 August 2016, R. Young (iNaturalist record 3933189). City of Staunton, 31 May 2011, M. Morris (BugGuide photo 634653).

The known distribution of *N. segregata* in Virginia is shown in Figure 3, with most records from along the James River. I have collected adults during the day on Japanese hops (*Humulus japonicus* Siebold & Zucc.), an exotic plant that forms dense monocultures along the banks of the river in many areas, and also taken adults at ultraviolet light along the river's shoreline.

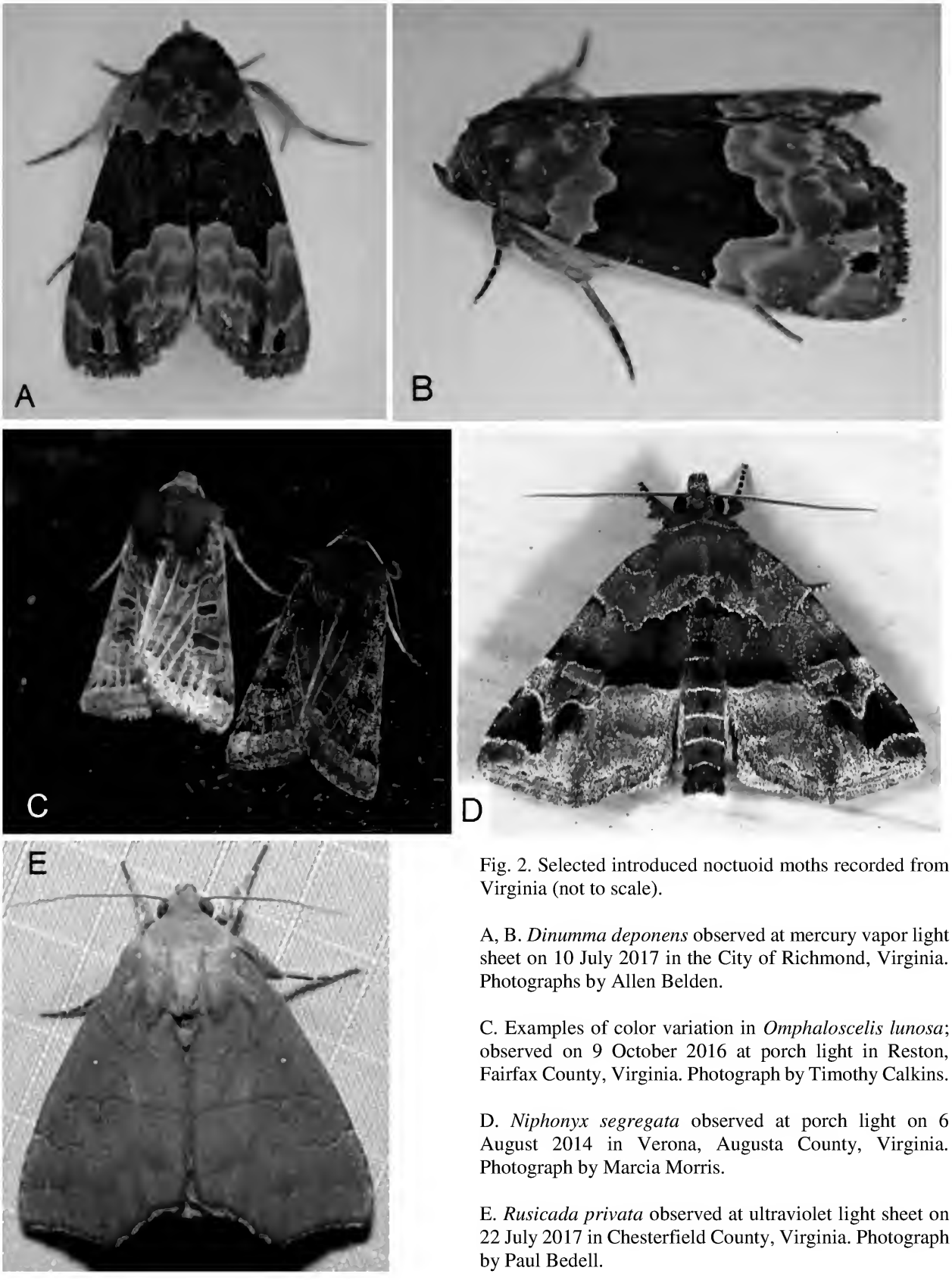

Fig. 2. Selected introduced noctuoid moths recorded from Virginia (not to scale).

A, B. *Dinumma deponens* observed at mercury vapor light sheet on 10 July 2017 in the City of Richmond, Virginia. Photographs by Allen Belden.

C. Examples of color variation in *Omphaloscelis lunosa*; observed on 9 October 2016 at porch light in Reston, Fairfax County, Virginia. Photograph by Timothy Calkins.

D. *Niphonyx segregata* observed at porch light on 6 August 2014 in Verona, Augusta County, Virginia. Photograph by Marcia Morris.

E. *Rusicada privata* observed at ultraviolet light sheet on 22 July 2017 in Chesterfield County, Virginia. Photograph by Paul Bedell.

ADDITIONAL RECORDS

The following two introduced noctuoid moths were reported previously from Virginia, but updated information on their distribution in the state has not been published until now.

Erebidae

930604/8547 *Rusicada privata* (Walker, 1865)
[Hibiscus Scalloped Moth, Hibiscus-leaf Caterpillar Moth]

Forbes (1954) discussed this Asian species (as *Anomis commoda* [Butler, 1878]) in his treatise on the moth fauna of New York and eastern North America, noting the existence of a record from Arlington, Virginia. More than a half century later, Wagner et al. (2011) remarked that, unlike several related migratory species, it seems to be rather sedentary because it had spread only as far as eastern Massachusetts and southeastern Virginia in the approximately seven decades since its introduction to North America near Moorestown, New Jersey. However, current maps on the BugGuide, BAMONA, and MPG websites include records (all based on photographs) of *R. privata* that extend from New Hampshire and Vermont south to the Carolinas, Tennessee, and Georgia, with an apparently disjunct record in extreme southern Texas, thus documenting a much larger range.

I have not seen any additional museum specimens from Virginia since the report by Forbes (1954), but have collected several larvae on Rose of Sharon (*Hibiscus syriacus* L.) bushes (an exotic ornamental) and captured several adults in my suburban Richmond yard: Chesterfield Co., Scotford Road, ca. 1.2 km SE jct. Rt 175 and 679, reared larva emerged 7 January 2001, S. M. Roble (VDCR-DNH, 1); same but emerged August 2003; same but larva collected on Rose of Sharon, 1 August 2003, pupated but failed to emerge (not kept); same but single adults collected at incandescent light on 1 May 2003, 14 October 2005, 11 November 2005, 10 September 2007, and 28 August 2016 (all VDCR-DNH); I also collected an adult at a motel porch light in Warm Springs, Bath County on 10 August 2010 (VDCR-DNH, 1). The collection of the late W.R. Grooms (currently housed at VDCR-DNH) contains 10 specimens captured between 28 April and 26 September in Loudoun County (mostly Ashburn) during 2007–2009.

Photographs of *R. privata* are available on the BugGuide, BAMONA, MPG, and iNaturalist websites for the following Virginia jurisdictions: Augusta (M. Morris, 2013, 2015), Chesterfield (P. Bedell, 2016, 2017; see Fig. 2E), Culpeper (L. Alloway, 2018 [larva]), Fairfax (anonymous, 2015; K. Rosenthal, 2018), Prince William (J. Gallagher, 2010, 2017), and Rockingham (D. Wendelken, 2016) counties, and the cities of Richmond (A. Belden, 2015) and Williamsburg (M. Anthony, 2018; N. Newberry, 2018). The known distribution of *R. privata* in Virginia is shown in Figure 4.

Despite the current lack of confirmed records for southwestern Virginia, *R. privata* occurs regularly in areas of the North Carolina mountains where Rose of Sharon is present in abundance, and the larvae defoliate the shrubs occasionally (J.B. Sullivan, pers. comm.). Future sampling will likely identify populations of *R. privata* in southwestern Virginia.

Noctuidae

933551/11003.1 *Noctua pronuba* (Linnaeus, 1758)
[Large Yellow Underwing, Large Yellow-winged Dart, European Yellow Underwing]

Noctua pronuba is native to Europe and northern Africa, ranging eastward to India (Lafontaine, 1998). It was introduced into North America at Halifax, Nova Scotia around 1979 (Neil, 1981). This highly variable species spread rapidly across North America, reaching the West Coast in less than three decades (Passoa & Hollingsworth, 1996; Wagner et al., 2011; see also BAMONA and MPG range maps). Roble et al. (1999) documented the first Virginia records, reporting it from the following jurisdictions on the basis of 13 specimens collected by VDCR-DNH staff during 1998–1999: Accomack, Bath, Fairfax, Nottoway, Prince William, and Wythe counties and the City of Virginia Beach. An addendum to that paper cited a collection from the Fauquier-Prince William county line (Roble, 2000). Subsequent ultraviolet light trapping throughout Virginia by me and other VDCR-DNH staff has yielded collections from 24 additional counties: Albemarle, Augusta, Bedford, Brunswick, Chesterfield, Dickenson, Dinwiddie, Floyd, Giles, Grayson, Greene, Hanover, Highland, Madison, Montgomery, Northampton, Page, Pulaski, Rockbridge, Rockingham (specimen also in K. Richers collection), Russell, Smyth, Warren, and Wise. I have also seen one specimen each from Loudoun (W.R. Grooms collection) and Southampton (VPISU) counties, the latter collected in July 1997 and thus apparently the first documented record for the state. *Noctua pronuba* was also collected in Lancaster County in August 2012 (P. Dennehy collection, 1). Photographs submitted to the BugGuide, BAMONA, MPG, and iNaturalist websites add Clarke, Frederick (larva), Roanoke (larva), Tazewell, and Washington counties and the cities of Alexandria (larva), Harrisonburg, Radford (larva), and Richmond to the known Virginia

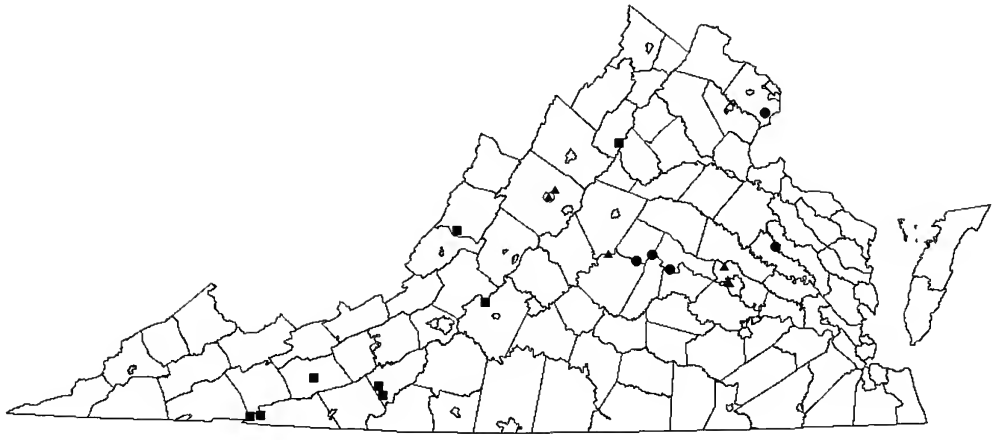

Fig. 3. Distribution of *Amphipyra tragopoginis* (squares = voucher specimens) and *Niphonyx segregata* (dots = voucher specimens, triangles = photographs) in Virginia.

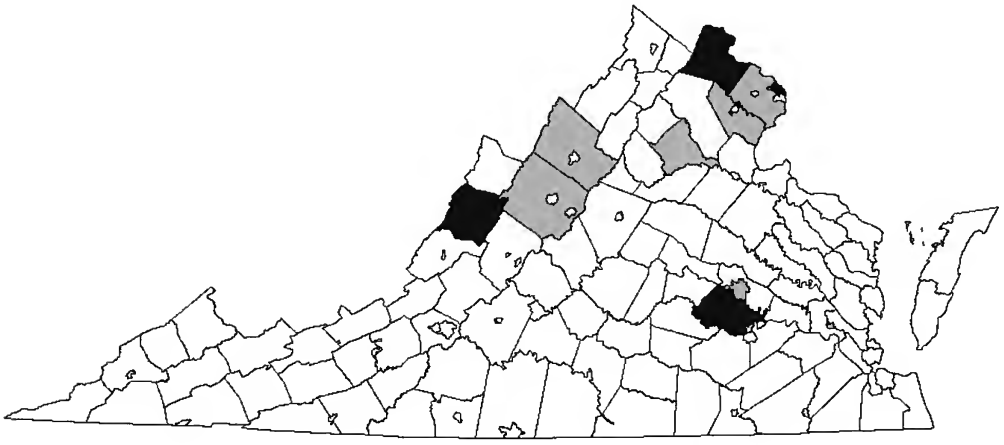

Fig. 4. County and city distribution of *Rusicada privata* in Virginia (dark shading = voucher specimens, light shading = photographs).

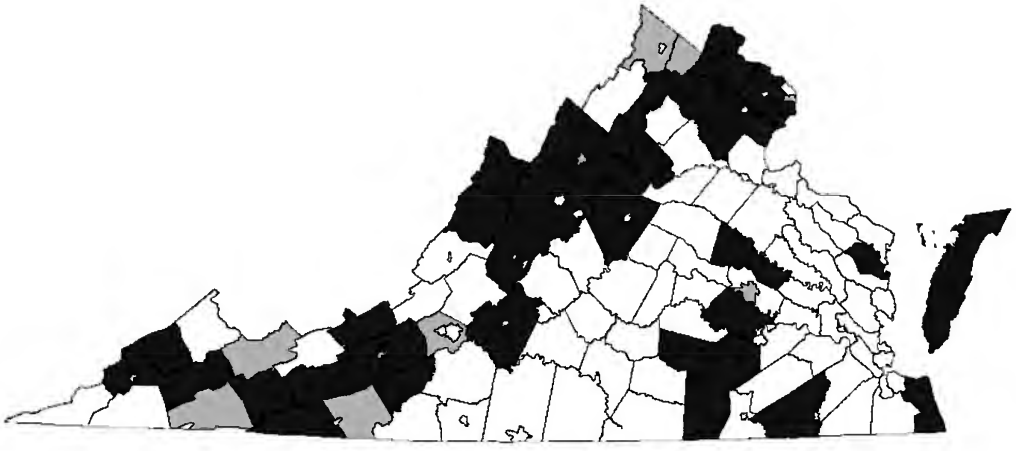

Fig. 5. County and city distribution of *Noctua pronuba* in Virginia (dark shading = voucher specimens, light shading = photographs).

distribution (Fig. 5). *Noctua pronuba* has also been photographed in Carroll County (W. Cook website).

The larvae of *N. pronuba* feed on a wide variety of weedy and cultivated herbaceous plants including grasses, chrysanthemums, carnations, strawberries, tomatoes, potatoes, grapes, carrots, beets, cabbage, and lettuce (Passoa & Hollingsworth, 1996).

OTHER INTRODUCED NOCTUOIDS

Several other introduced noctuoid moths that currently inhabit eastern North America may eventually be documented in Virginia as their ranges expand, and future arrivals to the continent may also occur in Virginia. The following two readily identifiable, exotic noctuids (images available in Beadle & Leckie [2012] and various websites) have been recorded from counties adjacent to Virginia within the past decade. These species will undoubtedly be added to the state's fauna in the near future.

931771/10177 *Calophasia lunula* (Hufnagel, 1766) [Toadflax Brocade Moth]

This European species was introduced into North America (initially Canada) for the biological control of toadflax (*Linaria* spp.) (McDermott et al., 1990). The MPG map shows that its current North American range includes the Pacific Northwest and northeastern U.S., south to Maryland and West Virginia. This species is known from two counties in western Maryland, with the earliest records obtained in 1994 (Glaser et al., ms; Maryland Biodiversity Project). It was recorded in Pendleton County, West Virginia by C. Lehman in August 2011 (BugGuide photo 565664). This county borders Augusta, Highland, and Rockingham counties in western Virginia. The larvae feed on *Linaria vulgaris* P. Mill. (yellow toadflax, butter-and-eggs), which is a widespread, common weed in Virginia (VBA, 2018).

932363/9385.1 *Lateroligia ophiogramma* (Esper, 1793) [Double Lobed Moth]

A borer of marsh plants with thick stems, such as *Phalaris* (canary grass) and *Phragmites* (common reed), this introduced Eurasian species is currently spreading in northeastern Canada and the U.S. (Mikkola et al., 2009). The MPG map shows a transcontinental range across the northern U.S. and southern Canada, extending south to Pennsylvania and Ohio with a disjunct record for western North Carolina. There are also two recent records (2015–2016) from Maryland (Maryland Biodiversity Project). Since 2007, *L. ophiogramma* has been recorded in three counties (Alleghany, Ashe, and Avery) in northwestern North Carolina (BugGuide, iNaturalist, and North Carolina Biodiversity Project websites), the first two of which border Grayson County, Virginia. Suspected host plants in North Carolina include ornamental grasses such as zebra grass (*Miscanthus sinensis*) and pampas grass (*Cortaderia selloana*) (J. B. Sullivan, pers. comm.).

The following introduced species is also likely to be found in Virginia eventually given the abundance of its hostplant in coastal areas of the state.

932437/9447.2 *Rhizedra lutosa* (Hübner) [Large Wainscot Moth]

McCabe & Schweitzer (1991) first documented this Eurasian species in North America in 1988 from New Jersey salt marshes, where the larvae feed on the introduced common reed (*Phragmites australis* [Cav.] Trin. ex Steud.). The moth has since spread west, north, and south (e.g., New York, Mikkola & Lafontaine, 1994; Michigan, Summerville, 1998). Mikkola & Lafontaine (1994) speculated that *R. lutosa* (and two other noctuids) was introduced to North America via modern ships containing fragments of *Phragmites* or other grasses harboring immature life stages of the moth.

A non-native genotype (nominate subspecies) of common reed colonized North America and has become widespread and abundant across the continent during the past 150 years (Saltonstall, 2002). In Virginia, it is an abundant, highly invasive species that readily colonizes suitable wetland habitats in coastal areas and is known from about half of the counties in the state (VBA, 2018). Common reed forms nearly monotypic stands that are of limited value to wildlife (Marks et al., 1994). Recent studies have revealed that there is also a more localized, native North American genotype (subspecies *americana*) of common reed (Saltonstall et al., 2004). In Virginia, it is known from only three counties in the Coastal Plain (VBA, 2018).

Blossey & Weber (2000) briefly sampled two stands of exotic common reed in coastal Virginia for insect herbivores. They documented four introduced insects new to the Virginia fauna, but did not detect *R. lutosa*. However, their sampling was conducted in early spring and did not include ultraviolet light trapping for adults. The deployment of such traps in coastal marshes containing *Phragmites* may eventually confirm the existence of this introduced moth in Virginia.

DISCUSSION

The actual or potential impacts of the introduced moths discussed above on native species and ecosystems

are poorly known. *Noctua pronuba*, a polyphagous, migratory species, is clearly the most widespread and abundant of these, and thus perhaps most worthy of study with regard to its potential impacts to native plants as well as vegetables and agricultural crops. Most of the other species apparently are feeding on introduced plants, but further information is desired on the use of native plants as hostplants by all of these species.

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Fellow VDCR-DNH staff Anne Chazal, Chris Hobson, and Chris Ludwig collected some of the specimens cited above. I thank Paul Bedell, Allen Belden, Timothy Calkins, and Marcia Morris for permission to publish their photographs and data. Eric Day (VPISU) and Mike Pogue (NMNH) granted access to collections in their care. The late Robert Lyon salvaged the collection of the late William R. Grooms and donated it to VDCR-DNH. Paul Dennehy and Kelly Richers graciously provided records from their private collections, and James Reilly shared a photo record.

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Annotated Checklist of Checkered Beetles from the George Washington Memorial Parkway, Virginia (Coleoptera, Cleridae)

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ABSTRACT

Malaise trap samples collected during a 19-year period (1998–2017) from four national park sites in northern Virginia were sorted for checkered beetles (Coleoptera, Cleridae). Eighteen species and one subspecies were documented, including the first published record of *Phyllobaenus verticalis* Say from the Commonwealth. Periods of adult activity, based on dates of capture, are given for each species. Relative abundance is noted for each species based on the number of captures.

Keywords: Fairfax County, Malaise trap, national park, new state record, Potomac River Gorge.

INTRODUCTION

Most adult and larval checkered beetles (Coleoptera, Cleridae) are large-jawed predators of adult and larval wood-boring insects. Diverse and generalist predators, checkered beetles are often observed feeding on pollen as a secondary protein source. Some genera are associated with carrion and stored animal products, and there are several anecdotal observations of predation on Hymenoptera (Leavengood, 2008). Some species have been introduced to control beetles infesting conifers (Hopkins, 1899). Many are brightly colored with red and yellow patterns, and most possess a dense vesture of long setae. Some species may be velvet ant (Hymenoptera, Mutillidae) mimics and are presumed to be a part of a mimicry ring that includes other beetles in the families Lampyridae and Lycidae (Mawdsley, 2002).

Clerids occur in all areas of the world and over 290 species inhabit North America north of Mexico (Opitz, 2002; W. F. Barr, *in litt.*, 2018). They are most diverse in the southwestern United States and Mexico. The purpose of this paper is to increase our knowledge of checkered beetle distribution, particularly of the parklands of the George Washington Memorial Parkway (GWMP) in Virginia.

STUDY SITES

The study sites include lands managed by the National Park Service as units of the George Washington Memorial Parkway (GWMP) in Fairfax County, Virginia. Malaise traps were placed at four sites within GWMP: Dyke Marsh Wildlife Preserve, Great Falls Park, Little Hunting Creek, and Turkey Run Park. A map of these park sites is provided in Steury (2011). Great Falls and Turkey Run parks fall within the Piedmont physiographic province and Dyke Marsh Wildlife Preserve and Little Hunting Creek are on the Coastal Plain. All sites are situated near the shore of the Potomac River. Most of the study sites are dominated by maturing, secondary growth, primarily upland, deciduous woodlands with a band of floodplain forest along the Potomac River. However, older-age stands, with dominant trees over 100 years old, occur on ridges

at the northern and southern ends of Great Falls Park. Abrams & Copenheaver (1999) documented white oak (*Quercus alba* L.) individuals between 208 and 251 years old and a black gum (*Nyssa sylvatica* Marshall) 166 years old along the northern ridge. Counts of radial growth rings on a short-leaf pine (*Pinus echinata* Mill.) that fell in 1994 from a ridge along the southeastern edge of the Park, dated to at least 220 years old. More open, herbaceous dominated, habitats can be found along the river shores and in the tidal, freshwater marsh habitats at Dyke Marsh. The vascular flora of the GWMP is diverse, with more than 1,313 taxa recorded (Steury et al., 2008; Steury, 2011).

Traps at Dyke Marsh were located in tidal, freshwater marsh dominated by narrow-leaf cattail (*Typha angustifolia* L.), in floodplain forest dominated by red and silver maple (*Acer rubrum* L. and *A. saccharinum* L.) and tulip poplar (*Liriodendron tulipifera* L.), and at the marsh/forest ecotone. In Great Falls Park, a trap was set in each of three habitats: dry, upland forest; swamp dominated by red maple; and floodplain forest dominated by oaks (*Quercus* spp.) and tulip poplar. In Turkey Run Park one trap was set in upland forest dominated by oaks and tulip poplar and two traps in floodplain forest along the Potomac River, dominated by oaks, basswood (*Tilia americana* L.), and sycamore (*Platanus occidentalis* L.). At Little Hunting Creek, four traps were set in upland forest dominated by an ericaceous understory and a canopy of oaks, hickory (*Carya* sp.), American beech (*Fagus grandifolia* Ehrh.), and some Virginia pine (*Pinus virginiana* Mill).

MATERIALS AND METHODS

Six Townes style Malaise traps were set at Dyke Marsh (April 1998–December 1999), three each at Great Falls and Turkey Run parks (March 2006-November 2009), and four at Little Hunting Creek (March–November 2017). Beetles were removed from the samples by citizen science volunteers and clerid beetles were removed from these subsamples by the first author. Three specimens were added to this study by hand collecting, and one was collected only in this manner. Collectors included C. Acosta, E. Barrows, C. Davis, A. Evans, S. Lingafelter, D. Smith, W. Steiner, B. Steury, J. Swearingen, and N. Woodley. Specimens were pinned, labeled, and deposited in the collections maintained at the GWMP, Turkey Run Park Headquarters in McLean, Virginia. The state record determination was based on reviews of Knull (1951), Downie & Arnett (1996), Hoffman et al. (2002), Leavengood (2008), and Burke et al. (2015), among other literature.

RESULTS AND DISCUSSION

Six subfamilies containing 10 genera, 18 species, and one subspecies were documented from the study areas. Despite having well-developed wings, clerids were uncommon in Malaise trap samples. By comparison, Knull (1951) recorded 41 clerid species from Ohio and nine additional species that could possibly occur in the state. Majka (2006) reported 15 species from the Maritime Provinces of Canada, and 42 species were documented from Florida (Leavengood, 2008). One species collected in Great Falls Park, *Phyllobaenus verticalis*, represents a new record for Virginia. Brown (2008) did not include clerid beetles in the checklist of the invertebrate fauna of the Potomac River Gorge, located between Maryland and Virginia, an area with over 100 years of biodiversity studies. Thus, all species captured during this study from Great Falls and Turkey Run parks represent the first reported records for the gorge. *Enoclerus nigripes nigripes* was the most commonly collected species. Five species were documented by single specimens. All of the genera recorded from the study area are known predators of beetle larvae that live under loose bark of dead wood (Knull, 1951; Evans, 2014). Additionally, scattered anecdotal accounts of *Cymatodera* and *Phyllobaenus* report rearing from galls or predation on insect larvae inside galls, mostly observed in cynipid wasps (Osten Sacken, 1861; Balduf, 1926; Sabrosky, 1934; Knull, 1951; Eliason & Potter, 2000).

Thirteen other clerid genera are recorded from Virginia or nearby states, or the District of Columbia, but have not yet been found in the study area. Most of these also feed on beetle larvae and adults under loose bark, but may also opportunistically prey on bee larvae, larval insects developing inside plant galls, insects (particularly larvae) on carrion, dung, and detritus, or their diet is unknown (Table 1).

LIST OF SPECIES

Species are listed alphabetically within subfamilies following Opitz (2010). The number of specimens in the collection is indicated in parentheses after each taxon. Sites where specimens were collected are abbreviated Dyke Marsh Wildlife Preserve (DM), Great Falls Park (GF), Little Hunting Creek (LH), and Turkey Run Park (TR). All collections are from Malaise traps, or indicated as collected with a beating sheet (bs) or Lindgren funnel (lf). Label data for hand-picked specimens (hp) are provided when available. Dates separated by a hyphen indicate that the taxon was documented on at least one day during each month within this continuum of months,

Table 1. Clerid genera not documented from the George Washington Memorial Parkway, with known occurrence in or near Virginia (Downie & Arnett, 1996; Hoffman et al., 2002; Burke et al., 2015), and reported diet (Opitz, 2002).

Genus	Occurrence	Diet (in part)
Ababa	District of Columbia	Unknown; adults reared from bracket fungi.
Isohydnocera	Virginia	Lepidopteran larvae, coleopteran larvae inside herbs, hymenopteran larvae inside galls.
Lebasiella	Pennsylvania	Unknown; collected on various hardwoods.
Lecontella	Virginia	Hymenopteran (bee and wasp) larvae in hives.
Monophylla	Virginia	Coleopteran larvae and adults (bark beetles, subfamily Scolytinae).
Necrobia	Cosmopolitan	Insect larvae associated with carrion (hides), dung, and detritus.
Opilo	Pennsylvania	Introduced from Europe; North American prey unknown.
Pelonium	Pennsylvania	Probably coleopteran larvae found under loose bark of dead wood, especially in moist areas with cypress.
Tarsostenus	Cosmopolitan	Powder post beetles, genera *Lyctus* and *Xylobius*.
Thanasimus	Virginia	Coleopteran larvae and adult bark beetles found under loose bark of dead wood, especially conifers.
Trichodes	Virginia	Bee larvae, orthopteran (grasshopper) egg pods; adults frequently found on flowers.
Wolcottia	Virginia	Unknown; collected on herbs and oaks.
Zenodosus	North Carolina	Coleopteran larvae found under loose bark of dead wood.

whereas dates separated by a comma represent a gap in months between collection dates. For traps set over multiple weeks, the first day of the set is used as the earliest date and the last day of the set as the latest date. Taxa newly recorded for the Potomac River Gorge are marked by an asterisk.

Cleridae

Tillinae

**Cymatodera bicolor* (Say) – (11); DM, GF, LH, TR; 23 Apr–21 Jul. Four of these specimens possess the "light transverse band at middle of elytron" as described by Knull (1951) for this species in Ohio; the others have all black elytra as is more typical for *C. bicolor* in Florida (Leavengood, 2008).

**Cymatodera inornata* (Say) – (5); GF, LH; 21 May–13 Jul. Burke et al. (2015) reported the first Virginia record for this species (using the abbreviation VI, and TE for Tennessee; Burke, *in litt.*, 2018).

Cymatodera undulata (Say) – (1); LH; 17–28 Jul. (Fig. 1a).

**Cymatodera wolcotti* Barr – (9); DM, GF, LH; 19 May–10 Oct. (Fig. 1b). This species was only recently reported from Virginia (Burke et al., 2015). These specimens represent the northernmost records to our knowledge. We used Burke & Zolnerowich (2014) to distinguish *C. undulata* from *C. wolcotti* based on the shape of the male sixth abdominal segment. Additionally, in *C. wolcotti*, the punctures on the head are dense and the spaces between them are rugulose, while on the center of the apical portion of the pronotum (especially near the attachment of the head), the punctures are more widely spaced and the surface between them is smooth (Fig. 1b). In contrast, the density of the punctures in *C. undulata* is similar on the head and pronotum (both being dense and rugulose) (Fig. 1a) as described by Leavengood (2008). Also, the apical fasciae of the elytra are typically more zig-zag in *C. undulata* as opposed to more smooth-edged in *C. wolcotti* (Fig. 2a-b). Only one of our specimens of *C. wolcotti* is from the Piedmont, the others were captured in, or near, freshwater, tidal marsh habitat on the Coastal Plain.

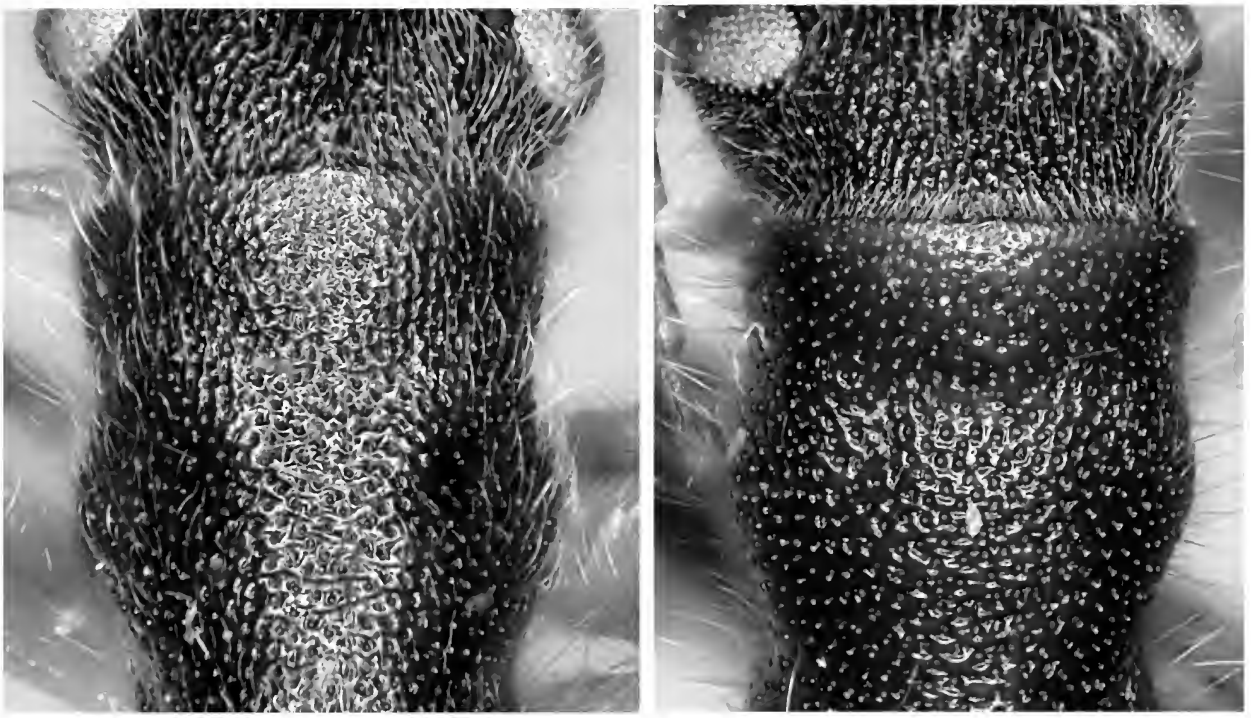

Fig. 1a-b. *Cymatodera undulata* (Say), left, showing similar rugulose punctuation on neck and pronotum. Specimen is from Little Hunting Creek, Fairfax County, Virginia. Right, *Cymatodera wolcotti* Barr, showing dissimilar punctuation on neck and center of the apical portion of the pronotum, which is smooth between punctures. Specimen is from Dyke Marsh Wildlife Preserve, Fairfax County, Virginia.

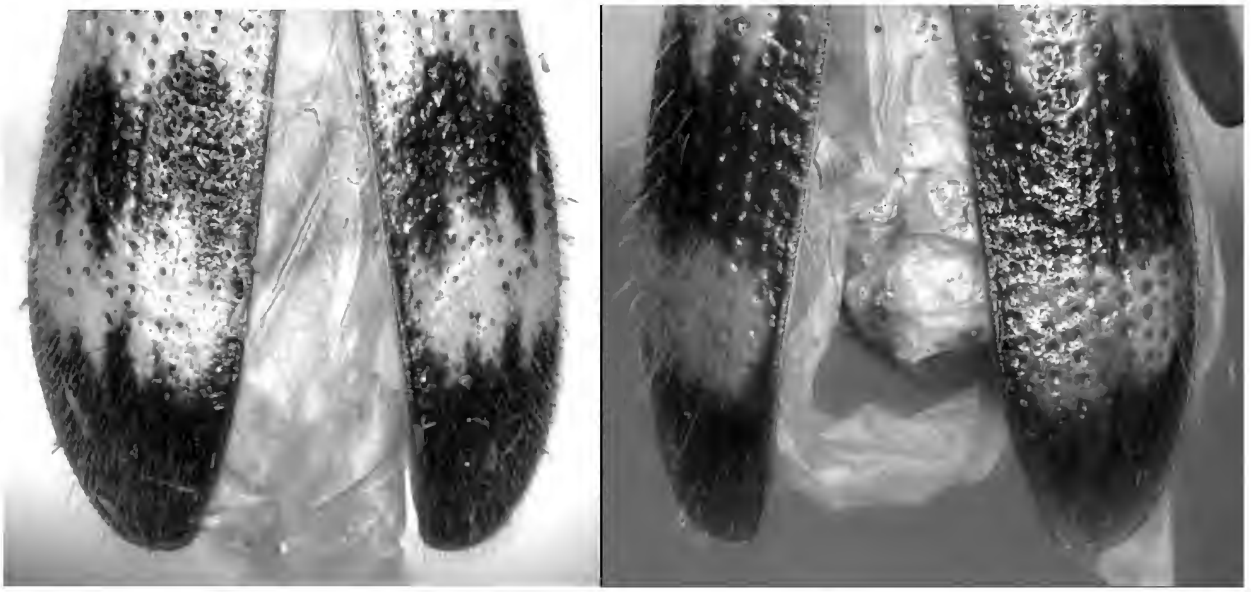

Fig. 2a-b. Apical elytral band of *Cymatodera undulata* (Say) (left) and *Cymatodera wolcotti* Barr (right) showing more zig-zag edge to band in *C. undulata*. Same specimens as in Figure 1a-b.

Hydnocerinae

Phyllobaenus humeralis (Say) – (1); Riverside Park; 10 Jun; hp (grassy area along river).

**Phyllobaenus maritimus* (Wolcott) – (1); TR; 5–25 Aug. (Fig. 3). This species and *P. lecontei* (Wolcott) were recently synonymized by Barr (2018).

Phyllobaenus verticalis* Say – (1); GF; 19–30 Jun. (Fig. 4). **NEW STATE RECORD. This species has been documented from Prince Edward Island, Canada (Majka, 2006), south along the east coast to Florida, and west to Kansas (Leavengood, 2008). Knull (1951) recorded it from a number of woody plants that are common in Great Falls Park (Steury et al., 2008), including grape (*Vitis* sp.) and linden (*Tilia* sp.) infested with longhorned beetle larvae (Cerambycidae), black oak (*Quercus velutina* Lam.) infested with jewel beetle larvae (Buprestidae), and hickory (*Carya* sp.) infested with undetermined wood-boring beetle larvae. It was also recorded from a cynipid wasp gall on white oak (*Quercus alba* L.).

Clerinae

Enoclerus nigripes dubius Spinola – (1); DM; 25 Apr–9 May. (Fig. 5). This subspecies is characterized by having a dark spot between the eyes and having the basal elytral coloration not extending to the midpoint of the elytra.

**Enoclerus nigripes nigripes* (Say) – (24); DM, GF, TR; 10–30 Apr.

**Enoclerus ichneumoneus* (Fabricius) – (16); LH, GF, TR; 10 Apr–25 Aug.

**Enoclerus rosmarus* (Say) – (4); GF, TR; 15 Jun–26 Jul.

**Placopterus thoracicus* (Oliver) – (3); DM, GF; 28 Apr–5 Jun.

**Priocera castanea* (Newman) – (7); GF, TR; 19 Jun–26 Jul.

Epiphloeinae

**Madoniella dislocata* (Say) – (19); DM, LH, TR; 5 May–21 Jul; bs (1).

Pyticeroides laticornis (Say) – (2); DM, LH; 3–16 Jun, 26 Sep–11 Oct, lf (1).

Fig. 3. *Phyllobaenus maritimus* Wolcott, dorsal habitus. Length 3.6 mm. Specimen is from Turkey Run Park, Fairfax County, Virginia.

Fig. 4. *Phyllobaenus verticalis* Say, dorsal habitus. Length 4 mm. Specimen is from Great Falls Park, Fairfax County, Virginia.

Fig. 5. Dorsal habitus of *Enoclerus nigripes dubius* Spinola (top) and front of head (bottom). Length 5.5 mm. Specimen is from Dyke Marsh Wildlife Preserve, Fairfax County, Virginia.

Peloniinae

**Chariessa pilosa* (Forster) – (4); LH, TR; 18 Apr–20 Jun; hp (1). Two specimens each have either all black elytra or pale-margined elytra.

**Cregya mixta* LeConte – (8); DM, GF, TR; 19 Jun–25 Aug.

**Cregya oculata* (Say) – (19); DM, GF, LH, TR; 14 Jun–9 Aug; hp (1; mature forest on bluff above river).

Orthopleurinae

**Neorthopleura thoracica* (Say) – (7); DM, GF, LH, TR; 19 May–26 Jul.

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Shorter Contributions

Banisteria, Number 51, pages 59-60

Three Checkered Beetles (Coleoptera, Cleridae) New to Virginia and Additional Records for *Phyllobaenus verticalis* (Say) and *Wolcottia pedalis* (LeConte)

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ABSTRACT

The checkered beetles (Coleoptera, Cleridae) *Isohydnocera curtipennis*, *Phyllobaenus pallipennis*, and *Phyllobaenus unifasciatus* are documented for the first time from Virginia. Additional Virginia records are provided for *Phyllobaenus verticalis* and *Wolcottia pedalis*, two species recently reported from the Commonwealth.

Keywords: *Isohydnocera curtipennis*, new state record, *Phyllobaenus pallipennis*, *Phyllobaenus unifasciatus.*

Examination of specimens of checkered beetles (Coleoptera, Cleridae) on loan from collections at the California Academy of Sciences (CASC; San Francisco, CA), Carnegie Museum of Natural History (CMNH; Pittsburgh, PA), Florida State Collection of Arthropods (FSCA; Gainesville, FL), United States National Museum of Natural History, Smithsonian Institution (NMNH; Washington, DC), and the Robert A. Androw Collection (RAAC; Gibsonia, PA) uncovered three species new to Virginia and additional records for two species recently documented from the Commonwealth. Additional specimens determined as *Phyllobaenus pallipennis* (Say) and *P. unifasciatus* (Say) were found in the entomological collections at the Virginia Museum of Natural History (VMNH; Martinsville, VA). No specimens of the species reported below were found in the collection at Virginia Tech (VTEC; Blacksburg, VA). State record determinations are based on reviews of Knull (1951), Downie & Arnett (1996), Hoffman et al. (2002), Leavengood (2008), and Burke et al. (2015).

VIRGINIA

Isohydnocera curtipennis (Newman) – Mecklenburg Co.: Kerr Dam, June 1974, D. Richman (NMNH, 1). Montgomery Co.: Radford environs, 5 June 1969, J. B. Karren (NMNH, 1). **NEW STATE RECORD.**

This species has been recorded from Ontario, Canada, south to Florida, and westward to Kansas, although there is some confusion as to whether past literature referred to *I. curtipennis* or a member of *Phyllobaenus* (Leavengood, 2008).

Phyllobaenus pallipennis (Say) – Augusta Co.: Mt. Elliott, 20 June 1934, H. A. Allard (NMNH, 1); George Washington National Forest, 5 miles (8 km) west of Stokesville, 1 October 1998, B. Flamm (VMNH, 5); same location and collector, 10 October 1998 (VMNH, 1), and 15 October 1998 (VMNH, 3). Bath Co.: Cowpasture River, Route 629 bridge, 18 August 1999, S. M. Roble (VMNH, 1); Warm Springs Mountain, Bald Knob, pine barren, 4200 ft (1280 m), Malaise trap, 20 August–1 September 1999, S. M. Roble, (VMNH, 1). Dickenson Co.: Breaks Interstate Park, 1–14 July 2000, R. Vigneault (VMNH, 1). Essex Co.: 1.5 km southeast of Dunnsville, 11 July 1991, D. R. Smith, (VMNH, 1). Fauquier Co.: Bull Run Mountain, 30 July 1998, Hobson, Chazal, & Fleming (VMNH, 1). Floyd Co.: Buffalo Mountain, 3500 ft (1067 m), 27 August 1994, VMNH Survey (VMNH, 1). Madison Co.: 10–20 miles (17–32.2 km) south of Rt. 211, Skyline Drive, beating *Quercus alba*, 27 July & 29 July 1951, G. H. Nelson (FSCA, 2). Prince William Co.: Prince William Forest Park, loop road, oak site, 17 March 1989, D. A. Young (VMNH, 1). City of Chesapeake: Northwest River Park, 5 miles (8 km) southeast of Hickory, 5–16 July 2004, R. Vigneault (VMNH, 1). City of Virginia Beach: First Landing State Park, 23 June-6 July 2003, R. Vigneault, (VMNH, 2), same site, dune woodland, 16 June 2007, S. M. Roble & B. M. Roble, (VMNH, 2). **NEW STATE RECORD.**

Phyllobaenus pallipennis has been recorded from Ontario, Canada, south to Florida, and west to Texas and Colorado (Leavengood, 2008).

Phyllobaenus unifasciatus (Say) – Augusta Co.: George Washington National Forest, 1 mile (1.6 km) northwest of Craigsville, Malaise trap, 23-29 June 1998, J. Strazanac (RAAC, 1). Bath Co.: Warm Springs Mountain, Bald Knob, pine barrens, 4200 ft (1280 m), Malaise trap, 20 August–1 September 1999, S. M. Roble (VMNH, 1). Dickenson Co.: Breaks Interstate Park, 20-25 May 2001, R. Vigneault & P. Harrison (VMNH, 1); same site, 1–14 July 2000, R. Vigneault (VMNH, 1). Fairfax Co.: on pine, 1930, A. Nicolay (CASC, 1). Louisa Co.: 4 miles (6.4 km) south of Cuckoo, Malaise trap, 6–13 June 1986, D. R. Smith (VMNH, 1). Wythe Co.: Sand Mountain, boggy stream, Malaise trap, 23 July–5 August 1998, Roble & Hobson (VMNH, 1); same site and collectors, UV light, 23 July 1998 (VMNH, 1). **NEW STATE RECORD.**

Phyllobaenus unifasciatus has been reported from Ontario, Canada, south to Florida, and west to Arizona and Colorado (Leavengood, 2008).

Phyllobaenus verticalis (Say) – The first Virginia report of this species was made by Steury & Leavengood (2018). Older Virginia records are: Fairfax Co.: Burke, 15 June 1989, R. D. Ward (CMNH, 1); Giles Co.: Mountain Lake area, 28 July 1968, H. Greenbaum (FSCA, 1); Prince William Co.: 16 May 1976, R. D. Ward (CMNH, 1); [City of Virginia Beach]: Munden, beating maple, 9 May 1952, G. H. Nelson (FSCA, 2).

This species has also been recorded from Ontario (Toronto), Canada, south to Florida, and west to Texas and South Dakota (Leavengood, 2008).

Wolcottia pedalis (LeConte) – The first Virginia record of this species was documented by Hoffman et al. (2002). Additional records are: Augusta Co.: George Washington National Forest, plot #2 site #1, 12 June 1995, Malaise trap, L. Butler & J. Strazanac (CMNH, 1); same collectors, plot #3, site #6, 28 June 1999, Malaise trap (CMNH, 1); same site and collectors, 5 July 1999, Malaise trap (CMNH, 1); George Washington National Forest, 1 mile (1.6 km) northwest of Craigsville, 1–7 July 1997, J. Strazanac (RAAC, 1).

This species has been documented from Wisconsin, south to Virginia, and west to Nebraska (Downie & Arnett, 1996).

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Specimen loans were facilitated by Chris Grinter and David H. Kavanaugh (CASC), Paul E. Skelley and Kyle Schnepp (FSCA), Bob Androw and Robert Davidson (CMNH, RAAC), and Natalia Vandenberg and David Furth (both retired, NMNH). Reviews of the collections at VMNH and VTEC were provided by Kal Ivanov (VMNH) and Paul Marek and Jackson Means (VTEC). Steven M. Roble, Virginia Department of Conservation and Recreation, Division of Natural Heritage, provided helpful comments on the draft manuscript.

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Miscellanea

Banisteria, Number 51, pages 61-72

Obituary

John R. Holsinger (1934-2018)

Dr. John Robert Holsinger, world renowned biospeleologist, cave conservationist, and amphipod crustacean systematist, died on November 10, 2018, at the age of 84 in Richmond, Virginia after a long illness. A longtime resident of Norfolk, Virginia, he was born on April 6, 1934, in Harrisonburg, Virginia, and grew up in the Shenandoah Valley. After graduating from Dayton High School in 1951, he attended Virginia Polytechnic Institute (Virginia Tech), where he served in the Corps of Cadets, was a member of the Hokie Cheerleading Squad, and was introduced to caving (in 1954) through the Virginia Tech cave club. He was a rabid fan of Hokie football for many years prior to his death. Following graduation (B.S., Biology) in 1955, John served in the US Army Security Agency in the Pacific Theater (Army Signal Corps in Hawaii), achieving the rank of Specialist 4th Class. After completion of his military service in 1958, John began what would become his lifelong passion for teaching others. He taught biological and earth sciences in the Fairfax County, Virginia public school system for the next five years (1958–1963) and pursued graduate studies at George Washington University and James Madison University (then Madison College), earning a Master of Science degree in biology from the latter institution in 1963.

Starting in late 1958 upon his return to Virginia from military duty, John became more seriously and permanently interested in caving and his biological sampling of caves during the next several years formed the basis for his Master's thesis research titled "Studies on the ecology and geographic distribution of macroscopic cavernicolous invertebrates of the central Appalachians." His thesis was the basis for the first (Holsinger, 1963) of his six papers published in the *Bulletin of the National Speleological Society* over the next three decades. In the fall of 1963, John began graduate studies at the University of Kentucky (UK) and earned a Ph.D. in evolutionary and systematic biology three years later. His dissertation, titled "Systematics, speciation, and distribution of the subterranean amphipod genus *Stygonectes* (Gammaridae)," was published in 1967 as *United States National Museum Bulletin* 259. Following graduation from UK, John was an assistant professor of biology at East Tennessee State University for two years. In 1968, he returned to his home state and joined the faculty of the Department of Biological Sciences at Old Dominion University (ODU) in Norfolk, where he remained for the rest of his career. John attained the rank of Full Professor a decade later and achieved the rare status of Eminent Scholar of Biological Sciences in August 1990.

John taught upper level undergraduate and graduate courses in invertebrate zoology, cave biology, biogeography, and systematics at ODU. His cave biology class included a weekend-long field trip to southwestern Virginia to visit several caves. Besides traditional students, several members of the Virginia Natural Heritage Program took this class because of John's reputation and his close association with the program. During his tenure at ODU, John directed the research of five Ph.D. and nine Master's degree students, co-chaired one Ph.D. student (Lynn Ferguson) at Virginia Tech, and also served on the committees of graduate students at several other institutions around the world. In 1995, John was one of the first recipients of a Partnerships for Enhancing Expertise in Taxonomy (PEET) grant from the National Science Foundation; these grants were established for the purpose of training a new generation of systematists. He also served one year (1972–1973) as a Visiting Curator at the U.S. National Museum of Natural History, Smithsonian Institution (NMNH). Upon his retirement from ODU at the end of 2008, John was named Eminent Scholar Emeritus and Professor Emeritus of Biological Sciences. In addition to his work at ODU, John was a research associate for several decades in the Department of Invertebrate Zoology at NMNH (appointed 1990) and the Virginia

Museum of Natural History (VMNH; appointed 1993). In 1992, he received the Thomas Jefferson Medal for outstanding contributions to the natural sciences in Virginia from VMNH, and also served on the museum's scientific advisory board beginning in 2006.

John was known both nationally and internationally for his lifetime work on the study and conservation of cave habitats and their faunas as well as the systematics and biogeography of freshwater amphipod crustaceans (see Culver [2018] for more details and a list of 135 of John's publications). John published numerous papers describing new species of amphipods, not only in the Appalachian region, but throughout North America, as well as other parts of the world. Especially during the latter half of his career, John frequently collaborated with colleagues in foreign countries to describe new species of amphipods. His publications also include significant summaries of the invertebrate cave faunas of Virginia (Holsinger & Culver, 1988; Holsinger et al. 2013), West Virginia (Holsinger et al. 1976), and several other states, as well as isopod systematics and ecology, cave conservation, and groundwater crustaceans (e.g., Edwards Plateau aquifer in Texas). He is also the author of "Descriptions of Virginia Caves" published in 1975 by the Virginia Division of Mineral Resources. John's scientific publications span more than 50 years (1963–2014; at least one more paper, containing descriptions of 22 new species of the subterranean amphipod genus *Stygobromus*, will be published posthumously). He also authored a semi-popular article on cave-dwelling organisms for *American Scientist* (Holsinger, 1988).

John was a pioneer in the exploration and documentation of the biological, geological, and historical significance of Virginia caves. He personally surveyed hundreds of caves in the Virginias, and many others elsewhere, and collected numerous biological specimens of all taxa from these habitats. John considered the discovery of new caves and extensive virgin passages in Lee, Scott, and Wise counties in southwestern Virginia during the 1960s and 1970s at or near the top of his most memorable caving experiences. Many of these early caving expeditions involved vertical caving techniques and were conducted with the late John Cooper (Figs. 1–2; retired from the North Carolina Museum of Natural Sciences); together they embarked on the "Biological Survey of Virginia Caves" project, which was affiliated with the National Speleological Society. John was director of the Virginia Cave Survey (since renamed Virginia Speleological Survey) from 1965 to 1974. Dr. Holsinger was also well versed in karst geology, and his biological sampling included groundwater organisms in non-karst habitats, especially *Stygobromus* amphipods (e.g., see Culver et al., 2012). In a paper presented at the 1993 International Congress of Speleology in Beijing, China, he reported that about two-thirds of the species of *Stygobromus* inhabit caves (mostly pools and streams) and the remaining one-third inhabit springs, seeps, hyporheic zones, and phreatic waters (Holsinger, 1993a). Consequently, John was a strong advocate for groundwater protection, as well as cave and karst systems. He served as co-organizer/co-chairman of an international symposium on groundwater biology that was held in Blacksburg in 1978, and co-edited the proceedings published in *Crustaceana* and *International Journal of Speleology* in 1980 and 1981, respectively.

Fig. 1. John Holsinger and John Cooper at the entrance to Showalter's Cave, Rockbridge County, Virginia on a collecting trip in May 1961 that marked the beginning of the "Biological Survey of Virginia Caves" project. Photographer unknown.

Fig. 2. Bill Davies, John Holsinger, and John Cooper at the Virginia Cave Board meeting held in May 1988 at the Virginia Museum of Natural History in Martinsville. Cooper is holding the latest issue of *American Scientist* containing Holsinger's paper on cave-dwelling organisms. Photo by Lynn Ferguson.

John knew many landowners in southwestern Virginia who had caves on their properties and had permitted him to explore them, often multiple times spanning decades. He could readily recall their names, locations, and what he found in each cave decades later. Beginning in 1961, John was a primary organizer of and regular participant in the more than half century-long "DOM" (Dirty Old Men) tradition of cave exploration trips that was held annually in southwestern Virginia (usually Lee County) over the Thanksgiving weekend. Numerous cavers convened to conduct biological monitoring and sampling as well as cave exploration and mapping activities in multiple caves. Among his fellow cavers, John was affectionately known as "Captain Karst" (see tribute by Culver et al., 2019).

John described more than 100 species and genera worldwide and established 4 new amphipod families. He coauthored the description of the West Virginia Spring Salamander (*Gyrinophilus subterraneus*), a single cave endemic (Besharse & Holsinger, 1977). With reference to the Virginia fauna, he described at least 40 species and one subspecies, including 37 amphipods, three isopods, and one freshwater snail (Table 1); among these, 26 species and one subspecies were amphipods of the genus *Stygobromus*, the taxonomic group of greatest interest and effort during his career. John had also provisionally recognized at least a dozen additional new species of *Stygobromus* from Virginia, but he did not prepare formal descriptions of them during his lifetime, primarily because he desired larger samples before the status of each could be properly evaluated. He described 21 new species of *Stygobromus* from states bordering Virginia, as well as dozens more from other parts of the United States, plus several species each from Canada and Siberia. In total, John described about 80 percent of the approximately 140 species of *Stygobromus* in the world.

John interacted with the leading taxonomists of his generation (most are now deceased) to obtain identifications of his cave invertebrate collections, including such prominent figures as Tom Barr (his Ph.D. mentor) and Stewart Peck (beetles), Willis Gertsch (spiders), Bill Muchmore (pseudoscorpions), Ken Christiansen (springtails), Lynn Ferguson (diplurans), Bill Shear (millipeds and harvestmen), Roman Kenk (flatworms), Leslie Hubricht and Bob Hershler (snails), Harrison Steeves and Tom Bowman (isopods), and Horton Hobbs (crayfish). He also maintained a close association spanning a half century with cave ecologist and evolutionary biologist Dave Culver (dates of their coauthored papers range from 1969–2013), and also retained close ties with isopod taxonomist Jerry Lewis, one of his former students, and Dan Fong (a Culver student), a cave ecologist and evolutionary biologist.

Dr. Holsinger was honored by various colleagues through the description of patronyms for cave invertebrates in at least the following taxonomic groups: snails, spiders, pseudoscorpions, millipeds, beetles, isopods, amphipods, and flatworms (Table 2; additional patronyms may be forthcoming). In describing a new genus (*Holsingeria*) of freshwater snails in John's honor, Hershler (1989) identified him as "a pioneering figure in North American cave biology." In an interesting twist, Barnard & Karaman (1982) moved 2 of 3 subterranean amphipods from Texas that John had assigned to his new genus *Texiweckelia* just two years earlier (Holsinger & Longley, 1980) into their own monotypic genera, including one (*Holsingerius*) named in his honor. A decade later, John described a second member of this genus (Holsinger, 1992).

John attended many national and international conferences, congresses, and symposia concerning biospeleology, cave conservation and management, groundwater protection, and systematics, and regularly made presentations at those meetings, including giving plenary lectures at two International Symposia of Biospeleology (Italy, 2002; India, 2004). John was an Honorary Life Member (1980) and Fellow (1968) of the National Speleological Society (NSS; joined in 1959), served as Chairman of the 1963 NSS Convention at Mountain Lake, Virginia, was on the NSS Board of Governors (1962–1971), and chaired the NSS research advisory committee (1970–1975). In 1995, he received the NSS Science Award for lifetime contributions to the science of speleology. In 2007, John was honored by a special symposium at the annual NSS convention in Indiana (Fig. 3), and in 2014, he was invited to give the luminary talk at the NSS convention in Alabama.

Fig. 3. John Holsinger, Bill Elliott, Gordon Smith (cave owner), and Jerry Lewis during a field trip to Marengo Cave, Indiana, held in conjunction with the 2007 annual convention of the National Speleological Society, at which Dr. Holsinger was honored for his lifetime contributions to cave biology and conservation. Photo by Lynn Ferguson.

Closer to home, John participated in the invertebrate portion of the 1968 symposium on Appalachian Biogeography held in Blacksburg and contributed a paper on amphipods to the proceedings (Holsinger, 1969). He also participated in the 1978 and 1989 symposia on threatened and endangered species of Virginia and contributed chapters containing species accounts on amphipods and isopods (also flatworms for the first symposium) to both proceedings volumes (Holsinger, 1979a-c, 1991b-c).

John was the longest serving member (30 years total [1978–1996, 2000–2012]) of the Virginia Cave Board (and its predecessor the Virginia Cave Commission), a governor-appointed citizen advisory board to the Virginia Department of Conservation and Recreation (and its predecessor agencies), and was its Chairman in 1982 and 1988–1994. In December 1976, he testified before the House Rules Committee of the Virginia General Assembly in support of a bill to create a Study Commission for Cave Protection in Virginia, which ultimately led to the creation of the Virginia Cave Commission. John developed the first list of "significant caves" for Virginia (Holsinger, 1980), one of the principal tasks of the Commission during its early years. The designation of "significant" was assigned to less than ten percent of the known caves in the state. A smaller subset of caves was designated as "very significant" (Fig. 4). Each cave was assessed for its potential significance based on the following criteria: archeological, biological, depth, economic, esthetic, geological, historical, hydrological, paleontological, length, and recreational. The initial list identified 220 caves and seven karst areas. John updated the list five years later (Holsinger, 1985), adding four more caves. The Significant Caves List continues to be updated periodically to the present day by the Virginia Speleological Survey based on new information obtained for previously known caves and the evaluation of newly discovered caves. Its main purposes are to identify the most important caves in the state and thus be more able to defend the need to protect them, specifically for the reasons defined by their significance criteria.

John was the leading early advocate for cave conservation in Virginia and the region, a cause to which he remained devoted throughout his career. He was a member of the Arthropod/Invertebrate Taxa Committee of the Virginia Department of Game and Inland Fisheries; in that role he provided advice to the agency concerning species worthy of conservation attention and state listing. John personally advocated for the federal listing (by the US Fish and Wildlife Service) of *Antrolana lira* (Madison cave isopod, listed as threatened in 1982) and *Lirceus usdagalun* (Lee County cave isopod; listed as endangered in 1992) because of threats to their habitats; the latter listing was controversial and John drew the ire of many local citizens as a result. He also recommended the Madison cave amphipod (*Stygobromus stegerorum*) and several cave beetles (*Pseudanophthalmus*) for state-listed status.

Fig. 4. John Holsinger examining biological samples in Madison Saltpetre Cave, Augusta County, Virginia, type locality of the Madison Cave Isopod (*Antrolana lira* Bowman, federally threatened) and the Madison Cave Amphipod (*Stygobromus stegerorum* Holsinger, state threatened). Dr. Holsinger and his students conducted several detailed studies of both species in this cave, which is considered one of the most significant caves in Virginia. Photo (1992) by Dave Hubbard.

Beginning about 1970, and continuing for the rest of his career, John served as a consultant (often gratis) to many federal and state agencies and non-profit conservation organizations on matters related to cave, karst, and groundwater protection and threatened and endangered species biology and conservation. These agencies and groups included the US Fish and Wildlife Service, US Forest Service, US National Park Service, US National Marine Fisheries Service, US Natural Resources Conservation Service, Virginia Department of Transportation, Virginia Division of Mineral Resources, Virginia State Parks, the Natural Heritage Programs for Virginia, Maryland, Tennessee, Tennessee Valley Authority, Pennsylvania, California, Kansas, Michigan, Missouri, and Texas, The Nature Conservancy (multiple state chapters), World Wildlife Fund, and the Illinois Natural History Survey. He also consulted with media outlets such as National Geographic TV, Smithsonian World, Smithsonian Magazine, Time-Life Books, National Public Radio, and various newspapers on cave and endangered species-related issues. Among his many awards, John received the 2002 Karst Waters Institute Award in recognition of outstanding contributions to karst science.

John worked closely with the Virginia chapter of The Nature Conservancy to protect and ultimately purchase Unthanks Cave (now a dedicated state natural area

preserve), which he surveyed and studied periodically for 30 years (1961–1991), and other important karst habitats in Lee County in far southwestern Virginia. He also worked with the West Virginia chapter of The Nature Conservancy to purchase and permanently protect General Davis Cave in Greenbrier County, West Virginia. Beginning with its establishment as a state agency in 1986, John worked closely with the Virginia Department of Conservation and Recreation, Division of Natural Heritage (DCR-DNH), on cave conservation and groundwater protection issues, and is at least partly responsible for the current existence of a Karst Protection Program within that agency. In recent decades, DCR-DNH has purchased several additional caves in western Virginia that harbor rare species. The agency has also greatly expanded its holdings in "The Cedars" area of Lee County, the most significant karst landscape in Virginia. All of these properties are now protected as state natural area preserves.

A longtime supporter of the Virginia Natural History Society, John was a charter member (joined in its inaugural year, 1992) and published two papers that comprised a special cave issue of *Banisteria* (Holsinger, 2013; Holsinger et al., 2013). Besides those papers, I had the pleasure of editing John's contribution to Richard Hoffman's Festschrift volume (Holsinger, 2009) and served as guest editor of his coauthored paper on groundwater invertebrates that comprised an issue of *Northeastern Naturalist Monographs* (Culver et al., 2012). John also maintained longtime memberships in numerous other societies, including the National Speleological Society, International Society of Biospeleology, American Association for the Advancement of Science, Sigma Xi, Biological Society of Washington, Crustacean Society, Society for the Study of Evolution, Society of Systematic Biology, Willi Hennig Society, Association of Systematic Collections, American Association for Zoological Nomenclature, Cave Conservancy of the Virginias, and the American Cave Conservation Association. He served on the editorial boards of several of these societies.

In 2017, the Cave Conservancy of the Virginias and the Cave Conservancy Foundation provided funding to DCR-DNH to inventory Dr. Holsinger's research collection of freshwater amphipods and other crustaceans in preparation for its subsequent permanent donation to the Smithsonian (NMNH). John's collection was among the largest such collections in the world, but his failing health prevented him from completing this task himself. Less than a week after John's death, his entire specimen collection was transferred to NMNH, where it will be an invaluable resource to current and future researchers of freshwater amphipod systematics. A portion of Dr. Holsinger's research library now resides at DCR-DNH, with the remainder currently in the custody of the Virginia Speleological Survey.

With the passing of John Holsinger, Virginia and the world has lost an irreplaceable giant in the fields of biospeleology, systematics, conservation, and natural history. He was buried in Harrisonburg, Virginia with military honors and is survived by his wife of 33 years, Linda Bogan Holsinger (a fellow caver) of Norfolk, stepchildren Charmaine Villa-Lobos, Robert Villalobos, Rebecca Villa-Lobos Davatelis, Danielle Villa-Lobos Hicks, and nine stepgrandchildren, and extended family of niece Kathy Hilbert, nephew J. Steven Hilbert, and great nephew Hunter Hilbert of Rockingham County, Virginia. He was preceded in death by his sister and brother-in-law Mary Ann and John Hilbert and nephew Gary Hilbert.

In 2018, DCR-DNH established a special fund to honor Dr. Holsinger's contributions to cave conservation and research. All donations will be directed to the study, documentation, and protection of underground biodiversity. Persons wishing to contribute should make checks payable to the "Virginia Natural Area Preservation Fund" with "Holsinger Cave Conservation Fund" in the memo line and mail their donation to: Virginia Department of Conservation and Recreation, Division of Natural Heritage, 600 East Main Street, Richmond, VA 23219 (for questions call 804-786-7951).

I thank Lynn M. Ferguson for providing photos and information pertaining to the remarkable life and career of John R. Holsinger.

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Table 1. Virginia species described by John R. Holsinger and coauthors, with original citation and known states of occurrence.

Snails

Fontigens morrisoni Hershler, Holsinger and Hubricht, 1990 VA
Hershler, R., J. R. Holsinger, & L. Hubricht. 1990. A revision of the North American freshwater snail genus *Fontigens* (Prosobranchia: Hydrobiidae). Smithsonian Contributions to Zoology 509: 1–50.

Isopods

Caecidotea phreatica Lewis and Holsinger, 1985 VA
Lewis, J. J., & J. R. Holsinger. 1985. *Caecidotea phreatica*, a new phreatobitic isopod crustacean (Asellidae) from southeastern Virginia. Proceedings of the Biological Society of Washington 98: 1004–1011.

Lirceus culveri Estes and Holsinger, 1976 VA
Estes, J. A., & J. R. Holsinger. 1976. A second troglobitic species of the genus *Lirceus* (Isopoda, Asellidae) from southwestern Virginia. Proceedings of the Biological Society of Washington 89: 481–490.

Lirceus usdagalun Holsinger and Bowman, 1973 VA
Holsinger, J. R., & T. E. Bowman. 1973. A new troglobitic isopod of the genus *Lirceus* (Asellidae) from southwestern Virginia, with notes on the ecology and additional cave records for the genus in the Appalachians. International Journal of Speleology 5: 261–271.

Amphipods

Bactrurus angulus Koenemann and Holsinger, 2001 TN, VA
Koenemann, S., & J. R. Holsinger. 2001. Systematics of the North American subterranean amphipod genus *Bactrurus* (Crangonyctidae). Beaufortia (Bulletin Zoological Museum, University of Amsterdam) 51(1): 1–56.

Crangonyx acicularis Zhang and Holsinger, 2003	TN, VA
Crangonyx baculispina Zhang and Holsinger, 2003	VA
Crangonyx disjunctus Zhang and Holsinger, 2003	NC, VA
Crangonyx fontinalis Zhang and Holsinger, 2003	VA
Crangonyx longicarpus Zhang and Holsinger, 2003	NC, VA
Crangonyx montanus Zhang and Holsinger, 2003	VA, WV
Crangonyx orientalis Zhang and Holsinger, 2003	MD, NC, VA
Crangonyx palustris Zhang and Holsinger, 2003	MD, NC, NJ, VA
Crangonyx stagnicolous Zhang and Holsinger, 2003	MD, VA

Zhang, J., & J. R. Holsinger. 2003. Systematics of the freshwater amphipod genus *Crangonyx* (Crangonyctidae) in North America. Virginia Museum of Natural History Memoir 6. 274 pp.

Stygobromus conradi (Holsinger, 1967)	VA
Stygobromus gracilipes (Holsinger, 1967)	MD, PA, VA, WV
Stygobromus indentatus (Holsinger, 1967)	MD, NC, VA
Stygobromus morrisoni (Holsinger, 1967)	VA, WV
Stygobromus mundus (Holsinger, 1967)	VA
Stygobromus tenuis potomacus (Holsinger, 1967)	DC, MD, PA, VA, WV

Holsinger, J.R. 1967. Systematics, speciation, and distribution of the subterranean amphipod genus *Stygonectes* (Gammaridae). Bulletin of the United States National Museum 259: 1–176.

Stygobromus araeus (Holsinger, 1969)	NC, VA
Stygobromus ephemerus (Holsinger, 1969)	VA

Holsinger, J. R. 1969. The systematics of the subterranean amphipod genus *Apocrangonyx* (Gammaridae), with remarks on geography and zoogeography. American Midland Naturalist 81: 1–28.

Table 1 (continued).

Stygobromus abditus Holsinger, 1978	VA
Stygobromus baroodyi Holsinger, 1978	VA
Stygobromus biggersi Holsinger, 1978	MD, PA, VA, WV
Stygobromus cumberlandus Holsinger, 1978	VA
Stygobromus estesi Holsinger, 1978	VA
Stygobromus fergusoni Holsinger, 1978	VA
Stygobromus finleyi Holsinger, 1978	TN, VA
Stygobromus hoffmani Holsinger, 1978	VA
Stygobromus interitus Holsinger, 1978	VA
Stygobromus kenki Holsinger, 1978	DC, MD, VA
Stygobromus leensis Holsinger, 1978	VA
Stygobromus obrutus Holsinger, 1978	VA
Stygobromus phreaticus Holsinger, 1978	VA
Stygobromus pseudospinosus Holsinger, 1978	VA
Stygobromus stegerorum Holsinger, 1978	VA

Holsinger, J. R. 1978. Systematics of the subterranean amphipod genus *Stygobromus* (Crangonyctidae). Part II: Species of the eastern United States. Smithsonian Contributions to Zoology 266: 1–144.

Stygobromus hubbardi Holsinger, 2009	VA
Stygobromus mausi Holsinger, 2009	VA
Stygobromus sextarius Holsinger, 2009	DC, MD, VA

Holsinger, J. R. 2009. Three new species of the subterranean amphipod genus *Stygobromus* (Crangonyctidae) from the District of Columbia, Maryland, and Virginia. Pp. 261–276 *In* S. M. Roble & J. C. Mitchell (eds.), A Lifetime of Contributions to Myriapodology and the Natural History of Virginia: A Festschrift in Honor of Richard L. Hoffman's 80th Birthday. Virginia Museum of Natural History Special Publication No. 16, Martinsville, VA.

Stygobromus foliatus Holsinger, 2011	MD, VA

Holsinger, J. R., L. M. Ansell, & J. Shafer. 2011. Four new species of the subterranean amphipod genus *Stygobromus* (Amphipoda: Crangonyctidae) from shallow groundwater habitats on the Coastal Plain and eastern margin of the Piedmont in Maryland and Virginia, USA. Zootaxa 2972: 1–21.

Other taxa of note from nearby states

Gyrinophilus subterraneus Besharse and Holsinger, 1977 WV West Virginia Spring Salamander
Besharse, J. C., & J. R. Holsinger. 1977. *Gyrinophilus subterraneus*, a new troglobitic salamander from southern West Virginia. Copeia 1977: 624–634.

Caecidotea franzi (Holsinger and Steeves, 1971) KY, MD, PA, WV Cave isopod
(Described as *Asellus franzi* Holsinger and Steeves, 1971)
Holsinger, J. R., & H. R. Steeves, III. 1971. A new species of subterranean isopod crustacean (Asellidae) from the central Appalachians, with remarks on the distribution of other isopods of the region. Proceedings of the Biological Society of Washington 84: 189–200.

Caecidotea scypha (Steeves and Holsinger, 1968) TN, WV Cave isopod
(Described as *Asellus scyphus* Steeves and Holsinger, 1968)
Steeves, H. R., III, & J. R. Holsinger. 1968. Biology of three new troglobitic asellids from Tennessee. American Midland Naturalist 80: 75–83.

Gammarus cohabitus Holsinger and Shafer, 2008 PA Amphipod
Holsinger, J. R., J. Shafer, D. W. Fong, & D. C. Culver. 2008. *Gammarus cohabitus*, a new species of subterranean amphipod crustacean (Gammaridae) from groundwater habitats in central Pennsylvania, USA. Subterranean Biology 6: 31–41.

Table 2. North American genera and species described in honor of John R. Holsinger.

Genus patronyms

Holsingerius Barnard and Karaman. 1982 TX Genus of subterranean amphipods (Family Hadziidae)
Contains 2 described species: *Holsingerius samacos* (Holsinger, 1980) and *H. smaragdinus* Holsinger, 1992
Barnard, J. L., & G. S. Karaman. 1982. Classificatory revisions in gammaridean Amphipoda (Crustacea), Part 2. Proceedings of the Biological Society of Washington 95: 167–187.

Holsingeria Hershler, 1989 VA Monotypic genus of aquatic cave snail (Family Hybrobiidae)
Hershler, R. 1989. *Holsingeria unthanksensis*, a new genus and species of aquatic cavesnail from eastern North America. Malacological Review 22: 93–100.

Species patronyms

Sphalloplana holsingeri Kenk, 1977 VA Groundwater planarian
Kenk, R. 1977. Freshwater triclads (Turbellaria) of North America, IX: The genus *Sphalloplana*. Smithsonian Contributions to Zoology, Number 246. Smithsonian Institution Press, Washington, DC. 38 pp.

Fontigens holsingeri Hubrichti 1976 WV Aquatic snail
(now regarded as a junior synonym of *Fontigens tartarea* Hubricht, 1963)
Hubricht, L. 1976. The genus *Fontigens* from Appalachian caves (Hydrobiidae: Mesogastropoda). The Nautilus 90: 86–88.

Caecidotea holsingeri (Steeves, 1963) MD, VA, WV Cave isopod
(Described as *Asellus holsingeri* Steeves, 1963)
Steeves, H. R., III. 1963. Two new troglobitic asellids from West Virginia. American Midland Naturalist 70: 462–465.

Stygobromus holsingeri Ward, 1977 CO Amphipod
Ward, J. V. 1977. First records of subterranean amphipods from Colorado with descriptions of three new species of *Stygobromus* (Crangonyctidae). Transactions of the American Microscopical Society 96: 452–466.

Apochthonius holsingeri Muchmore, 1967 VA Cave pseudoscorpion
Muchmore, W. B. 1967. New cave pseudoscorpions of the genus *Apochthonius* (Arachnida: Chelonethida). Ohio Journal of Science 67: 89–95.

Hesperochernes holsingeri Muchmore, 1964 IN Cave pseudoscorpion
Muchmore, W. B. 1994. Some pseudoscorpions (Arachnica: Pseudoscorpionida) from caves in Ohio and Indiana, U.S.A. Transactions of the American Microscopical Society 113: 316–324.

Mundochthonius holsingeri Benedict and Malcolm, 1974 VA Cave pseudoscorpion
Benedict, E. M., & D. R. Malcolm. 1974. A new cavernicolous species of *Mundochthonius* from the eastern United States (Pseudoscorpionida: Chthoniidae). Journal of Arachnology 2: 1–4.

Cicurina holsingeri Gertsch, 1992 TX Cave spider
Gertsch, W. J. 1992. Distribution patterns and speciation in North American cave spiders with a list of the troglobites and revision of the cicurinas of the subgenus *Cicurella*. Texas Memorial Museum, Speleological Monograph 3: 75–122.

Nesticus holsingeri Gertsch, 1984 VA Cave spider
Gertsch, W. J. 1984. The spider family Nesticidae (Araneae) in North America, Central America, and the West Indies. Texas Memorial Museum Bulletin 31: 1–91.

Pseudotremia johnholsingeri Shear 2011 VA Cave milliped
Shear, W. A. 2011. Cave millipeds of the United States. X. New species and records of the genus *Pseudotremia* Cope. 2. Species from Virginia, USA (Diplopoda, Chordeumatida, Cleidogonidae). Zootaxa 3109: 1–38.

Pseudanophthalmus holsingeri Barr, 1965 VA Cave beetle
Barr, T. C., Jr. 1965. The *Pseudanophthalmus* of the Appalachian Valley (Coleoptera: Carabidae). American Midland Naturalist 73: 41–72.

Publications of John R. Holsinger relevant to Virginia and nearby states, plus selected other papers

(* = Not included in Holsinger bibliography compiled by Culver [2018]).

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Steeves, H. R., III, & J. R. Holsinger. 1968. Biology of three new species of troglobitic asellids from Tennessee. American Midland Naturalist 76: 100–124.

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Culver, D. C., & J. R. Holsinger. 1969. Preliminary observation on sex ratios in the subterranean amphipod genus *Stygonectes* (Gammaridae). American Midland Naturalist 82: 631–633.

Holsinger, J. R., & D. C. Culver. 1970. Morphological variation in *Gammarus minus* Say (Amphipoda, Gammaridae) with emphasis on subterranean forms. Postilla 146: 1–24.

Holsinger, J. R., & S. B. Peck. 1971. The invertebrate cave fauna of Georgia. Bulletin of the National Speleological Society 33: 23–44.

Barr, T. C., Jr., & J. R. Holsinger. 1971. Biogeography of troglobites. Bulletin of the National Speleological Society 33: 115–118.

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Holsinger, J. R. 1972. The freshwater amphipod crustaceans (Gammaridae) of North America. Biota of Freshwater Ecosystems, Identification Manual 5. U.S. Environmental Protection Agency, Washington, DC. 89 pp.

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Holsinger, J. R., R. A. Baroody, & D. C. Culver. 1976. The invertebrate cave fauna of West Virginia. West Virginia Speleological Survey Bulletin 7: 1–82.

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Holsinger, J. R., & L. Ansell. 2014. A new species of the subterranean amphipod genus *Stygobromus* (Amphipoda: Crangonyctidae) from two caves and a seep in western Maryland, USA with additional records of undescribed species from groundwater habitats in central Maryland. Zootaxa 3768: 386–394.

Unpublished reports

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*Holsinger, J. R. 1985. Annotated list of significant caves and karst areas in Virginia. Unpublished report for the Virginia Cave Board. 251 pp.

Banisteria, Number 51, pages 73-75

Obituary

Rowland M. Shelley (1942-2018)

Rowland M. Shelley, with specimen of *Scolopendra gigantea* Linnaeus, 1758.

Dr. Rowland M. Shelley, former Curator of Invertebrates at the North Carolina Museum of Natural Sciences and internationally renowned authority on millipedes (Class Diplopoda) died on November 11, 2018, in Raleigh, North Carolina. The cause of his death was pneumonia, following surgery for a knee replacement. Survivors include his wife of 38 years Lourdes O. Shelley, son Stephen (Theresa), stepson Demian Hardister (Lisa), three grandchildren, and a sister.

Dr. Shelley was born in Raleigh on September 9, 1942, and was a graduate of Broughton High School (1960), The University of North Carolina (BS, 1964), and North Carolina State University (PhD in physiology, 1970). He was employed by the North Carolina Museum of Natural Sciences for 44 years, until his retirement in 2015. In March 2013, the museum hosted a symposium in his honor on non-insect terrestrial invertebrates in the southeastern United States. Even after retiring, Dr. Shelley continued to work from a home laboratory and to publish significant scientific papers. He was a research associate in the Department of Entomology at the University of Tennessee, the Virginia Museum of Natural History, and the Florida State Collection of Arthropods, and an Adjunct Associate Professor of Zoology at North Carolina State University.

Dr. Shelley published more than 300 papers (some forthcoming posthumously) on the systematics and biogeography of millipedes, centipedes, scorpions, and several other taxa. His early field work in North Carolina included surveys for freshwater mussels. His research was supported by the National Science Foundation, the National Geographic Society, and the Smithsonian Institution, among others. Among his important achievements were a monograph on the scolopendromorph centipedes of North America, a revision and biogeographical treatise on the xystodesmid millipede genus *Sigmoria*, and a world-wide survey (with colleague Sergei Golovatch) of the distribution of millipede orders. A few months prior to his death, he published a revised classification of the important millipede family Xystodesmidae that included numerous innovations. He was a diligent and dedicated field worker and travelled over much of the North American continent in search of materials for his research, as well as visiting virtually every museum in the United States and Canada with a significant millipede collection; in many cases he reorganized the collections he found.

Dr. Shelley was the author of one millipede family (Hoffmanobolidae Shelley, 2001), two subfamilies, 11 tribes and subtribes, 38 genera, and 210 species. The millipede genus *Shelleyomorpha* Golovatch, 1997 was named for him, as were four millipede species, one opilionid, and one nematode. Among the species Dr. Shelley described is *Sigmoria whiteheadi*, one of only two millipedes with protected status in Virginia (listed as state threatened by the Virginia Department of Game and Inland Fisheries). He also maintained a website on myriapods (http://www.nadiplochilo.com/; also available at https://ag.tennessee.edu/EPP/Pages/Nadiplochilo/Nadiplochilo.aspx).

On a personal level, Dr. Shelley and his wife Lourdes enjoyed travel, particularly if it involved trains. Their international travel encompassed 50 countries and included attendance at numerous international myriapod

Lourdes and Rowland Shelley at Iguazú Falls (Argentina-Brazil border).

congresses. He had become an avid golfer in recent years.

Dr. Shelley's connections with Virginia were strong, and he regarded the late Richard L. Hoffman, formerly Curator of Recent Invertebrates at the Virginia Museum of Natural History, as his mentor. His works on millipedes often involved specimens from Virginia. Below is a short list of some of his publications with relevance to Virginia.

Shelley, R. M. 1976. Millipeds of the *Sigmoria latior* complex (Polydesmida: Xystodesmidae). Proceedings of the Biological Society of Washington 89: 17–38.

Shelley, R. M. 1979. A synopsis of the milliped genus *Cambala*, with a description of *C. minor* Bollman (Spirostreptida: Cambalidae). Proceedings of the Biological Society of Washington 92: 551–571.

Shelley, R. M. 1979. The status of *Sigmoria gracilipes* Chamberlin, with remarks on the milliped genus *Brachoria* (Polydesmida: Xystodesmidae). Florida Entomologist 62: 220–223.

Shelley, R. M. 1980. Revision of the milliped genus *Pleuroloma* (Polydesmida: Xystodesmidae). Canadian Journal of Zoology 58: 129–168.

Shelley, R. M. 1981. Revision of the milliped genus *Sigmoria* (Polydesmida: Xystodesmidae). Memoirs of the American Entomological Society No. 33. 141 pp.

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Reports

1. Minutes from the Virginia Natural History Society Executive Committee Meeting, December 1, 2018, University of Lynchburg, Schewel Hall, room 229

In attendance: Nancy Moncrief, Steve Roble, Ralph Eckerlin, Chris Milensky, Kal Ivanov, Karen Powers, Paul Marek, Michael Lachance

Absent: Al Gardner, Rachel Goodman, Todd Fredericksen

The meeting was called to order by Vice President Moncrief at 12:06 PM.

Topics:

Membership Report (Nancy Moncrief): Nancy received the membership list from Rachel. Nancy expressed uncertainty whether to delete names of members who don't renew. She hasn't sent reminder notices to those who haven't renewed. Steve Roble: stated that there are currently 68 members and 14 institutions in the membership. Nancy: discussed renewal notices and questioned if an online method would be efficient and easier. Nancy and Steve: discussed the issue of *Banisteria* synchrony with membership renewal; specifically, the question arose whether members who renew after the year's issue of *Banisteria* is shipped to members will receive the entire year including all issues, or just those issues remaining since their renewal date. Nancy: will send an email reminder to all members reminding them to renew. Nancy made a comment that the roll-over to VMNH Foundation from Hampden-Sydney should be a phased transfer and might be best to occur in more than one payment since members might renew with the old HSC address. Steve: made a comment that free student membership offer should be readvertised.

Treasurer Report (Nancy): The statement as of 31 July 2018 shows that the account has a balance of $17,830. Steve: The statement as of 1 November 2018 shows that the account has a balance of $17,945. Steve: Membership has decreased over time from a high of ca. 165, and is now at ca. 80 people. Steve: A couple of libraries that typically renew each year, Duke University and Christopher Newport University, have not renewed this year (but they may be accessing *Banisteria* via a subscription to EBSCO).

Newsletter and Webmaster Report (Marek): Marek: requests short bios for new Executive Committee

Members to include in the newsletter including Dr. Karen Powers and newly elected councilors (pending the results of the upcoming election). These bios were given to Paul in paper form by Roble during the meeting. Marek: will highlight the member meeting that took place at VMNH and include photos on the VNHS website. Ivanov: mentioned that he will send Marek some photos that he took during the meeting. Marek: provided the Executive Committee the results of an online poll to members asking to rank their interests in society activities. Out of 19 participants, 4 chose "bioblitz", 4 chose "field trip", 3 chose "workshop", 4 chose "picnic", 1 chose "camping", and 3 chose "conference (posters, talks)". Powers: commented that a taxidermy or specimen preparation (pinning, spreading, etc.) workshop would be an option. Other comments for Society activities included mini-grants (Marek's recommendation) and contributions to the International Code of Zoological Nomenclature (Eckerlin's recommendation). Marek: stated that he will add the following to VNHS website: history of the Society (Roble will provide), password protected storehouse for Society documents.

Nomination of Officers: Secretary-Treasurer Rachel Goodman's term expires in December 2020, but she has asked to have it expire once the by-laws have been updated, thereby splitting the Secretary-Treasurer positions into two. Marek is currently serving as Secretary-Webmaster, and Treasurer duties have been planned to be transitioned to the VMNH. A motion was proposed and Nancy Moncrief and Kal Ivanov were nominated as co-Treasurers. Six members voted in favor, 0 voted against, and 0 abstained.

Editor Report (Roble): *Banisteria* #50 was submitted to the printer on November 12 and will be mailed in early December. *Banisteria* #51 is to be published in February 2019. *Banisteria* #52 will be the last issue for Roble (target publication date June 2019). Todd Fredericksen will take over as editor for *Banisteria* #53. Steve Roble will train and assist Fredericksen in the transition.

New business:

Transition of Editor duties from Roble to Fredericksen (Roble): Roble: has assisted Biodiversity Heritage Library with serving *Banisteria* through their website as a free resource available to all. Much of the journal is now available through BHL, and the new editor will continue to send new issues to be posted at their website. After *Banisteria* #52, the journal distribution will be transferred to VMNH.

Review of Memorandum of Understanding between VNHS and VMNH Foundation. The VMNH auditors wanted to make sure that the VNHS paid some random state fee. VMNH Foundation will be paid $250 per year for financial services. The MOU between VNHS and VMNH Foundation will be a 3-year agreement, which can be renewed. A motion was proposed to approve the MOU between VNHS and VMNH. Eight members voted in favor of the MOU between VNHS and VMNH, 0 voted against, 0 abstained.

Revision of the VNHS bylaws: A motion was proposed to split the Secretary-Treasurer duties, and allow for concurrent councilor terms. Marek will edit the VNHS Bylaws, so that the Secretary is a separate office from the Treasurer. Marek will send edited Bylaws with these Minutes to the Executive Committee for review.

Web hosting service and VNHS domain name service. The web hosting and domain name service is paid until 2019. It was proposed that for the next year, the VNHS web hosting and VNHS domain name service be paid directly by the VNHS Treasury. Ivanov and Moncrief responded that it would be possible to pay this fee directly through the VMNH-VNHS MOU. Marek: will explore possibilities to host the VNHS website through Virginia Tech's hosting service, with the caveat of making sure the university would not cut the service without notification (as had happened in the past).

Online repository of all the digital files including membership list will be placed on VNHS or Google Drive/Docs/Spreadsheets. Moncrief: stated that the VMNH rules prevent sharing these documents through their Google Documents service. Powers: mentioned that she would look into Radford University's Google Documents as a place to store and share these documents.

Online payment of dues: Moncrief mentioned that this can occur in the same way as the VNHS Member Meeting payment through the VMNH store.

Electronic only format of *Banisteria*: Marek proposed a motion to make *Banisteria* #53 electronic-only, which was seconded by Powers. Discussion ensued regarding logistical issues of retaining paper copies of *Banisteria*. Paper copies must be printed and mailed and entails additional steps which would be obviated by electronic-only *Banisteria*. The printing and mailing process is currently managed by Roble and Goodman, respectively, and will be transferred to Fredericksen who expressed concern about logistical issues with mailing issues of *Banisteria*. There was general agreement that paper

copies were nice, but perhaps not worth the logistical challenges (e.g., stuffing envelopes). Marek: commented that electronic-only publication of *Banisteria*, which could include rolling publication of articles, would make submission of manuscripts even more appealing because of visibility, rapid publication, and higher probability of citations. Marek amended the motion to make *Banisteria*, starting with #53, electronic-only with the option to receive a paper copy. Five members voted in favor of the electronic-only format, 2 voted against, and one abstained.

Date and location of 2019 VNHS Conference: Moncrief mentioned that it could occur again at VMNH. Marek: will announce in the newsletter that another symposium is planned for the Fall 2019 and the exact date is TBD. Roble and Powers recommended paying all student presenters an honorarium for presenting a paper, and waive the cost of registration.

Location and date of next Executive Committee Meeting: Moncrief stated that the next meeting of the Executive Committee Meeting might occur southwest of Lynchburg and would be optimal if it was held at Ferrum or VMNH. The first Saturday in December still seems to be a good date with the present members of the Executive Committee.

The meeting was adjourned at 3:40 PM.

Respectfully submitted,
Paul E. Marek, Secretary and Webmaster

2. Editor's Report

I apologize for the tardiness of this issue, which is half a year late. I am actively working on the first issue (#52) of *Banisteria* for 2019, which will be my 38th and final issue as journal editor. Todd Fredericksen, a past president of VNHS, has graciously agreed to serve as the next editor. Effective immediately, please send your submissions (preferably as email attachments) for publication in *Banisteria* to him at the following address:

Todd Fredericksen
Ferrum College
212 Garber Hall
Ferrum, VA 24088
tfredericksen@ferrum.edu

Respectfully submitted,
Steve Roble
Editor, *Banisteria*

Announcements

1. Dues renewal notice

A 2019 membership renewal form is enclosed with this issue of *Banisteria*. Please renew your membership promptly by returning the form and a check to Co-Treasurer Dr. Nancy Moncrief of the Virginia Museum of Natural History (VMNH). Alternatively, a new payment option for VNHS dues has been established on the VMNH online store at this address:

www.vmnh.store/store/p22/virginia-natural-history-society-membership

You can also access the payment page via a link from the Membership page on the VNHS website: http://virginianaturalhistorysociety.com/

If you desire a printed (vs. electronic format) copy of *Banisteria* #53 (second issue for 2019), you must check the appropriate box on the renewal form. All members will receive a printed copy of *Banisteria* #52 (first issue for 2019). Beginning in 2020 with *Banisteria* #54, the journal will only be distributed in electronic format.

All members are encouraged to attempt to recruit at least one new member to our society. Faculty members may nominate up to 3 students for a free one-year membership in the society following the guidelines presented in the **Student Membership Incentive** on the following page.

2. Election results for 2019

Kal Ivanov, who had served as a councilor for the past two years, was elected Vice President, and Art Evans and Curt Harden were elected to 4-year terms as councilors. We thank Chris Milensky for his service as a councilor during the past 4 years and Al Gardner for serving as President during 2017-18.

3. Virginia Natural History Society members meeting on November 2, 2019

The second general meeting of the Virginia Natural History Society will be held on Saturday, November 2, 2019 at the Virginia Museum of Natural History in Martinsville. Like last year, Nancy Moncrief and Kal Ivanov are the co-organizers and co-hosts. This one-day event is open to everyone, so please "save the date," spread the word, and plan to join us.

More details will be provided in the next issue of *Banisteria*, on the VNHS website, and via an email message to current members of the society.

4. News of members – Alfred L. Gardner, Ph.D., former Vice President and President of the Virginia Natural History Society, retires after over 45 years as Curator of North American Mammals in the Division of Mammals, National Museum of Natural History, Smithsonian Institution.

Effective October 4, 2018, Dr. Gardner retired from the US Geological Survey, Patuxent Wildlife Research Center's Biological Survey Unit (BSU) stationed at the National Museum of Natural History (USNM). In 1973, following a brief career as a University assistant professor, first at his Ph.D. Alma Mater Louisiana State University, Baton Rouge, and then at Tulane University, New Orleans, Gardner joined the US Fish and Wildlife Service (USFWS) Bird and Mammal Laboratory, stationed in the USNM. The impetus for retirement was the decision by the USGS–PWRC to close the Biological Survey Unit and discontinue research on the systematics and nomenclature of non-fish vertebrates as well as primary curatorial responsibility for North American mammals, birds, reptiles, and amphibians in the USNM. These collections consist primarily of voucher specimens amassed by the Biological Survey during its inventory of the North American fauna in the late 19th and early 20th Century. The Biological Survey Unit was the oldest affiliated agency stationed in the USNM and dated from 1889. The BSU, whose name has changed several times, began as the Section on Geographical Distribution of Species, one of three primary functions of the organization headed by C. Hart Merriam that became the US Bureau of Biological Survey, which in 1940, became the US Fish and Wildlife Service. Research personnel were reassigned from the USFWS to the US National Biological Service in 1993, and in 1996, again reassigned to the US Geological Survey.

Gardner's research includes taxonomy, morphology, genetics, distribution, food habits, life history, and nomenclature of mammals of the Western Hemisphere. His research, based on a synthesis of fieldwork and the study of specimens in museum collections combined with published information, particularly the earlier literature from the late 18th through early 20th centuries, has resulted in over 160 publications. Gardner has received several awards during his career: Western Foundation of Vertebrate Zoology, elected Patron, 1968; Sociedad Mexicana de Historia Natural, elected Numerario, 1968; National Museum of Natural History, Research Associate, 1974 to present; US Fish and Wildlife Service, Special Achievement Award, 1977, 1980, 1985, 1987, and 1991; Denver Wildlife Research Center Award for Outstanding Publication, 1982 and 1987; American Association for the Advancement of Science, elected Fellow, 1991; National Biological Service, Special Achievement Award, 1994; American Society of Mammalogists Jackson Award, 2006; USGS-PWRC Special Achievement Award, 2009 and 2016; American Society of Mammalogists, Honorary Member, 2010; U.S. Department of the Interior Distinguished Service Award, 2014; Asociación Mexicana de Mastozoología, Ticul Álvarez-Solorzano Award, 2018.

He has also received several patronymic honors (one genus, seven species, and one subspecies): *Gardnerycteris* Hurtado and Pacheco, 2014; *Myotis oxyotus gardneri* LaVal, 1973; *Cummingsia (Acanthomenopon) gardneri* Price and Emerson, 1986; *Sciurodendrium gardneri* Guerrero, 1994; *Proechimys gardneri* da Silva and Patton, 1996; *Rhipidomys gardneri* Patton, da Silva, and Malcolm, 1999; *Molinema algardneri* Guerrero and Bain, 2001; *Monodelphis gardneri* Solari, Pacheco, Vivar, and Emmons, 2012; *Peromyscus gardneri* Lorenzo, Álvarez–Castañeda, Pérez–Consuegra, and Patton, 2016.

5. Recent publications of regional interest

Seabrooke Leckie & David Beadle. 2018. Peterson Field Guide to Moths of Southeastern North America. Houghton Mifflin Harcourt, Boston and New York. 652 pp. $29.00 (paperback).

This comprehensive field guide includes more than 2,300 digitally manipulated color photos of 1,800 common species of moths and is a companion to the Northeastern guide by the same authors. It includes tips on how to find and attract moths, as well as range maps and flight season graphs.

Student Member Incentive

The Virginia Natural History Society is offering **free one-year memberships** for students (high school, undergraduate, or graduate) nominated by an advisor/ teacher/mentor who is a member in good standing of the Society. This offer is available for up to 20 students each year, and nominations will be considered in the order in which they are received.

Nominators should include the following information for up to three students: name, institution, enrollment level, mailing address, e-mail address, and a short paragraph describing the student's interests in and activities related to Virginia natural history. Nominations should be sent to the Chair of the membership committee, Nancy Moncrief at nancy.moncrief@vmnh.virginia.gov.

Virginia Natural History Society

http://virginianaturalhistorysociety.com/

General Information

The Virginia Natural History Society (VNHS) was formed in 1992 to bring together persons interested in the natural history of the Commonwealth of Virginia. The VNHS defines natural history in a broad sense, from the study of plants, animals, and other organisms to the geology and ecology of the state, to the natural history of the native people who inhabit it. The goals of the VNHS are to promote research on the natural history of Virginia, educate the citizens of the Commonwealth on natural history topics, and to encourage the conservation of natural resources.

Dissemination of natural history information occurs through publication of the journal *Banisteria*, named for John Banister (1650-1692) who was the first university-trained naturalist to work in Virginia. The first issue was published in 1992, and the journal is published twice per year in spring and fall. Articles cover a wide array of subjects, and prospective authors are encouraged to submit manuscripts on any aspect of natural history in Virginia; papers may pertain to Virginia or regional archaeology, anthropology, botany, ecology, zoology, paleontology, geology, geography, or climatology. Book reviews, biographies, obituaries, and historical accounts of relevance to natural history in Virginia also are welcomed. Manuscripts are peer-reviewed for suitability and edited for inclusion in the journal.

Page charges ($20/page) are waived if the sole or first author is a VNHS member. All authors must pay $75/page if they desire color printing of figures. The society's website contains detailed instructions for prospective authors and PDF reprints of all *Banisteria* articles that are at least one year old.

Memberships

The VNHS is open to anyone with an interest in natural history and welcomes participation by all members in society activities and efforts to promote education and conservation. Membership includes a subscription to *Banisteria* and invitations to periodic symposia and field events. Annual dues for members are $20 (per calendar year); library subscriptions are $40 per year. Checks or money orders should be sent to the Secretary/Treasurer, who also has most back issues of *Banisteria* available for sale. The VNHS is a tax-exempt, nonprofit, society under Section 501(C)3 of the IRS. We welcome donations to support our mission in Virginia.

Virginia Natural History Society

Application for Membership

Name _____

Address _____

_____

_____

Zip Code _____

Phone _____

Email _____

Area(s) of Interest _____

ANNUAL DUES AND SUBSCRIPTIONS TO *BANISTERIA*

(memberships and subscriptions are by calendar year; subscribers/members outside the United States should add $3.00 for additional postage)

- ☐ $500.00 Life (not annual)
- ☐ $300.00 Benefactor
- ☐ $100.00 Patron
- ☐ $50.00 Supporting
- ☐ $40.00 Institutional
- ☐ $25.00 Family
- ☐ $20.00 Regular
- ☐ $5.00 Student (see below)
- ☐ I have added a contribution of $_____ to my membership dues.

The special student rate is applicable only when accompanied by the following certification signed by a faculty advisor (**students are also eligible for a 1-year free membership** if an advisor's nomination is approved by the society's Executive Committee; see nomination guidelines in *Banisteria*).

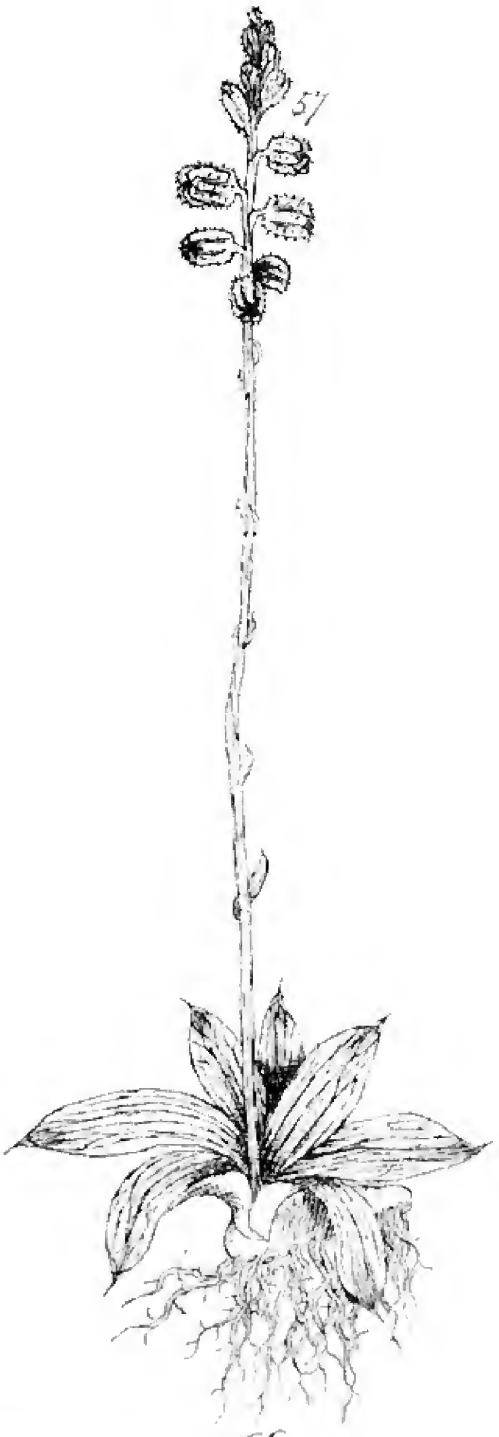
Institution _____

Advisor _____

Date _____

Make checks or money orders payable to:
Virginia Natural History Society

Send membership form and dues to:
Dr. Nancy Moncrief, VNHS Treasurer
Virginia Museum of Natural History
21 Starling Avenue
Martinsville, VA 24112



·66
Phalangium spicatum floreulo
Herbaceo, bullato, aureo.