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THE *HYDROPSYCHE SCALARIS* GROUP IN VIRGINIA, WITH THE DESCRIPTION OF TWO NEW SPECIES (TRICHOPTERA: HYDROPSYCHIDAE)

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Abstract.—Fifteen species of the *Hydropsyche scalaris* group are recorded from Virginia. Four sites on the North and South Anna Rivers, which harbor 8 species, are characterized and physico-chemical data given. *H. incommoda* Hagen is redescribed and diagnosed on the basis of the type and recently collected material. *H. incommoda, sensu* Ross 1944, is described and named *H. rossi* n. sp., and *H. bassi* n. sp. is described. The ranges and habitats of the species are discussed and suggestions explaining the diversity of the fauna advanced.

The Commonwealth of Virginia occupies a favorable position on the eastern seaboard of the United States from the standpoint of its potential faunal diversity. The state cuts across 5 physiographic provinces, 4 life zones (*sensu* Merriam) or 7 "regions" (*sensu* Hoffman, 1969), and ranges in elevation from sea level to 1,743 m (5,720 feet). As a consequence, a considerable faunal diversity is to be expected, but, for most insect groups, not yet reported. Our efforts to investigate the aquatic fauna of the state, both on a broad survey basis and an in-depth analysis of certain sites, are now showing the hoped-for richness of fauna.

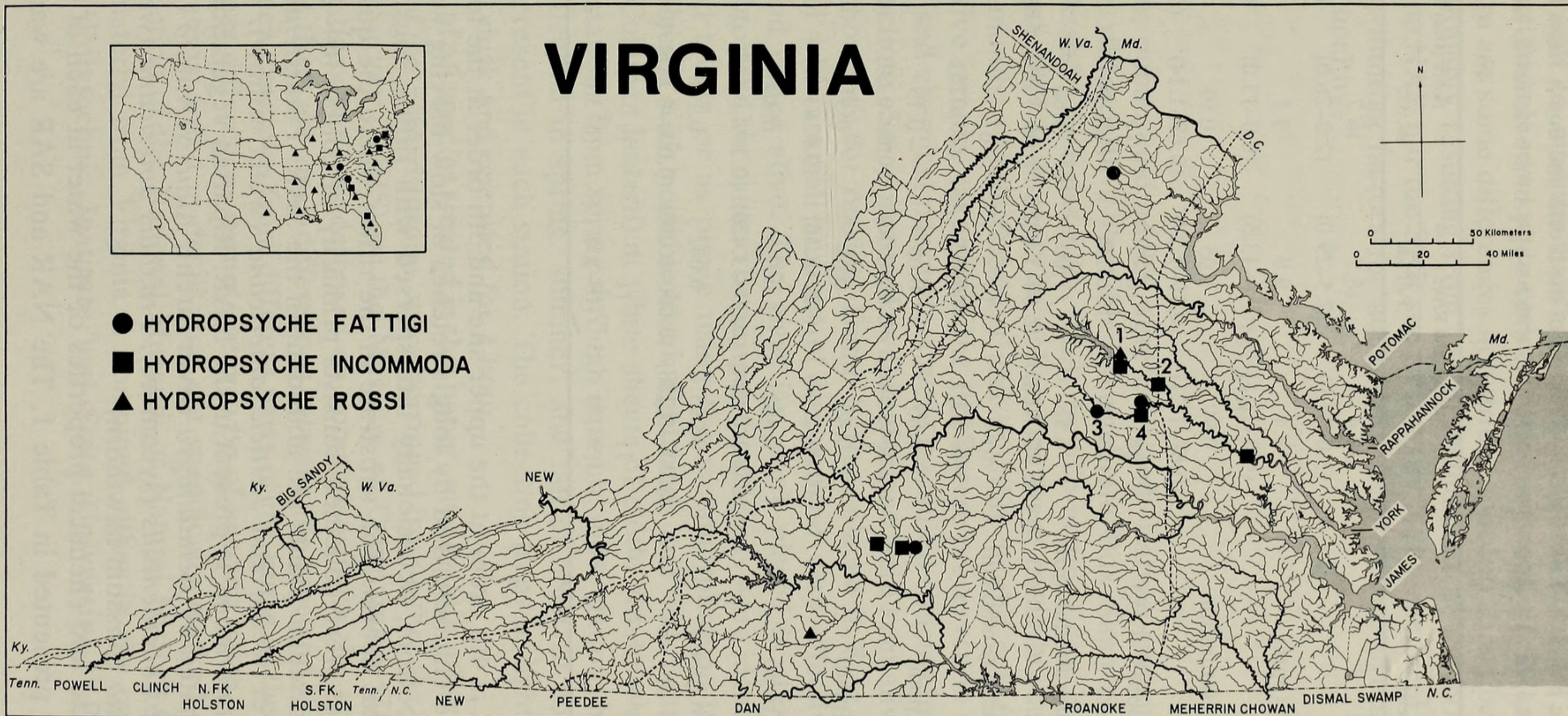
As a result of an in-depth study of 4 sites on the North and South Anna Rivers by Voshell and Parker, 8 species of the *Hydropsyche scalaris* group were discovered. Attempts to identify these species soon convinced Flint that the taxonomy of the group badly needed study. Types of problem species were borrowed, and their study revealed that the trouble was based on a misidentification of the species *H. incommoda* Hagen with its subsequent ramifications.

This paper, then, is an attempt to explain the diversity of the fauna at the Anna Rivers sites, to rectify the systematic problems, and to present the distribution and zoogeography of the *scalaris* group of species in the state.

Description of North and South Anna Rivers

The North and South Anna Rivers are tributaries of the York River Basin (Map 1) which lies in the central and eastern section of Virginia. The York River Basin drains 6,892 km²; from the headwaters in Orange County to the mouth in Chesapeake Bay is a distance of approximately 193 km. The basin varies in width from 8 km at the mouth of the York River to 64 km in the headwaters. The western part of the York River Basin lies within the Piedmont Physiographic Province, and the eastern part lies within the Coastal Plain Province. The Piedmont exhibits a rolling surface of gentle slopes and mild relief. Elevation varies from over 549 m in the extreme western portion to 76 m at the eastern edge of the Piedmont. The Fall Line separates the Piedmont from the Coastal Plain. The Coastal Plain slopes gently eastward from the Fall Line to the Chesapeake Bay. Elevation varies from 76 m to 0 m at the mouth of the York River. The topography of the Coastal Plain is gently sloping hills and flat farmland. Most of the basin is forested (70%) or in cropland and pasture (22%); very little of the land area is classified as urban (2%). There is very little variation in climate within the York River Basin. The climate is moderate with an average annual temperature of 14°C; extremes from less than −18°C to above 38°C are recorded. Average annual precipitation in the basin is approximately 109 cm, varying very little from 107–117 cm. Average annual snowfall is light, ranging from 25 cm along the Coastal Plain to 38 cm in the upper Piedmont (Virginia Division of Water Resources, 1970).

The length of the course of the North Anna River (NAR) in the Piedmont is 91 km. The gradient averages 2.7 m/km along this course, with an altitudinal range from 264 to 18 m. The Piedmont section of the South Anna River (SAR) extends for 154 km, with an average gradient of 2.9 m/km and an altitudinal range from 458 to 18 m. Four sampling sites were established in the lower Piedmont for the purpose of analyzing the downstream effects of Lake Anna on the NAR by comparison with the free-flowing SAR. One station was established on the NAR at Rt. 601, approximately 0.5 km below Lake Anna (Map 1, number 1). At this point the NAR serves as the boundary between Louisa and Spotsylvania Counties. Another station was established on the NAR approximately 32 km downstream at the Fall Line (Map 1, number 2). At this point the NAR serves as the boundary between Hanover and Caroline Counties. On the SAR, stations were established at Rt. 522 in Louisa County (Map 1, number 3) and approximately 54 km downstream at the Fall Line (Map 1, number 4). The latter station at the Fall Line was on Rt. 657 in Hanover County. Both rivers meander slowly across the Piedmont. The elevation of the study area ranges from 55 to 20 m on the NAR and from 70 to 38 m on the SAR. The average slope of each river between the study sites is 1.1 m/km for the NAR and 0.6 m/km for the SAR. Within the study area the maximum slopes for each river (21.8 m/km for the NAR and 3.4 m/km for the SAR) occur at the Fall Line where the lower sampling sites were established. The average mean daily discharge of the NAR during the study was 12 m^3/sec (range: 1–260 m^3/sec); the average for the SAR was 7 m^3/sec (range: 2–77 m^3/sec). The rivers vary in width from 20 to 75 m along their courses. The NAR is a 5th order stream at both study



Map 1.—Distribution of *H. scalaris* group species. 1 & 2, North Anna River collection sites (see p. 838); 3 & 4, South Anna River collection sites (see p. 838).

Table 1.—Basic physical and chemical properties of the North and South Anna Rivers from June 1977 to June 1978. The upper number is the mean and the lower numbers in parentheses are the range.

	North Anna River		South Anna River	
Parameter	Rt. 601	Fall line	Rt. 522	Fall line
Temperature (°C)	18.4 (3.0–31.0)	18.7 (2.5–29.0)	16.7 (2.0–26.0)	17.6 (4.0–28.0)
Dissolved oxygen (ppm)	9.4 (6.0–13.5)	9.8 (6.0–13.5)	9.1 (6.0–13.0)	9.5 (6.5–13.0)
Dissolved oxygen saturation	0.99 (0.67–1.21)	1.05 (0.79–1.27)	0.93 (0.68–1.14)	1.00 (0.78–1.20)
Total alkalinity (ppm $CaCO_3$)	18 (12–25)	18 (12–29)	25 (13–45)	26 (15–35)
Hydrogen ion concentration (pH)	6.86 (6.20–7.60)	7.00 (5.90–7.70)	6.80 (6.30–7.35)	7.07 (6.40–8.05)
Specific conductance (μmho/cm)	61 (40–92)	61 (40–93)	67 (20–125)	69 (12–120)
Orthophosphate (ppm)	0.05 (0.00–0.34)	0.03 (0.00–0.06)	0.13 (0.00–0.60)	0.08 (0.00–0.40)
Total phosphate (ppm)	0.48 (0.00–2.94)	0.52 (0.00–3.56)	0.51 (0.02–3.03)	0.51 (0.07–2.64)
Nitrate nitrogen (ppm)	0.362 (0.000–0.804)	0.615 (0.000–3.420)	0.480 (0.249–0.848)	0.443 (0.127–0.707)
Ammonia nitrogen (ppm)	0.095 (0.000–0.238)	0.042 (0.000–0.096)	0.188 (0.000–0.516)	0.018 (0.000–0.954)
Sulfate (ppm)	11 (9–13)	11 (8–15)	11 (6–30)	11 (5–19)

sites; the SAR is 4th order at the upper site and 5th order at the lower site. Both rivers are characterized by long stretches of slow-moving water with shifting-sand bottom, occasionally interspersed with riffles, logs, and accompanying leaf debris. The substrate in the riffles where the quantitative benthic samples were collected consists primarily of cobble (64–256 mm). Two aquatic vascular plants are abundant in the SAR, *Podostemum ceratophyllum* (river weed) and *Justicia americana* (water willow), whereas, only *Justicia americana* is present in the NAR. Riparian vegetation of both rivers is dominated by *Betula nigra* (river birch), *Alnus serrulata* (speckled alder), *Platanus occidentalis* (sycamore), *Fraxinus americana* (white ash), and *Ilex decidua* (possum hawthorn).

Basic physical and chemical properties of the water at each of the sampling sites are presented in Table 1. The NAR and SAR are warm-water rivers of soft to medium hardness and circum-neutral pH, typical of the Piedmont. Dissolved oxygen concentration is usually near saturation in riffles. There are some differences in nutrient concentrations between the two rivers, probably resulting from the impoundment of the NAR. However, neither the NAR nor the SAR seems to exhibit any chemical properties that would be limiting factors for aquatic insect life, and, overall, both rivers appear "healthy."

Methods

Larvae, pupae, and adults were collected. Larvae and pupae were collected in riffles with a Portable Invertebrate Box Sampler (PIBS) (Ellis-Rutter Assoc., Douglassville, Pa.), by dip-netting, and by handpicking. From June 1977 to June 1978, collections were made biweekly during the warmer months (April–October) and monthly in the colder months. The quantitative samples taken with the PIBS were preserved in the field. Basic physical and chemical parameters were measured concurrent with the benthic collections. Some mature larvae and pupae were kept alive and returned to the laboratory for rearing. Damp burlap, placed in 8 oz. glass jars and kept cool with a small amount of ice, proved very effective for keeping larvae and pupae alive. The glass jars were placed in styrofoam coolers designed to hold six canned beverages. Specimens were identified to species as reared adults or as pupae using the metamorphotype method. Adults were collected with portable black light traps and with lights (either black light or Coleman lantern) at white sheets of cloth. Adults were collected at various stations from spring through autumn; most stations had at least one adult collection in spring, summer, and fall in order to collect all of the species present at each station. The collecting traps or lights were usually set up at dusk and operated for 1 hour.

Types of all species treated in this paper, plus certain other closely related species of the *scalaris* group, were borrowed from either the Illinois Natural History Survey (INHS) or the Museum of Comparative Zoology (MCZ). Identifications were made based on comparison with the types. In certain instances there are small differences between the type and Virginia material, or between examples from different parts of the range of the species. However, these differences do not seem to be of specific value.

All material listed in detail, and not specifically marked otherwise is in the collection of the National Museum of Natural History (USNM). Most of the material from Virginia is contained either in the collection of the Virginia Polytechnic Institute and State University (VPI&SU) or the USNM.

Taxonomy

Hydropsyche alvata Denning
Figs. 1–5, Map 2

Hydropsyche alvata Denning, 1949, p. 40.—Gordon and Wallace, 1975, pp. 413, 415. Unzicker *et al.*, 1970, p. 171.

This poorly known species was described from Mississippi, Illinois and Michigan, and subsequently recorded from Georgia and Arkansas. It thus appears to be a basically southern species extending northward in the Mississippi basin and along the Atlantic Coastal Plain and Piedmont.

It is very closely related to *H. orris* and overlaps the latter in most characteristics. Apparent specific differences are to be found in the apex of the phallus which is clearly larger than the adjacent phallobase and has a domed mesal cavity in lateral aspect. In ventral aspect the inner margins of the lateral plates are sinuous and a bit more open posteriad than in *orris*. The figures here presented were prepared from a paratype from Momence, Illinois.

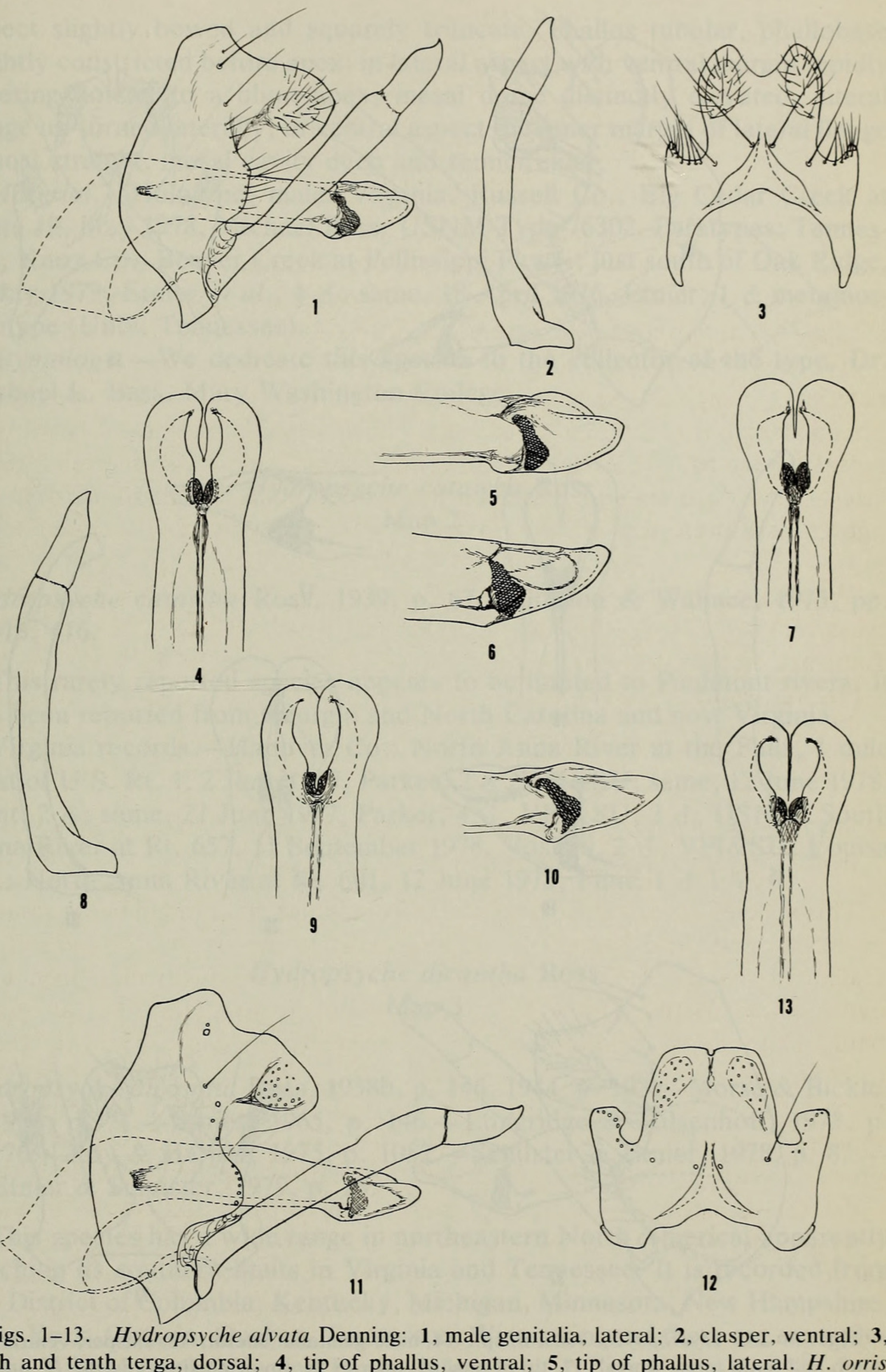
Virginia records.—Hanover Co.: North Anna River at the Falls, 1 mile west of U.S. Rt. 1, 21 June 1977, Parker, 3 ♂, VPI&SU, 1 ♂, USNM. Louisa Co.: South Anna River at Rt. 522, 22 June 1977, Voshell, 2 ♂, VPI&SU; same, 5 July 1977, 1 ♂.

Hydropsyche bassi Flint, Voshell, and Parker, n. sp.
Figs. 19–23, Map 5

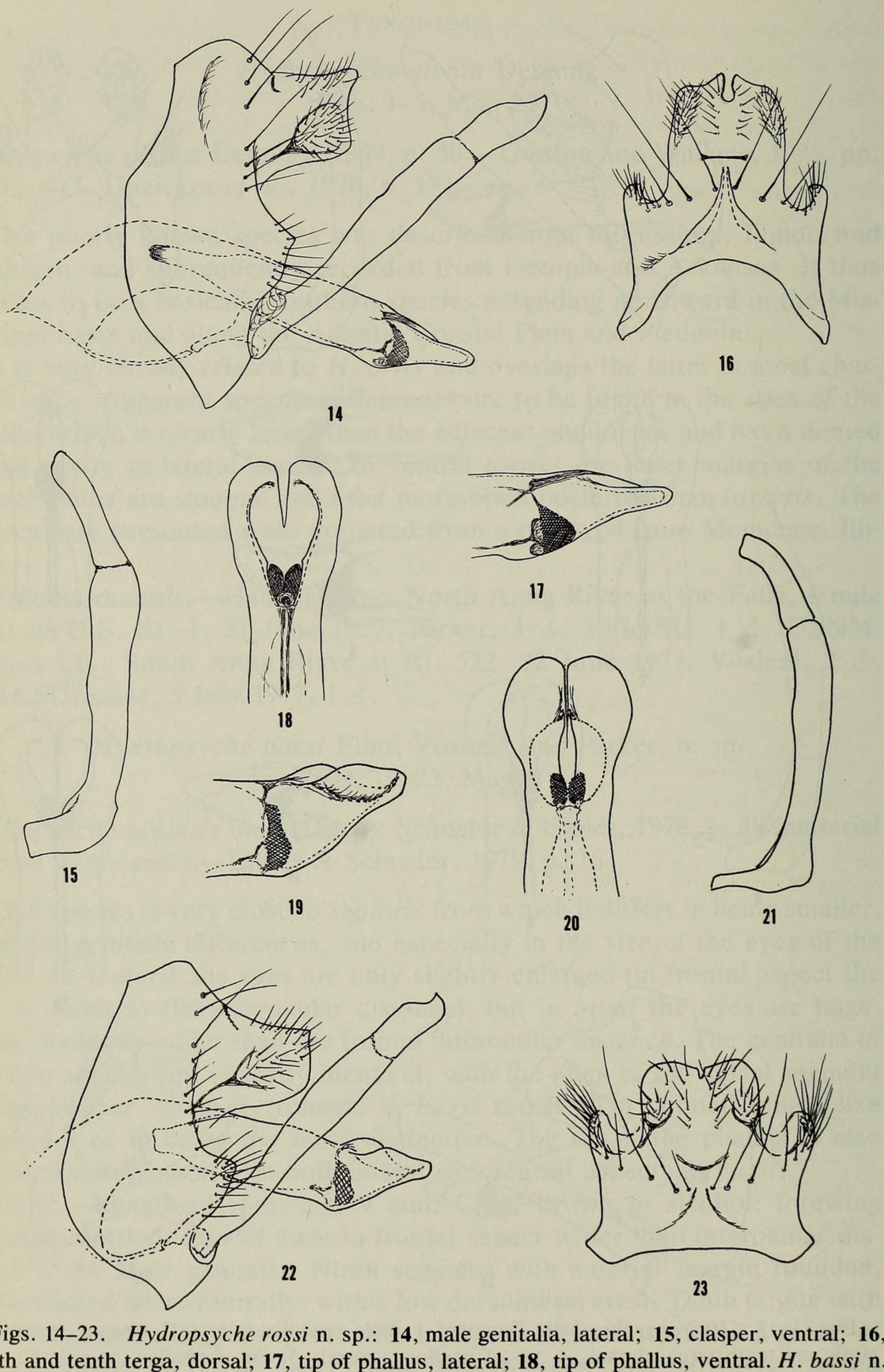
Hydropsyche scalaris (*nec* Hagen): Schuster & Etnier, 1978, p. 89 (material from Tennessee).—Etnier & Schuster, 1979, p. 16.

This species is very close to *scalaris* from which it differs in being smaller, in minor genitalic differences, and especially in the size of the eyes of the males. In *scalaris* the eyes are only slightly enlarged (in frontal aspect the eye is about ⅔ the interocular distance), but in *bassi* the eyes are huge, being distinctly wider than the frontal interocular distance. The genitalia of the two species are virtually identical, with the apex of the apical segment of the clasper which is truncate in *bassi* rather than pointed (much like Figures 2 or 8) being the most distinctive. The tip of the phallus is also proportionately shorter in both lateral and ventral aspects in *bassi*.

Adult.—Length of forewing, 9 mm. Color brown in alcohol; forewing strongly mottled. Eye of male in frontal aspect wider than interocular distance (5:4). Male genitalia: Ninth segment with anterior margin rounded, and enlarged lateroventrally; with a low dorsomesal crest. Tenth tergite with apex truncate in lateral aspect, with a large setiferous wart and a group of setae dorsally; in dorsal aspect with apex truncate and narrowly excised mesally. Clasper with basal segment long, slender, and straight; apical segment in lateral aspect with tip curved into a dorsally directed point, in caudal



Figs. 1–13. *Hydropsyche alvata* Denning: **1**, male genitalia, lateral; **2**, clasper, ventral; **3**, ninth and tenth terga, dorsal; **4**, tip of phallus, ventral; **5**, tip of phallus, lateral. *H. orris* Ross: **6**, tip of phallus, lateral; **7**, tip of phallus, ventral. *H. incommoda* Hagen: **8**, clasper, ventral; **9**, tip of phallus (type), ventral; **10**, tip of phallus, lateral; **11**, male genitalia, lateral; **12**, ninth and tenth terga, dorsal; **13**, tip of phallus (Virginia specimen), ventral.



Figs. 14–23. *Hydropsyche rossi* n. sp.: **14**, male genitalia, lateral; **15**, clasper, ventral; **16**, ninth and tenth terga, dorsal; **17**, tip of phallus, lateral; **18**, tip of phallus, ventral. *H. bassi* n. sp.: **19**, tip of phallus, lateral; **20**, tip of phallus, ventral; **21**, clasper, ventral; **22**, male genitalia, lateral; **23**, ninth and tenth terga, dorsal.

aspect slightly bowed and squarely truncate. Phallus tubular, phallobase slightly constricted before apex; in lateral aspect with ventral margin rapidly tapering dorsad to a blunt apex, mesal dome distinctly elevated, lateral flange up-turned laterally; in ventral aspect the inner margin of lateral flange almost straight, mesal cavity deep and semicircular.

Material.—Holotype, male: Virginia, Russell Co., Big Cedar Creek at route 19, May 1978, Michael Bass. USNM Type 76302. Paratypes: Tennessee, Knox Co., Beaver Creek at Pellissippi Pkwy., just south of Oak Ridge, 9 May 1979, Etnier *et al.*, 1 ♂; same, 18 April 1976, Etnier, 1 ♂ metamorphotype (Univ. Tennessee).

Etymology.—We dedicate this species to the collector of the type, Dr. Michael L. Bass, Mary Washington College.

Hydropsyche catawba Ross
Map 2

Hydropsyche catawba Ross, 1939, p. 67.—Gordon & Wallace, 1975, pp. 413, 416.

This rarely reported species appears to be limited to Piedmont rivers. It has been reported from Georgia and North Carolina and now Virginia.

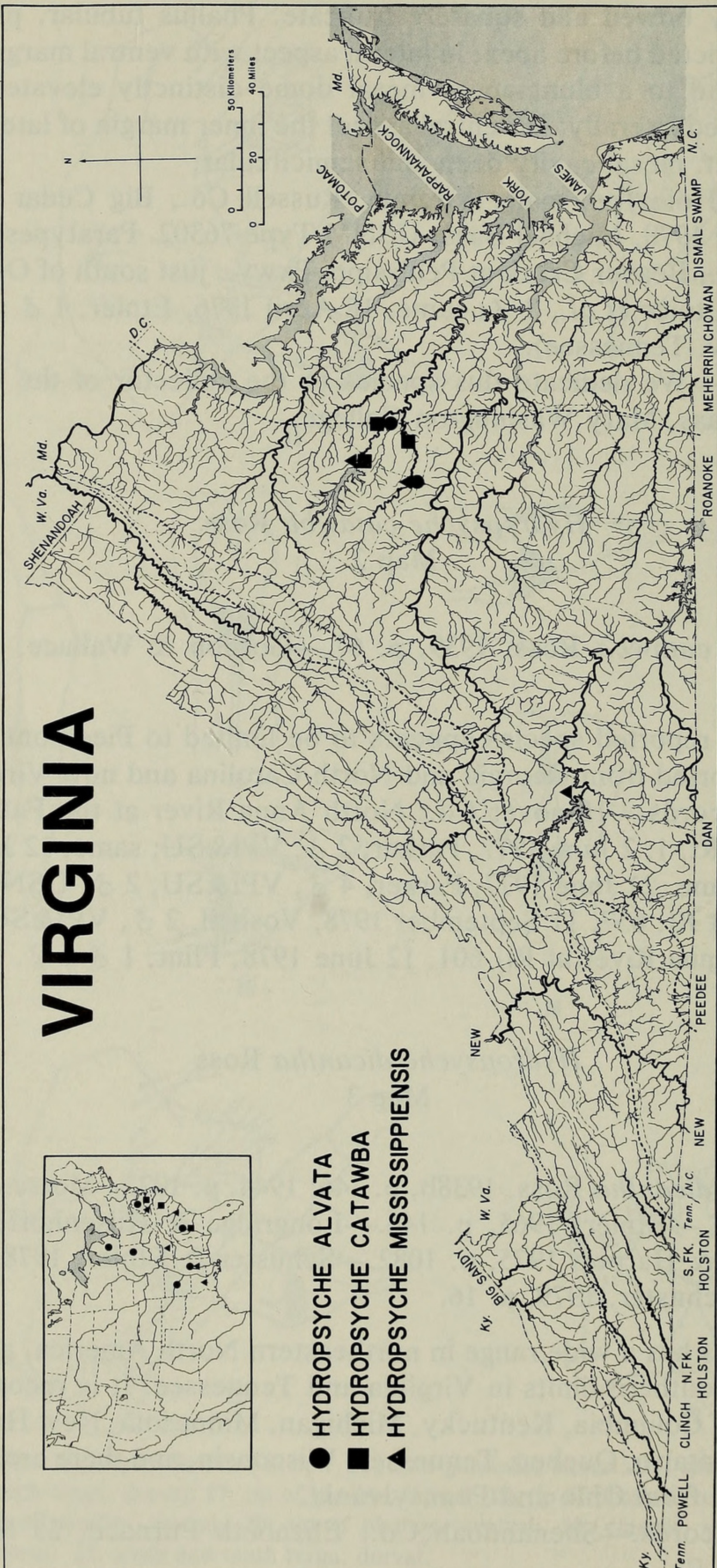
Virginia records.—Hanover Co.: North Anna River at the Falls, 1 mile west of U.S. Rt. 1, 2 June 1977, Parker, 2 ♂, VPI&SU; same, 12 June 1978, Flint, 2 ♂; same, 21 June 1977, Parker, 4 ♂, VPI&SU, 2 ♂, USNM; South Anna River at Rt. 657, 11 September 1978, Voshell, 2 ♂, VPI&SU. Louisa Co.: North Anna River at Rt. 601, 12 June 1978, Flint, 1 ♂ 1 ♀.

Hydropsyche dicantha Ross
Map 3

Hydropsyche dicantha Ross, 1938b, p. 146; 1944, p. 102.—Morse & Bickle, 1953, p. 71.—Etnier, 1965, p. 146.—Longridge & Hilsenhoff, 1973, p. 176.—Roy & Harper, 1975, p. 1082.—Schuster & Etnier, 1978, p. 82.—Etnier & Schuster, 1979, p. 16.

This species has a wide range in northeastern North America, apparently reaching its southern limits in Virginia and Tennessee. It is recorded from the District of Columbia, Kentucky, Michigan, Minnesota, New Hampshire, New York, Ontario, Quebec, Tennessee, Wisconsin, and there are examples in the USNM from Ohio and Pennsylvania.

Virginia records.—Shenandoah Co.: Elizabeth Furnace, 25 May 1966, Beard, 1 ♂ 1 ♀.



Map 2.—Distribution of *H. scalaris* group species.

Hydropsyche fattigi Ross
Map 1

Hydropsyche fattigi Ross, 1941, pp. 88–89.—Gordon & Wallace, 1975, pp. 411, 415.—Etnier & Schuster, 1979, p. 16.

This species has been reported from Georgia and Tennessee previously. It is widely distributed in the Piedmont of Virginia where it reaches the northernmost known limits of its distribution.

Virginia records.—Campbell Co.: Bennett Farm, about 28.3 km SE of Rustburg on Rt. 615, 27 June 1978, Zimmerman, 1 ♂, VPI&SU. Fauquier Co.: Broad Run, Thorofare Gap, 26 July 1975, Flint, 17 ♂ 32 ♀; same, 20 September 1965, 3 ♂ 1 ♀. Hanover Co.: South Anna River at Rt. 657, 12 June 1978, Voshell, 10 ♂, VPI&SU; same, Flint, 2 ♂ 2 ♀, USNM; same, 20 June 1977, Parker, 1 ♂, VPI&SU; same, 21 June 1977, Voshell, 13 ♂ 5 ♀; same, 19 July 1977, 2 ♂; same, 3 August 1977, 1 ♂; same, 11 September 1978, 5 ♂; same, 13 September 1977, Parker, 2 ♂. Louisa Co.: South Anna River at Rt. 522, 19 July 1977, Voshell, 3 ♂, VPI&SU.

Hydropsyche hageni Banks
Map 4

Hydropsyche hageni Banks, 1905, p. 14.—Denning, 1943, pp. 119–120.—Ross, 1944, p. 173.—Longridge & Hilsenhoff, 1975, p. 176.—Etnier & Schuster, 1979, p. 16.

H. hageni has a wide distribution throughout the eastern United States, being reported from Illinois, Kentucky, Manitoba, Maryland, Minnesota, North Carolina, Tennessee, and Wisconsin. In addition, we have seen material from the District of Columbia.

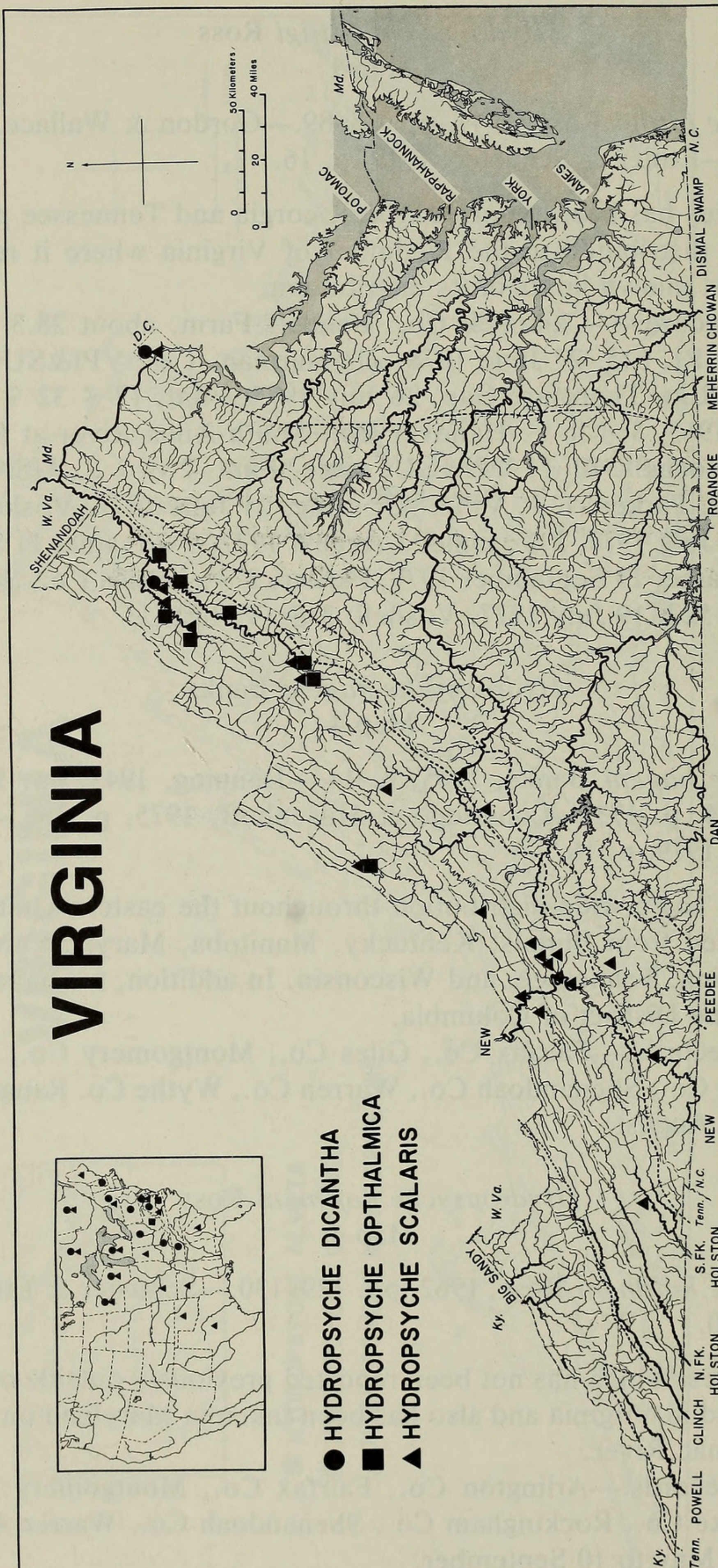
Virginia records.—Fairfax Co., Giles Co., Montgomery Co., Page Co., Rockingham Co., Shenandoah Co., Warren Co., Wythe Co. Range of dates, 3 May to 30 August.

Hydropsyche hoffmani Ross
Map 4

Hydropsyche hoffmani Ross, 1962, pp. 129–130.—Schuster & Etnier, 1978, pp. 98–100.

This species, which has not been reported previously outside of Virginia, is widespread in Virginia and also has been taken in Maryland on the banks of the Potomac River.

Virginia records.—Arlington Co., Fairfax Co., Montgomery Co., Page Co., Roanoke Co., Rockingham Co., Shenandoah Co., Warren Co. Range of dates, 17 May to 10 September.



Map 3.—Distribution of *H. scalaris* group species.

Hydropsyche incommoda Hagen
Figs. 8–13, Map 1

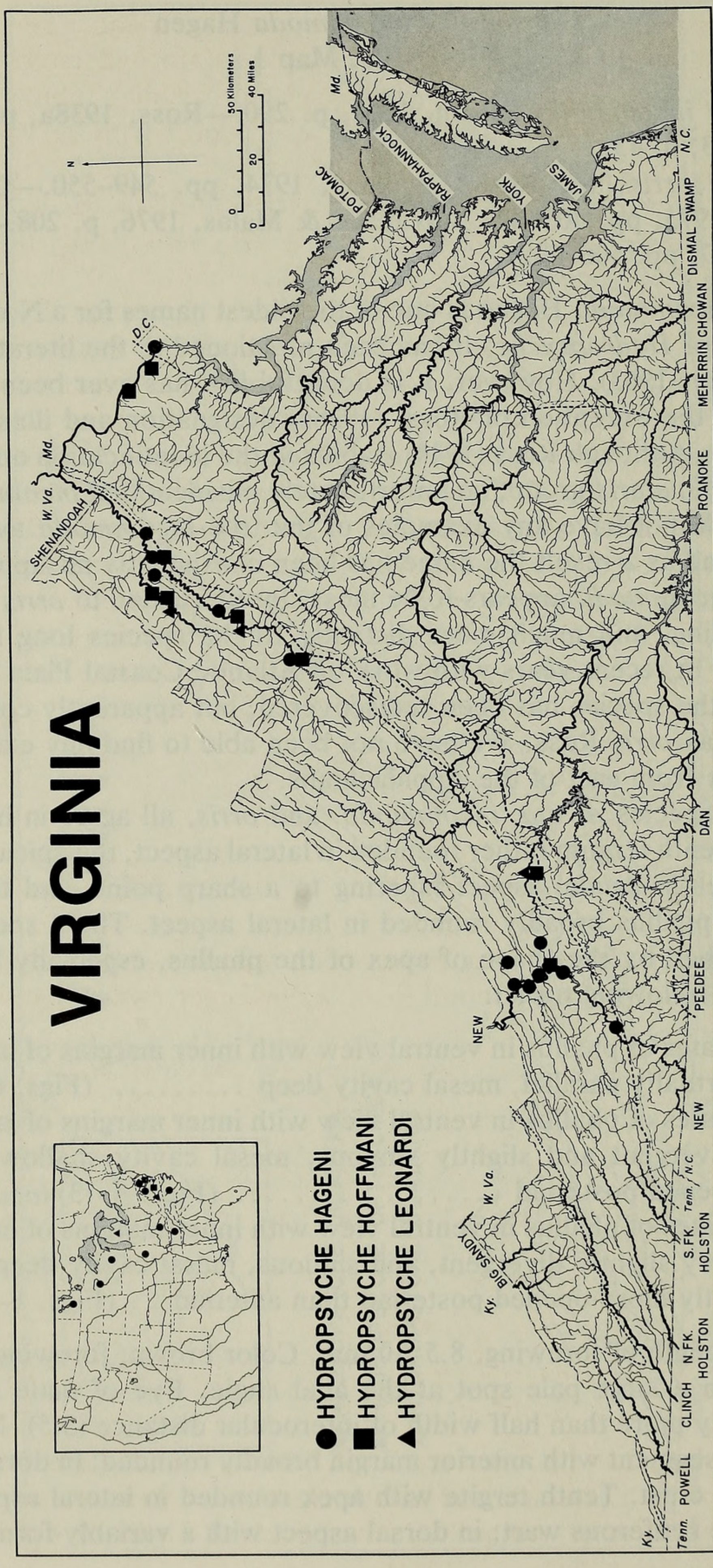
Hydropsyche incommoda Hagen, 1861, p. 290.—Ross, 1938a, p. 17.—Fischer, 1963, p. 43.
Hydropsyche orris (*nec* Ross): Wallace, 1974, pp. 549–550.—Gordon & Wallace, 1975, pp. 405–423.—Wallace & Malas, 1976, p. 208.—Wallace *et al.,* 1977, pp. 506–532.

Because *incommoda* Hagen is one of the oldest names for a North American species of *Hydropsyche,* it has been mentioned in the literature many times (Fischer, 1963). However, it is doubtful if it has ever been correctly applied with the exception of Ross' (1938a) designation and illustration of the lectotype. Although Ross (1944) stabilized the identification and nomenclature in the *scalaris* group, he unfortunately misidentified *incommoda* (he apparently did not have any examples of the true *incommoda* available at that time), and as a result the name has been consistently misapplied since then. True *incommoda* appears to be most closely related to *orris* Ross and *alvata* Denning, and much more distantly to the species long known as *incommoda.* In recent years with work on Atlantic Coastal Plain and Piedmont rivers the species has been rediscovered, but apparently consistently misreported as *orris* Ross. We have not been able to find any examples of the true *orris* from east of the Appalachians.

The three species *alvata, incommoda,* and *orris,* all agree in having the apex by the tenth tergum rather rounded in lateral aspect, the apical segment of the clasper in caudal aspect tapering to a sharp point, and the lateral lobes of the phallus broadly rounded in lateral aspect. The 3 species may be distinguished by the shape of apex of the phallus, especially in ventral view, by the following triplet:

1. Lateral plates of phallus in ventral view with inner margins of lateral flanges virtually parallel, mesal cavity deep .... (Figs. 6–7) *orris*
2. Lateral plates of phallus in ventral view with inner margins of lateral flanges divergent and slightly sinuous, mesal cavity shallow and widely opened posteriad .... (Figs. 8–13) *incommoda*
3. Lateral plates of phallus in ventral view with inner margins of lateral flanges very slightly divergent, and sinuous, mesal cavity deep and only slightly more opened posteriad than anteriad .. (Figs. 1–5) *alvata*

Adult.—Length of forewing, 8.5–10 mm. Color brown; forewing strongly mottled, with a large pale spot at the anal angle. Eye of male in frontal aspect slightly more than half width of interocular distance (3:5). Male genitalia: Ninth segment with anterior margin broadly rounded; in dorsal aspect with a mesal crest. Tenth tergite with apex rounded in lateral aspect, with a single large setiferous wart; in dorsal aspect with a variably-formed, shal-



Map 4.—Distribution of *H. scalaris* group species.

low mesal excision. Clasper with basal segment long, slender and straight; apical segment in lateral aspect with tip curved into a dorsally directed point, in caudal aspect with tip tapered to a point. Phallus tubular, phallobase slightly constricted before apex, in lateral aspect with ventral margin tapering dorsad to a broadly rounded apex, with mesal dome slightly elevated, in mesial aspect with inner margin of lateral flange slightly sinuous, flared laterad at apex, with mesal cavity very shallow (in the type the lateral plates are crushed slightly with a resultant skewing of the parts).

Material.—Lectotype, male [M.C.Z.]: Georgien, Winthem, Type 11018. Virginia records.—Campbell Co.: Ferris Farm, about 10 km SE of Rustburg on Rt. 615, 13 June 1978, Zimmerman, 2 ♂, VPI&SU; Bennett Farm, about 28 km SE of Rustburg on Rt. 615, 27 June 1978, Zimmerman, 22 ♂ 8 ♀, VPI&SU; same, 4 July 1978, 1 ♂; same, 18 July 1978, 1 ♂. Hanover Co.: North Anna River at the Falls, 1 mile west of U.S. Rt. 1, 27 May 1978, Voshell, 1 ♂, VPI&SU; South Anna River at Rt. 657, 8 October 1977, killed 5 May 1978, Voshell, 1 ♂ mmt, VPI&SU. Louisa Co.: North Anna River at Rt. 601, 12 June–14 September 1977–78, Voshell and Flint, many ♂♂ and ♀♀ and mmt, VPI&SU, USNM. New Kent Co.: Pamunkey R., at White House, 15 July 1971, Simmons, 4 ♂ 1 ♀. In addition we have seen material of this species from Florida, Georgia, and Maryland.

Hydropsyche leonardi Ross
Map 4

Hydropsyche leonardi Ross, 1938b, pp. 145–146.—Schuster & Etnier, 1978, pp. 100–102.

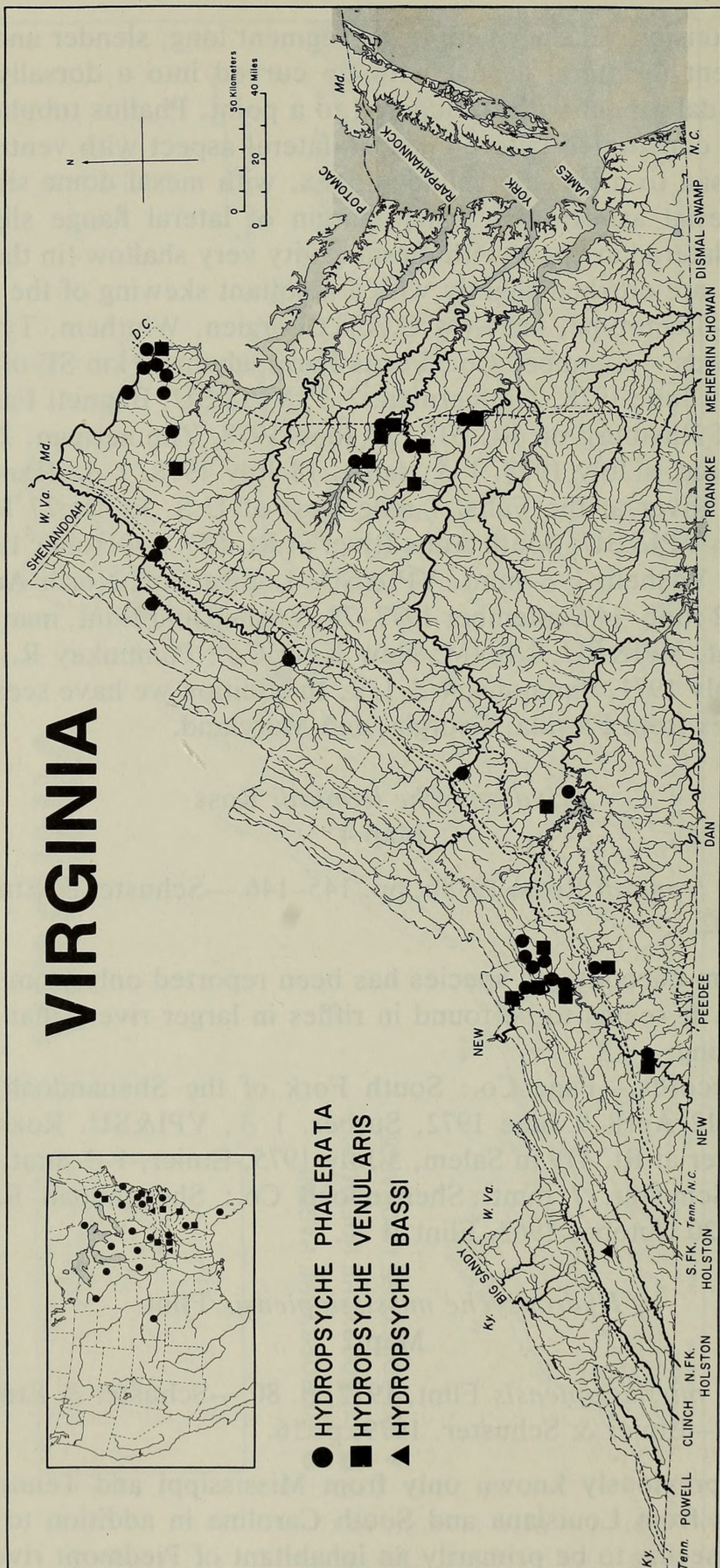
This seldom encountered species has been reported only from Michigan and Virginia. It seems to be found in riffles in larger rivers that are clean and fast-flowing.

Virginia records.—Page Co.: South Fork of the Shenandoah River at Grove Hill, 12 April–9 June 1972, Surber, 1 ♂, VPI&SU. Roanoke Co.: Roanoke River at Rt. 419 in Salem, 5 July 1975, Etnier, 1 ♂ mmt, same, 10 July 1975, Schuster, 7 mmt. Shenandoah Co.: Shenandoah River near Woodstock, 20 October 1962, Flint, 1 ♂.

Hydropsyche mississippiensis Flint
Map 2

Hydropsyche mississippiensis Flint, 1972, p. 80.—Schuster & Etnier, 1978, pp. 95–96.—Etnier & Schuster, 1979, p. 16.

Although previously known only from Mississippi and Tennessee, we have records from Louisiana and South Carolina in addition to Virginia. The species seems to be primarily an inhabitant of Piedmont rivers of the southeastern United States.



Map 5.—Distribution of *H. scalaris* group species.

Virginia records.—Bedford Co.: Carter Mill Creek, Rt. 734, 16 July 1975, Flint & Ronderos, 4 ♂ 1 ♀. Louisa Co.: North Anna River at Rt. 601, 12 June 1978, Voshell & Flint, 2 ♂, VPI&SU, 3 ♂, USNM; same, 21 June 1977, Voshell, 3 ♂, VPI&SU; same, 20 July 1977, 1 ♂; same, 30 July 1977, Parker, 1 ♂; same, 14 September 1977, 3 ♂; South Anna River at Rt. 522, 5 July 1977, Voshell, 13 ♂, VPI & SU.

Hydropsyche opthalmica Flint
Map 3

Hydropsyche opthalmica Flint, 1965, p. 169.

This species, unreported since its original description from West Virginia, is now recorded from several localities in Virginia. The records all cluster around rather large streams that are clear, cool and fast flowing.

Virginia records.—Augusta Co.: Middle River at Mt. Meridian, 20 May 1978, Seagle, 1 ♂, VPI&SU. Bath Co.: Jackson River, approx. 400 m below Back Creek, 1973, Strickler, unpublished M.S. Thesis, VPI&SU. Page Co.: South Fork of the Shenandoah River at Brumback's Cabin, 10 May 1971, Surber, 3 ♂, VPI&SU, 1 ♂, USNM. Rockingham Co.: South Fork of the Shenandoah River at Goods Mill, 26 May 1971, Surber, 1 ♂, VPI&SU. Shenandoah Co.: North Fork of the Shenandoah River, Rt. 707, 15 June 1971, Surber, 1 ♂, VPI&SU; North Fork of the Shenandoah River, Swope Hollow, Rt. 661, Mauertown, 21 July 1971, 1 ♂; North Fork of the Shenandoah River, 1971, Surber, 39 ♂, VPI&SU. Warren Co.: South Fork of the Shenandoah River, Bentonville Bridge, 24 May 1971, Surber, 1 ♂, VPI&SU, 1 ♂, USNM; South Fork of the Shenandoah River, Public Boat Landing at Front Royal, 30 May 1978, Seagle, 3 ♂, VPI&SU; same, 8 June 1977, Parker, 2 ♂ 4 ♀; same, 27 June 1978, Seagle, 2 ♂.

Hydropsyche phalerata Hagen
Map 5

Hydropsyche phalerata Hagen, 1861, p. 287.—Ross, 1944, p. 102.—Leonard & Leonard, 1949, p. 10.—Fischer, 1963, p. 77.—Etnier, 1965, p. 146.—Longridge & Hilsenhoff, 1973, p. 176.—Resh, 1975, p. 12.—Schuster & Etnier, 1978, pp. 78–80.—Etnier & Schuster, 1979, p. 16.

This is a commonly collected species, widespread in the eastern half of the United States and southeastern Canada. Records are available from the District of Columbia, Georgia, Illinois, Indiana, Kansas, Kentucky, Michigan, Minnesota, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Tennessee, Wisconsin, and Canada. Material of the species from Florida and Maryland is also present in the USNM.

Virginia records.—Arlington Co., Bedford Co., Carroll Co., Fairfax Co., Floyd Co., Giles Co., Hanover Co., Louisa Co., Montgomery Co., Richmond City, Rockingham Co., Shenandoah Co., Warren Co. Range of dates, 25 May to 27 September.

Hydropsyche rossi Flint, Voshell, and Parker, n. sp.
Figs. 14–18, Map 1

Hydropsyche incommoda (*nec* Hagen): Ross, 1944, p. 106.—Unzicker et al., 1970, p. 171.—Gordon & Wallace, 1975, pp. 405–423.—Resh, 1975, p. 12.—Wallace, et al., 1977, pp. 506–532.—Schuster & Etnier, 1979, pp. 92–93.—Etnier & Schuster, 1979, p. 16.

This is a rather common southern species, ranging as far north at least as Illinois in the Mississippi Basin and Virginia on the Atlantic Coast. This species is the one misidentified by Ross in 1944 as *incommoda,* and reported as such by all subsequent authors. Based on this concept, the species has been recorded from Arkansas, Florida, Georgia, Illinois, Kentucky, Louisiana, North Carolina, Tennessee, and we have records from Mississippi, Missouri, South Carolina, and Virginia.

The species differs from *alvata, incommoda,* and *orris* on the basis of the more rectangular apex of the tenth tergum, the more nearly truncate apex of the clasper, and in the apex of the phallus. In *rossi* the lateral plates are thin and long in lateral aspect, and are very narrow and widely open in ventral aspect. There is some variation in the width of the lateral flange, some examples from Illinois being almost as wide as Fig. 13.

Adult.—Length of forewing, 10–11 mm. Color brown; forewing strongly mottled, generally with a paler band longitudinally in middle. Eye of male in frontal aspect almost as wide as interocular distance (4:5.5). Male genitalia: Ninth segment with anterior margin broadly rounded; in dorsal aspect with a mesal crest. Tenth tergite with apex truncate in lateral aspect, with a large setiferous wart and a row of setae dorsally; in dorsal aspect with apex truncate and narrow excised mesally. Clasper with basal segment long, slender, and straight; apical segment in lateral aspect with tip curved into a dorsally directed point, in caudal aspect with tip obliquely truncate. Phallus tubular, phallobase scarcely constricted before apex, in lateral aspect with ventral margin rapidly tapering dorsad to a long, narrow apex, with mesal dome slightly elevated; in ventral aspect with inner margin of lateral flange very narrow, with scarcely any mesal cavity, widely open apicad.

Material.—Holotype, male: MISSISSIPPI, Forrest Co., Hattiesburg, 25 Sept. 1967, Bryant Mather. USNM Type 76303. Paratypes: Same, 1 ♂; same, 19 Sept. 1967, 1 ♂ 3 ♀; Warren Co., Bovina, 21–28 April 1971, Mather, 1 ♂ 1 ♀; Washington Co., Wayside, 27 June 1966, Bruce, 1 ♂; State College, 16 June 1972, Robinson, 1 ♂ 1 ♀; same, 25–30 Apr. 1966, Davis, 3 ♂ 20 ♀, I.N.H.S.; Marshall Co, 1 mi. W. Waterford, 26 June 1973, Stark, 7 ♂ 3 ♀; Stoneville, May 1959, Pfrimmer, 4 ♂, I.N.H.S.; Leland, 17–28 May 1958, Pfrimmer, 1 ♂, I.N.H.S.; Columbus, Tombigbee R., 21 May 1976, Schuster, 1 ♂, U.T.

ARKANSAS, Bradley-Drew County line, Saline R., 21 May 1977, Etnier et al., 2 ♂, U.T. FLORIDA, Alachua Co., Gainesville, 20 Apr. 1967, Wirth, 1 ♂; Columbia Co., O'Leno State Park, 31 May 1966, Beard, 1 ♂ 2 ♀; Marion Co., Juniper Springs, 28 Apr. 1970, Wirth, 6 ♂ 5 ♀; Lake Co., Tavares, 23 Mar. 1936, Young, 4 ♂ 5 ♀, I.N.H.S.; Jackson Co., Blue Springs Cr., 3 mi. E. Marianna, 5 June 1940, Berner, 1 ♂ 4 ♀, I.N.H.S. GEORGIA, Effingham Co., Savanna R. at end Rt. 275, 15 May 1970, Wallace & Sherberger, 5 ♂; Altamaha R., nr. Baxley, Hatch Power Plant, 22 Apr. 1974, Ga. Power Co., 2 ♂ 1 ♀.

ILLINOIS, Carmi, Little Wabash R., 24 Apr. 1935, Frison, 1 ♂, I.N.H.S.; Carlyle, 9 Aug. 1943, Sanderson & Leighton, 3 ♂ 1 ♀, I.N.H.S.; Mahomet, 3 Aug. 1937, Ross & Burks, 12 ♂ 10 ♀, I.N.H.S.; Oakwood, 20 Sept. 1935, DeLong & Ross, 1 ♂, I.N.H.S.; Benton, 11 June 1945, Ross, 1 ♂ 1 ♀, I.N.H.S.; Monticello, 7 May 1936, Ross & Burks, 1 ♂, I.N.H.S.; Pontiac, 22 Aug. 1938, Ross, 3 ♂, I.N.H.S.; Kappa, Mackinaw R., 14 Sept. 1937, Ross & Burks 4 ♂, I.N.H.S.; Momence, 16 Aug. 1938, Ross & Burks, 4 ♂, I.N.H.S.; Momence, Kankakee R., 29 May 1939, Frison & Ross, 1 ♂, I.N.H.S.; Poplar Bluff, 2 June 1948, Frison, 1 ♂, I.N.H.S.; Urbana, 1–7 July 1958, Klatt, 19 ♂ 2 ♀, I.N.H.S.; same, 22 July 1958; 11 ♂ 1 ♀; same, 6 Aug. 1958, 2 ♂ 22 ♀; same, 20 Aug. 1958, 52 ♂; same, 26 Aug. 1958, 7 ♂.

KENTUCKY, 25 mi. N.E. Bowling Green, 3 Sept. 1967, Druckenbrod, 1 ♂. LOUISIANA, Bossier Parish, 10 May 1938, Turner, 1 ♂ 1 ♀; Curtis, Red R. Valley Exp. Sta., 22 July 1958, 2 ♂ 2 ♀, I.N.H.S.; Washington Parish, Silver Cr. 6 mi N.E. Franklinton, 5 May 1979, Louton, 1 ♂, U.T. MISSOURI, Columbia, 21 July 1974, Craig, 1 ♂. NORTH CAROLINA, Statesville, Catawba R., 23 Apr. 1938, Ross & Burks, 1 ♂, I.N.H.S. SOUTH CAROLINA, Jackson, 22 Apr. 1969, Tarpley, 2 ♂; Savanna R., Calhoun Falls (Ca. 3 mi. S. of town), 27 Apr. 1969, Wallace, 3 ♂; Colleton Co., Hwy, 61, Edisto R., 5 mi. E. Canadys, 19–22 May 1968, Cartwright, 2 ♂ 1 ♀. TENNESSEE, Madison Co., Jackson, 13 May 1957, 2 ♂, I.N.H.S.; same, 20 May 1957, 1 ♀; Lauderdale Co.; Ripley, 6 May 1957, 1 ♂, I.N.H.S.; Cumberland Co., Crossville, 13 Sept. 1970, 1 ♂, U.T.; Robertson Co., 1 June 1966, 1 ♂, U.T.; Fentress Co., 12–14 July 1972, Van Landingham, 1 ♂, U.T.; same 20–24 July 1972, 1 ♂. TEXAS, Brazos Co., Little Brazos R., at Tex. 21, 23 May 1977, 13 ♂, U.T.

VIRGINIA, Louisa Co., North Anna River at Rt. 601, 17 December 1977, emerged 5 March 1978, Voshell, 1 ♂, VPI&SU; same, emerged 12 April 1978, Parker, 1 ♂; same, 14 September 1977, Voshell, 3 ♂, 1 ♀ mmt, VPI&SU; Pittsylvania Co., Chatham, 7 July 1963, Tarpley, 1 ♂.

Etymology.—We dedicate this species to the late Dr. H. H. Ross, in memory of his many contributions to trichopterology, especially the basic work on the *scalaris* group.

Hydropsyche scalaris Hagen
Map 3

Hydropsyche scalaris Hagen, 1861, p. 286.—Ross, 1944, p. 106.—Blickle & Morse, 1966, p. 6.—Nimmo, 1966, p. 691.—Unzicker et al., 1970, p. 171.—Edwards, 1973, p. 504.—Schuster & Etnier, 1978, pp. 87–90 (in part).

Although this species is widespread throughout eastern North America, records before Ross (1944) are suspect because of widespread misidentifications. There appear to be valid records from Arkansas, Georgia, Indiana, Maine, Minnesota, Missouri, Oklahoma, Ontario, Quebec, Texas, Wisconsin, and material at the USNM from Maryland and New York.

Virginia records.—Augusta Co., Bath Co., Bedford Co., Botetourt Co., Carroll Co., Craig Co., Floyd Co., Giles Co., Montgomery Co., Rockbridge Co., Rockingham Co., Shenandoah Co., Washington Co. Range of dates, 21 May to 20 October.

Hydropsyche venularis Banks
Map 5

Hydropsyche venularis Banks, 1914, p. 252.—Resh, 1975, p. 12.—Wallace, 1975, pp. 463–472.—Schuster & Etnier, 1978, pp. 96–98.

This is often a common species in the southeastern United States. It is found from the Coastal Plain into the Cumberland Plateau, generally favoring medium to large rivers. Apparently valid records are from the District of Columbia, Georgia, Kentucky, North Carolina, Tennessee, and in material at the USNM, South Carolina.

Virginia records.—Bedford Co., Caroline Co., Carroll Co., Fauquier Co., Floyd Co., Giles Co., Hanover Co.. Louisa Co., Montgomery Co., Richmond City. Range of dates, 3 May to 28 September.

Distribution

We have found 15 species belonging to the *H. scalaris* group in Virginia. This is approximately the same number reported in two other southeastern states: 14 in Tennessee (Etnier and Schuster, 1979) and 11 in Georgia (Gordon and Wallace, 1975). Fewer species have been reported in midwestern and northern United States. Ross (1944) reported 11 species belonging to the *H. scalaris* group from Illinois in his comprehensive survey of the state fauna. Etnier (1965) included 10 species of this group in his list of Minnesota

Trichoptera, Longridge and Hilsenhoff (1973) listed 9 species from Wisconsin, Leonard and Leonard (1949) recorded 9 species from Michigan, and Resh (1975) substantiated 8 species in Kentucky. Morse and Blickle (1953) only recorded 1 species in New Hampshire, and in 1966 (Blickle & Morse) listed a different species from Maine. Nimmo (1966) and Roy and Harper (1975) listed 5 species from Quebec, however, some of these species were misidentified.

Of the 15 species of the *H. scalaris* group that occur in Virginia (Maps 1–5), 6 are southeastern species that appear to reach their northern limit in Virginia, or in two instances, Maryland or the District of Columbia. These species are *H. alvata, H. catawba, H. fattigi, H. incommoda, H. mississippiensis,* and *H. venularis.*

Two species have northern distributions that extend into the southeast. *H. leonardi* is known only from Michigan and Virginia, and in Virginia is limited to the Ridge and Valley Physiographic Province. *H. dicantha* is known from 7 northern states and Canada and extends into Kentucky, Tennessee, and Virginia. Within Virginia it has been collected in the northern mountains and across the Potomac in the District of Columbia along the Fall Line. Thus, at least 8 species of the *H. scalaris* group that occur in Virginia appear to be southern species reaching their northern limit or northern species reaching their southern limit. In addition, 3 species are known only from Virginia and one bordering state. *H. hoffmani* has been recorded from Maryland, *H. opthalmica* has been recorded from West Virginia, and *H. bassi* has been recorded from Tennessee. The 4 remaining species, *H. hageni, H. phalerata, H. rossi,* and *H. scalaris* are widespread in the east.

Of the 15 species in the *H. scalaris* group found in Virginia, 12 species have been collected in the Piedmont, but only 9 species have been collected at higher elevations to the west of the Piedmont (Table 2). In Georgia, Gordon and Wallace (1975) found 7 species in the Piedmont and 6 species in the headwaters. Combining the records from Georgia and Virginia, 14 species belonging to the *H. scalaris* group have been found in the Piedmont and 13 species at higher elevations to the west. In Virginia we have collected 8 species from the lower Piedmont sections of the NAR and SAR in the York River Basin. Gordon and Wallace (1975) reported only 5 species from the lower Piedmont sections of the Savannah River Basin. A review of the distribution records of the species in the *H. scalaris* group raises the questions: why are there so many species in the southeastern Piedmont, and, in particular, why are there so many species in a relatively small area of the lower Piedmont in Virginia?

Ross (1963) speculated that the entire *scalaris* complex of the *H. scalaris* group evolved in the temperate deciduous forest, in large creeks or rivers with sufficient current to result in rock or gravel bottom. The number of

Table 2.—Distribution of species belonging to the *H. scalaris* group in Virginia and Georgia. Georgia records are from Gordon and Wallace (1975).

	Virginia			Georgia—Savannah River Basin		
Species	Higher elevations west of Piedmont	Piedmont	Lower Piedmont sections of NAR and SAR	Headwaters	Piedmont	Lower Piedmont
H. alvata		X	X	X		
H. bassi	X					
H. bidens				X	X	X
H. catawba		X	X		X	
H. demora				X		
H. dicantha	X	X				
H. fattigi		X	X	X		
H. hageni	X	X				
H. hoffmani	X	X				
H. incommoda		X	X		X	X
H. leonardi	X					
H. mississippiensis		X	X			
H. opthalmica	X					
H. phalerata	X	X	X			
H. rossi		X	X		X	X
H. scalaris	X	X		X	X	X
H. nr. *scalaris*					X	X
H. venularis	X	X	X	X	X	

different species found in southeastern Piedmont rivers provides support for Ross' hypothesis. The following comparison of the results of several recent ecological investigations with our observations from the NAR and SAR is an attempt to further explain the distribution of this abundant group of caddisflies.

Cummins (1977) stated that greater diversity of species is expected in the midreaches (width: 10–75 m; stream order: 4–6) than in the upstream or downriver areas of a River Continuum. His delimitation of midreaches coincides with the widths and stream orders of the NAR and SAR. He mentioned thermal diversity, variety of organic substrates, and physical heterogeneity as important factors affecting the diversity of the midreaches.

In regard to thermal regime, Sweeney and Vannote (1978) hypothesized that the distribution of species, both locally and over large geographic areas, is limited by lowered fecundity as adult size gradually diminishes in streams of increasingly cold or warm temperature cycles. Each species has an optimum temperature regime for larval growth that permits the insect to achieve maximum adult weight and fecundity. Small adults and reduced fecundity result when temperatures are either warmed or cooled with respect to more optimal thermal conditions. However, aquatic insects have evolved means of surviving unfavorable conditions such as diapause, hibernation, estivation, or quiescence, all of which can occur in various stages. Therefore, it is possible to have species with different optimum temperature regimes coexisting in the same habitat if the annual temperature cycle of the habitat includes the optimum temperature of all the species. In fact, one would expect higher species diversity in habitats with more diverse temperature regimes. Vannote (in Cummins, 1977) has suggested that greater diversity of species is expected in the midreaches because the water temperature is more variable than in the groundwater controlled headwaters or in the large volume rivers. These hypotheses certainly appear to be supported by the high diversity of species occurring in the low Piedmont sections of the NAR and SAR, where the temperature varies as much as 28°C at a given site during the year (Table 1). The wide range in the annual temperature cycle allows the coexistence of both spring and summer species. In addition, the wide range in temperatures is conducive to range extensions by northern and southern species. Boreal species are able to reduce the competition for resources by dispersing downstream into the Piedmont. Austral species are able to accomplish the same thing by dispersing upstream to the limits of their optimum thermal regime. *H. dicantha* is a good example of a boreal species which is found in both the mountains and Piedmont in Virginia (Map 3). *H. alvata, H. catawba, H. mississippiensis, H. fattigi, H. incommoda,* and *H. rossi* are examples of austral species that occur in the Piedmont of Virginia, particularly the lower Piedmont.

The diversity of species in the Piedmont may also be explained by the overall physical heterogeneity of rivers in this physiographic province. For example, the most abundant size-class of substrate in individual benthic samples from the NAR and SAR varied from boulder (>256 mm) to coarse sand (0.5–1 mm). The flow measured at individual benthic samples varied from 168 cm/sec to <1 cm/sec. The variable flow and substrate reflect the irregular longitudinal profile of Piedmont rivers. While much of the NAR has only a moderate gradient, the gradient at the Fall Line (21.8 m/km) is equivalent to that found in many headwater streams. Because riparian vegetation does not entirely shade Piedmont rivers, aquatic vascular plants are sometimes abundant. *Podostemum,* a preferred attachment site for many Hydropsychidae, was found in mats as dense as 698.7 g dry weight/m^2 in the SAR. Snags are another characteristic feature of Piedmont rivers. As river banks erode, large trees topple in and remain in the river for many years. Such snags have been shown to be preferred attachment sites for some Hydropsychidae that are most common in very large rivers (Wallace *et al.*, 1977).

The available food cannot be overlooked as an explanation for the diversity of species belonging to the *H. scalaris* group in the Piedmont. Gordon and Wallace (1975) indicated that subtle differences in feeding habits of the larvae and change in available food along the course of the stream affect the distribution of Hydropsychidae. Wallace *et al.* (1977) stated that the type and size of drifting stream seston has influenced the evolution of filter-feeding Trichoptera. Species that occur in fast-flowing headwater streams have capture nets with large mesh sizes, and species that inhabit slow-flowing coastal rivers have capture nets with very small mesh openings. The evolution of the filter-feeding Trichoptera that occupy both habitats has produced individual species capable of cropping various types and sizes of seston. Cummins (1977) reported that the ratio of course particulate organic matter (CPOM) to fine particulate organic matter (FPOM) decreases in the midreaches because large amounts of FPOM are introduced from tributaries and sloughed from algal mats and vascular plant beds. However, there are still inputs of CPOM in the midreaches from both riparian vegetation and aquatic vascular plants. In addition, the flood plain of the Piedmont is a source of input of CPOM and FPOM. Therefore, the variety of types and sizes of seston in Piedmont rivers is probably reflected in the number of different species in the *H. scalaris* group that occur there. It does not appear that the seston input from the reservoir on the NAR affects the diversity of species in the *H. scalaris* group. All species except *H. rossi* have been collected from both the regulated NAR and free-flowing SAR.

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Literature Cited

Banks, N. 1905. Descriptions of new Nearctic neuropteroid insects.—Trans. Amer. Ent. Soc. 32:1–20.

———. 1914. American Trichoptera—notes and descriptions.—Can. Ent. 46:252–258.

Blickle, R. L. and W. J. Morse. 1966. The caddisflies (Trichoptera) of Maine, excepting the family Hydroptilidae.—Maine Agr. Exp. Sta. Tech. Bull. 24:1–12.

Cummins, K. W. 1977. From headwater streams to rivers.—Amer. Biol. Teacher 39:305–312.

Denning, D. G. 1943. The Hydropsychidae of Minnesota (Trichoptera).—Entom. Amer. 23:101–127.

———. 1949. New species of Nearctic caddis flies.—Bull. Brooklyn Ent. Soc. 44:37–48.

Edwards, S. W. 1973. Texas caddisflies.—Texas J. Sci. 24:491–516.

Etnier, D. A. 1965. An annotated list of the Trichoptera of Minnesota, with description of a new species.—Ent. News 76:141–152.

Etnier, D. A. and G. A. Schuster. 1979. An annotated list of Trichoptera (caddisflies) of Tennessee.—J. Tennessee Acad. Sci. 54:15–22.

Fischer, F. C. J. 1963. Hydropsychidae, Arctopsychidae.—Trichopt. Catalog IV:1–225.

Flint, O. S., Jr. 1965. New species of Trichoptera from the United States.—Proc. Ent. Soc. Washington 67:168–176.

———. 1972. Three new caddisflies from the southeastern United States.—J. Georgia Ent. Soc. 7:79–82.

Gordon, A. E. and J. B. Wallace. 1975. Distribution of the Hydropsychidae (Trichoptera) in the Savannah River Basin of North Carolina, South Carolina, and Georgia.—Hydrobiologia 46:405–423.

Hagen, H. H. 1861. Synopsis of the Neuroptera of North America.—Smiths. Misc. Coll. 4(1):xx + 1–347.

Hoffman, R. L. 1969. The biotic regions of Virginia.—Virginia Polytech. Inst., Res. Div. Bull. 48:23–62.

Leonard, J. W. and F. A. Leonard. 1949. An annotated list of Michigan Trichoptera.—Occasional Papers Mus. Zool. Univ. Michigan 522, 35 pp.

Longridge, J. L. and W. L. Hilsenhoff. 1973. Annotated list of Trichoptera (caddisflies) in Wisconsin.—Wisconsin Acad. Arts Sci. & Lett. 61:173–183.

Morse, W. J. and R. L. Blickle. 1953. A checklist of the Trichoptera (Caddis Flies) of New Hampshire.—Ent. News 64:68–102.

Nimmo, A. P. 1966. A list of the Trichoptera taken at Montreal and Chambly, Quebec, with descriptions of three new species.—Can. Ent. 98:688–693.

Resh, V. H. 1975. A distributional study of the caddisflies of Kentucky.—Trans. Kentucky Acad. Sci. 36:6–16.

Ross, H. H. 1938a. Lectotypes of North American caddisflies in the Museum of Comparative Zoology.—Psyche 45:1–61.

———. 1938b. Descriptions of Nearctic caddis flies (Trichoptera).—Bull. Ill. Nat. Hist. Surv. 21:101–183.

———. 1939. New species of Trichoptera from the Appalachian Region.—Proc. Ent. Soc. Washington 41:65–72.

———. 1941. Descriptions and records of North American Trichoptera.—Trans. Amer. Ent. Soc. 67:35–126.

———. 1944. The caddis flies, or Trichoptera, of Illinois.—Bull. Ill. Nat. Hist. Surv. 23:1–326.

———. 1962. Three new species of Trichoptera from eastern North America.—Ent. News 73:129–133.

———. 1963. Stream communities and terrestrial biomes.—Arch. Hydrobiol. 59:235–242.

Roy, D. and P. P. Harper. 1975. Nouvelles mentions de trichopteres du Quebec et description de *Limnephilus nimmoi* sp. nov. (Limnephilidae).—Can. J. Zool. 53:1080–1088.

Schuster, G. A. and D. A. Etnier. 1978. A manual for the identification of the larvae of the caddisfly genera *Hydropsyche* Pictet and *Symphitopsyche* Ulmer in eastern and central North America (Trichoptera: Hydropsychidae).—USEPA, Environmental Monitoring and Support Laboratory, EPA-600/4-78-060, pp. xii + 129.

Sweeney, B. W. and R. L. Vannote. 1978. Size variation and the distribution of hemimetabolous aquatic insects: two thermal equilibrium hypotheses.—Science 200:444–446.

Unzicker, J. D., L. Aggus, and L. O. Warren. 1970. A preliminary list of the Arkansas Trichoptera.—J. Georgia Ent. Soc. 5:167–174.

Virginia Division of Water Resources. 1970. York River Basin: Comprehensive Water Resources Plan. Volume I—Introduction.—Planning Bulletin 225, 112 pp.

Wallace, J. B. 1974. Silk spinning as an escape mechanism in *Hydropsyche orris* larvae following removal from water (Trichoptera: Hydropsychidae).—Ann. Ent. Soc. Amer. 68:549–550.

———. 1975. Food partitioning in net-spinning Trichoptera larvae: *Hydropsyche venularis, Cheumatopsyche etrona,* and *Macronema zebratum* (Hydropsychidae).—Ann. Ent. Soc. Amer. 68:463–472.

Wallace, J. B. and D. Malas. 1976. The significance of the elongate, rectangular mesh found in capture nets of fine particle feeding Trichoptera larvae.—Arch. Hydrobiol. 77:205–212.

Wallace, J. B., J. R. Webster, and W. R. Woodall. 1977. The role of filter feeders in flowing waters.—Arch. Hydrobiol. 79:506–532.

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