1-1-1983

A Survey of the Aspidogastrean and Hydracarine Parasites of Bivalue Molluscs in Western West Virginia

Donald W. Danford
dcdan@compascable.net

A SURVEY OF THE ASPIDOGASTREAN AND HYDRACARINE PARASITES OF BIVALVE MOLLUSCS IN WESTERN WEST VIRGINIA

A Thesis

Presented to

The Faculty of the Graduate School

Marshall University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

by

Donald W. Danford

May 1983

This Thesis was accepted on April 22 1983
Month Day Year

as meeting requirements for the Master's Degree.

Advisor James E. Joy
Dept. of Biological Sciences

Dean of Graduate School

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGEMENTS

This author wishes to thank Steve Lawton, George Bakewell, Steve McBride, Dr. James Joy, and Cathy Danford, for their help with collection of mussels in the field. Anita J. Pritchard was very helpful with the Laboratory work.

This author is very appreciative of the aid of Dr. Ralph W. Taylor and Dr. Stanley W. Ash for their help with this manuscript.

The author is indebted to his advisor, Dr. James Joy, for all the help he had given me. Without his help the manuscript and field work would not have come together.

ABSTRACT

Aspidogaster conchicola and Cotylaspis insignis were only two aspidogastrid trematodes recovered in a year long study involving 500 bivalves (22 species) collected from a thirteen county area in western West Virginia. Also collected were three species of aquatic mites identified as: Unionicola fossulata, Unionicola formosa, and Najadicola ingens. Only ten species of mussels were infested with trematodes: Pleurabema cordatum (100%); Anodonta grandis (70% for A. conchicola, 60% for C. insignis); Potamilus alata (50%); Tritogonia verrucosa (46%); Strophitus undulatus (6.25%); Quadrula quadrula (33%); Amblema plicata (31%); Quadrula postulosa (50%); Lampsilis ventricosa (7.11%); Lampsilis radiata luteola (7.12% for A. conchiocola, 10.2% for C. insignis). A total of 1067 trematode individuals (990 A. conchicola; 77 C. insignis) was recovered from the above clams. Parasite load was greatest in Potamilus alata at 39.5 per host, and lowest in Lampsilis radiata luteola at 2.0 per host. Numbers of A. conchicola for each species were highest in Potamilus alata at 435 per species and lowest in Quadrula pustulosa at 4.0. The number of C. insignis for each bivalve species was highest in Anodonta grandis at 14.3 per host, and lowest in Lampsilis radiata luteola at 2.0 per host.

Larval trematodes were collected from mussels on two occasions. Beechfork of Twelvepole Creek on 20 July 1981,

and again on 7 May 1982 at South Fork of Hughes River site #3. Beechfork had two trematodes with low numbers of immatures in each host.

Of 176 mites, 133 were U. fossulata, 41 were U. formosa individuals and two additional mites were recovered but the author was unable to assign it to a genus. Unionicola fossulata individuals were recovered from seven mussel species while five mussel species were hosts for Unionicola formosa. Najadicola ingens was found in two Lampsilis radiata luteola individuals.

CHAPTER I

INTRODUCTION

The Class Trematoda has been subdivided into three orders: the Monogenea, Digenea, and Aspidocotylea. The Monogenea and Digenea are very large groups each having thousands of species. Less is know about the Aspidocotylea than the Monogenetic or Digenetic trematodes. Perhaps this is because of the small size of the order, or because members of the order do not harm man. A great portion of the literature on the Aspidocotylea deals with phylogenetic considerations of the order.

Burmeister (1856) divided the trematodes into three subdivisions, and he termed the aspidogastrid trematodes the Aspidobothrii. Monticelli (1892) changed Aspidobothrii to Aspidocotylea. Rohde (1972) stated that the aspidogastrid trematodes were parasites of teleosts, turtles, gastropods, elasmobranchs, and pelecypods. Recently Huehner and Etges (1977) published an account of aspidogastrid trematodes. They found aspidogastrid trematodes in the snails Viviparous malleatus and Gonibasis livescens.

Parasites of bivalves in North America have been reported from several states. These states include New York, Tennessee, Oklahoma, Texas, Washington, Illinois, Florida, Ohio, and Maine. Among the parasites found were the relatively well known aspidogastrid trematodes, Aspidogaster conchicola and Cotylaspis insignis.

Objectives of this study were to determine the prevalence and intensity of aspidogastrid trematodes and aquatic mite infections in bivalves from four southwestern drainage areas in western West Virginia.

Citations and terminology presented in this thesis follow the style set forth by the American Association of Parasitologists (Mac Innis, 1980; Margolis, et al., 1982).

CHAPTER II

REVIEW OF LITERATURE

The two aspidogastrid trematodes recovered from mussels in this study were Aspidogaster conchicola and Cotylaspis insignis. Aspidogaster conchicola was first described by the Prussian, von Baer, in 1826. Burmeister (1856) divided the trematodes into three subdivisions. Aspidobothrii was the term given for the aspidogastrid trematodes. Monticelli (1892) divided the phylum into three orders, giving the aspidogastrids the order name Aspidocotylea. He thought the Aspidocotylea should be a suborder or a subclass, and this became widely accepted (Cheng 1973). Faust and Tang (1936) thought the Aspidogastridae were intermediate between Monogenea and Digenea. Cunningham (1887) placed aspidogastreans with the polystomes, a group of monogenetic trematodes. Baer and Joyeaux (1961) regarded the Aspidogastridae as closer to the Digenea than Monogenea. Stunkard (1917) thought that Aspidogastridae was closer to Digenea. Rohde (1972) agreed with Stunkard, he thought they were related closely with the Digenea but that they deserved to be placed in a separate order. Rohde (1972) stated that Aspidogastrid trematodes shared features in common with both Digenea and Monogenea. For example, members of the Aspidogastridae have direct development, like Monogeneans. However, unlike Monogeans, they often produce large numbers of eggs. On the other hand, they like Digentic larvae, are parasites of molluscs, and are structurally more similar to the Digeneans.

Surveys consisting of locality records and geographical distribution, make up a large portion of the literature of the Aspidogastridae. Voeltskow (1888) was the first to recover A. conghicola in mussels from the United States. In 1899 Kelly reported A. conchicola from Illinois, Iowa, and Pennsylvania. Leidy (1858) originally described C. insignis from mussels of the Schuylkill River (Anodonta fluviatilis, A. lacustris). Najarian (1955) surveyed Reelfoot Lake in Tennessee, and found C. insignis adults, larvae, and eggs, as well as aquatic mites. Hendrix (1968) reported a new locality record for A. conchicola from the Tennessee River at Coffee Landing, Tennessee. Pauley and Becker (1968) found aspidogastreans in the Columbia River in Washington. Michelson (1970) was first to report A. conchicola from the Massachussetts' snails Viviparous malleatus and V. japonicus. He discussed the length of gestation in snails to justify his belief that the snail was a natural host to A. conchicola. Huehner and Etges (1972) described a new species of Aspidogaster from the Cincinnati, Ohio area. They, later in 1977, published an article on the occurrence of A. conchicola found in Ohio snails.

Some of the literature dealt with the structure and function of organs in the aspidogastreans. Steinberg (1931) noted seasonal changes in reproductive organs of trematodes. Halton and Lyness (1971) discussed the tegument and other structures of A. conchicola. Huehner and Etges (1971)

reported on a possible host response by mussels infected with A. conchicola. Rohde (1972) published a review of the Literature, and a detailed account of the aspidogastrid, Multicotyle purvisi, its structures and functions, along with a brief review of the family.

Cotylaspis insignis was first described by Leidy (1858) from Anodontine mussels of the Schuylkill River in New York. Fulhage (1954) reported the first C. insignis individuals from Oklahoma (Lake Texoma). Nelson et al. (1975), citing Fulhage collected additional C. insignis from Oklahoma. Flook and Ubelaker (1972) surveyed Garza-Little Elm Reservoir in Texas. They found C. insignis in Lampsilis radiata luteola individuals, and using statistical methods found a relationship between size of host and number of C. insignis.

Aquatic Mites All Drainages Combined:

Three species of mites were identified from mussels in this study. These three mites are: Unionicola fossulata; Unionicola formosa; and Najadicola ingens.

Unionicola fossulata was first described by Koenike in 1895 as Atax fossulata. The North American species was formerly placed in the genus Pentatax (Vidrine 1981). Kelly (1899) found U. fossulata in mussels from streams in Illinois, Iowa, Pennsylvania. Wolcott (1898, 1899) published two articles, the first concerned only the genus Atax, and the second discussed the species found in the genus.

Marshall (1924) said that U. fossulata was a parasite of the tribe of Lampsiline mussels.

Unionicola formosa was originally described by Dana and Whelpley (1836) who named it Hydrachna formosa. Vidrine (1981) in his dissertation discussed the various synonomies of Unionicola formosa and synonomies may be found there.

Mitchell (1965) published an article on those mites parasitizing freshwater mussels of the Genus Anodonta. He wrote that these mites were mostly unmodified (e.g. legs of mites that were freeliving were identical to the legs of parasitic mites). He found forms that resided in mussels for only short periods of time. Other mites resided in the mussels for their entire life. He also reported four species of mites that parasitize Lampsilis radiata luteola they were: U. formosa; U. fossulata; U. abnormipes and Najadicola ingens. Vidrine (1979) observed that U. formosa appeared to have a population in each host of nine female mites to one male mite, later he changed his mind citing the fact that there was too much variation to be more convinced of his 9 to 1 ratio. Vidrine (1981) believed U. formosa was part of a large complex of mites distributed throughout the northern hemisphere.

Najadicola ingens was first described by Koenike in 1895, he termed it Atax ingens. Vidrine discussed synonomies of N. ingens; so they will not be dealt with here.

Humes and Jamnback (1950) stated that specimens of N. ingens are so large that individuals damage gills and marsupia. They examined mites from New England and southeastern Canada. They frequently collected N. ingens from Anodonta cataracta and Elliptio complanata and occasionally from Lampsilis radiata luteola. Vidrine (1981) gave the distribution for N. ingens as North America and southeast Asia.

Humes and Jamnback (1950), and Mitchell (1965) agreed that a population in host mussel was typically found to be one male to two females. Vidrine (1981) added that reproductively active females swell with eggs to an extent that their legs are unable to carry their own weight. He suggested that despite being an obligate parasite it is not frequently collected. In some sites (New England and southeastern Canada) N. ingens is common but in othersit is not (Vidrine 1981). Najadicola ingens according to Vidrine (1981) lacks host specificity among major groups of mussels. Najadicola ingens is found co-inhabiting the same hosts as members of the Unionicolinae. Humes and Jamnback (1950) found mites to live in outer suprabranchial chambers in the mussel Anodonta cataracta and in Elliptio complanata they found N. ingens in the inner suprabranchial chambers.

Nakana (1957) thought gill morphology was a possible factor in attracting certain species of mites to certain clams. Murray (1965) collected three species of mites (U. wolcotti, U. crassipes, and U. formosa) from mussels

in Kansas. Davids (1973) examined the relationship of mites to the mussels Anodonta and Unio from Amsterdam, Netherlands. Davids compared the location of the mites in the mussel and their degrees of parasitism. U. aculeata and U. bonzi were determined to be not parasitic. U. ypsilophora and U. intermedia as parasitic. Gordon et. al. (1979) suggested a three year lifecycle for U. formosa. They proposed a population ratio in mussels of one male to two females. Thus, agreeing with Mitchell and Vidrine. Gordon et al. (1979) thought that different lifecycle stages reside in different areas of the host thus allowing larger numbers in one mussel.

CHAPTER III

MATERIALS AND METHODS

Nearly all clams were collected by hand, from shallow areas of small streams throughout a thirteen county area in western West Virginia (Figure 1). The one exception was a deep water collection (approximately 2-12 Meters) on the Kanawha River mile mark 42-46 (18 September 1981) which utilized two boats operated by DNR personnel. Each boat was equipped with a clam brail and manned by four individuals over a four hour period.

Specimens were placed in buckets with water from the site of collection and transported to the lab that same day, usually within two hours. Specimens were placed in holding tanks containing stream water with a sand and gravel substrate. Mussels were left in holding tanks no longer than three days before examination. The water was continually aerated while the mussels were in the tank.

Each shell was first cleaned by hand, scraping mud and debris from outside of the shell, and rinsed with tap water. Bivalves were measured to determine length, height, width and then weighed on a triple beam balance. A definition of length and height can be found in an article by Taylor (1980). Length, height, and width were measured by Vernier calipers. Sexing was done when possible mainly by shell shape when Lampsilis radiata luteola and occasionally

by the presence of marsupia. Weight measurements were generally accomplished by use of an Ohaus triple beam balance, however, some bivalves were beyond the limits of the triple beam balance and a top loading scale was employed Sartorius, 2354 . Water displacement was obtained by using either a 500 or 1800 ml graduated beaker.

Bivalves were opened by severing adductor muscles, with a scalple inserted between the valve (BP 60 blade), then prying the two valves apart. Areas examined were the mantle, gills, foot, kidney, and pericardial region. The total numbers of mites and helminths were recorded along with other information such as species of clam, site, collector, identifier, date, and species of parasite.

Mites were killed and fixed in 10% buffered formalin then preserved in 70% ethanol or formalin. Live trematodes were placed on slides and flattened with the weight of a coverslip. Ten percent formalin, a killing and fixing solution, was introduced under the edge of the coverslip to prevent contraction of thetrematodes. Trematodes were left on the slides for approximately thirty minutes then transferred to 10% buffered formalin in 65 ml screw cap bottles for storage.

Specimens were removed from the formalin, or in a few instances 70% ethanol, and placed in two rinses of distilled water. Ten to fifteen minutes were required for both rinses. Dehydration at 50%, and 70% ethanol were completed at 15 minutes for each alcohol solution. Trematodes were then stained

in dilute Semichon's Acid Carmine prepared in 70% ethanol, for a period of 24 hours. Dehydration continued through 85, 95, and 99% ethanol. Proceeding from 99% a solution of equal volumes of ethanol and methyl salicylate, a clearing agent, were used. As the ethanol was replaced by methyl salicylate the specimens tended to sink. After they sank, 1:1 solution was decanted and pure methyl salicylate used to clear out the remaining alcohol. Specimens were mounted in Kleermount . Once mounted, the specimen was labeled indicating the date and place of collection, determiner, identifier, host's name, and species name. Mites were not stained.

Each bivalve was numbered with the intention of depositing desirable shells in the Marshall University Malacological Collection and for recording which parasites came from which clams.

All collection sites were located throughout western West Virginia. Collections were made from 17 May 1981 to 18 July 1982. Four drainage areas and thirteen counties were visited. The following collection sites are listed by their drainage areas (Roman Numerals). Military grids were used for sites from U.S.G.S. topographical maps (7.5 minute series). Site abbreviation appears in brackets.

I. OHIO RIVER DRAINAGE

Jackson County (5 sites)

►Mill Creek [MC] 1 August 1981. Site extends from bridge on road to Parchment Valley extending to a

point approximately 100 m. upstream. (MG 35369-686 to MG 35449644). Ripley Quadrangle.

- Sixteen Mile Creek [16C1] 1 August 1981. Approximately 1700 m. east of Mercers Bottom off road that connects Rt. 2 to site. (MG 002227800). Apple Grove Quadrangle.
- Sixteen Mile Creek [16C2] 7 August 1981. Same general area as previous site but slightly upstream. (MG 00337826). Apple Grove Quadrangle.
- Crooked Fork of Sandy Creek [CSC] 26 July; 1 August: directly underneath I-77 north bound and south bound bridges (MG 37140580) Sandyville Quadrangle.
- Sandy Creek [SC] 11 October 1981. On Rt. 2 1.92 kilometers south from I-77 Shadysprings exit (MG 39360683) Shadysprings Quadrangle.

Mason County (1 site)

- McClintic Wildlife Station Pond Number 6 [P-6] 17 May 1981 (MG 07470748). Chesire Quadrangle.

Wayne County (5 sites)

- Beech Fork of Twelvepole Creek [BF] 17, 23 May; 6, 17 June; 20 July (all 1981). Site near Lavalette W. Va. on Rt. 52 underneath bridge just south of Lavalette State Bank. (MG 73824130). Lavalette Quadrangle. (Beech Fork of Twelvepole Creek was termed through rest of thesis as Beech Fork).

- Twelvepole Creek [TP1]. 30 June 1981. At Shoals, W. Va. underneath bridge. Collection beginning underneath bridge and extending approximately 800 m. downstream. On Rt. 75. (MG 71004291). Lavalette Quadrangle.
- Twelvepole Creek [TP2]. 14 August 1981. On Rt. 52 cross stream at Lavalette State Bank upstream to about 2.56 kilometers. Site is a riffle area. (MG 72364097). Lavalette Quadrangle.
- Twelvepole Creek [TP3]. 2 September 1981. Site runs from .96 kilometers west of Junction of Rts. 52 and 75 at bend in Creek, is pool area, then riffle which is site. (MG 72164358). Lavalette Quadrangle.
- Twelvepole Creek [TP4] 16 October 1981. Same location as TP2 .

II. LITTLE KANAWHA DRAINAGE

Calhoun County (2 sites)

- Little Kanawha River [LK] 1 October 1981. Grantsville W. Va. 1.6 kilometers upstream from bridge at junctions of Rts. 16 and 5. In stream behind W. Va. State Police building in that city. (MG 92310707). Grantsville Quadrangle.
- West Fork Little Kanawha River [WK] 10 October 1981. at Orma, W. Va. on Rt. 16, 9.6 kilometers south of intersection of Rts. 16 and 33. Shallow meandering stream. (MG 92128335). Chloe Quadrangle.

Ritchie County (5 sites)

- North Fork Hughes River [NR1]. 25 July 1981. Approximately 1.6 kilometers southwest from downtown bridge at Cairo, W. Va. (MG 85693881). Cairo Quadrangle.
- North Fork Hughes River [NR2]. 1 October 1981. Site extends approximately 100 m. downstream at bend in river and pool are riffle next to a farm. (MG 86123799 to MG 86083808). Cairo Quadrangle.
- South Fork Hughes River [SR1]. 15 August 1981. 1.92 kilometers upstream from where south and north forks adjoin. (MG 77392829). Girtie Quadrangle.
- South Fork Hughes River [SR2]. 1 October 1981. 2.24 kilometers from Smithville, W. Va. toward Parkersburg, W. Va. on Rt. 47. (MG 89492467). Smithville Quadrangle.
- South Fork Hughes River [SR3] 7 May 1982. Site is at bridge where Rt. 53 and 47 connect, a riffle area directly under bridge to 400 m. downstream. (MG 77732807 to MG 77402828). Girta Quadrangle.

Roane County (1 site)

- Spring Creek [SpC] 12 September 1981. 2.56 kilometers south of junction of Rts. 33 and 119. Site is on 119 and extends 2.66 kilometers to 6.72 kilometers south of the intersection. (MG 67718793). Looneyville Quadrangle.

Wirt County (1 site)

- Sandstone Creek [SSC] 7 May 1982. Small stream

approximately 3 m. wide. On Rt. 53 at bridge to secondary road leading to Newark W. Va. Site is 75 m. long. (MG 68112407 to MG 68282408). Girta Quandrangle.

Wood County (2 sites)

- Tygart's Creek [TC1] 15 August 1981. Site is 1.2 kilometers south of Mineral Wells exit, site is small diverted stream that runs into Tygarts Creek. Starts at small bridge and runs 100 m. downstream. (MG 53803635). South Parkersburg Quadrangle.
- Tygart's Creek [TC2] 17 October 1981. Same location as above.

III. GUYANDOTTE DRAINAGE

Cabell County (2 sites)

- Mud River [MR1] 22 September 1981. Site extends from approximately 20 m. downstream of Mud River Falls to 400 m. upstream. (MG 09705322 to MG 93205319). Milton Quadrangle.
- Mud River [MR2] 23 July; 2 September. 1981 Pool approximately 20 m. downstream from MR1. (MG 92735324). Milton Quadrangle.

Lincoln County (1 site)

- Mud River number 3 [MR3] 13 September 1981. Riffle area approximately 6.88 kilometers from Rt. 3 on Upper Mud River Road. Approximately 100 m. long. (MG 02123107 to MG 02253129). Hager Quadrangle.

III. KANAWHA DRAINAGE

Kanawha County (3 sites)

- Elk River [ERQ] 12 September, 26 August. Queenshoals behind home of Charles Lynch, 266 Elk River Road. 4.16 kilometers upstream from bridge at intersection of Rts. 119 and 4. (MG 73405895). Blue Creek Quadrangle.
- Elk River [ERE] 26 August 1981. Elkview W. Va. (MG 57635462). Clendinin Quadrangle. Just downstream of bridge in Elkview that crosses Elk River. Bridge connects Rt. 119 and 10.
- Elk River [ERC] 26 August 1981. Clendinin W. Va. (MG 69586003). Just downstream of bridge crossing river. A junction of 119 and 4. Clendinin Quadrangle.

Putnam County (2 sites)

- Kanawha River [KR] 18 September 1981. Extends from underneath I-77 bridge at Nitro W. Va. to just upstream of Winfield Toll Bridge. (MG 26455525 St. Albans Quadrangle to MG 22006545). Winfield Quadrangle. River mark 42 to 46.
- HurricaneCreek [HC] 4.8 kilometers from Rt. 35 on Hurricane Creek Road. Site begins just downstream from bridge. (MG 13466427 to 13726443). Winfield Quadrangle.

Boone County (1 site)

- Coal River [CB] Near headwaters of Coal River near Madison W. Va. on little Coal River at Bridge carrying Rt. 17 across stream to Rt. 85.

CHAPTER IV

RESULTS

During the course of this investigation 31 collection sites--located on 18 streams and in one pond--in four drainage areas of western West Virginia were visited between 17 May 1981 and 18 July 1982. (Figs. 1 through 5). Five hundred bivalve molluscs, representing four families, 10 genera, and 22 species, were taken from those sites and examined for aspidogastrid trematodes and aquatic mites. The trematodes, Aspidogaster conchicola, von Baer and Cotylaspis insignis, Leidy, were found in only 10 of 22 species of mussels (Table I.) A total of 990 A. conchicola individuals was recovered from seven species of bivalves, while an additional 77 C. insignis were taken from five bivalve species. Only two molluscs, Lampsilis radiata luteola and Anodonta grandis served as hosts for both trematode species (Table I).

One thousand thirty-two aquatic mites were recovered. Only 176, or 17%, of them, however, could be accurately identified as belonging to Unionicola fossulata, U. formosa, or Najadicola ingens (Table XII). Two individuals of a fourth species could not be assigned to any known genus. Sixteen of the 22 bivalve species harbored aquatic mites. Lampsilis radiata luteola individuals harbored all four species of mites.

Aspidogastrid Trematodes--Ohio River Drainage:

As one can see in Figure 4 and Table II, the Ohio River Drainage was the largest in terms of total number of collection sites (12), and in total number of bivalves recovered (217). It was the second largest in terms of number of bivalve species (14) collected. Of those 14 species only 30 individuals, representing five species, were infested by A. conchicola (30/217, or 13.8%).

The highest prevalence rate was recorded for Potamilus alata (64.7%) where 11 of 17 individuals were infected. This was followed by: Anodonta grandis (50.0%), Tritogonia verrucosa (25.0%), Quadrula pustulosa (20.0%), and Lampsilis radiata luteola (10.4%). Zero prevalence rates were recorded for the remaining nine species of bivalves (Table II).

Not only did P. alata have the highest prevalence rate but it generally exhibited the highest intensity (mean number of A. conchicola individuals per host), ranging from a mean of 21.3 at Twelvepole site number three to 53.5 at Twelvepole site number four (Table III). Only L. r. luteola at Twelvepole site number four had a higher intensity, and that was 67.5. The intensity of A. conchicola infestations in Lampsilis radiata luteola was 9.9% at other sites. Intensities for the sites which constitute the Ohio River Drainage are shown in Table III.

The above results concerning trematode prevalence rates and intensity for mussels and sites, dealt with adult A. conchicola. There was only one instance, Beech Fork on 20 July 1981, where four immature forms of A. conchicola were found in each of two Lampsilis radiata luteola individuals.

Cotylaspis insignis was not found in any clam from the Ohio River Drainage.

Aspidogastrid Trematodes--Little Kanawha Drainage

The Little Kanawha River Drainage is depicted in Figure 3 and Table IV has data on prevalence rates. Eleven collection sites were visited in this drainage and sixteen mussel species were examined. The Little Kanawha River Drainage was the second largest in terms of number mussels collected (211). Only three species of mussels--Amblema plicata, Lampsilis radiata luteola and Tritogonia verrucosa were infested by A. conchicola. The prevalence rate of the entire drainage was 14/211 (6.6%). Tritogonia verrucosa had the highest prevalence rate (100%), where 1/1 individual was infested. Eight of 25 (32%); Amblema plicata carried A. conchicola while six of 146 (4.0%) Lampsilis radiata luteola individuals harbored this aspidogastrean.

Intensities for clams in the Little Kanawha River Drainage were generally low. Two Lampsilis radiata luteola individuals carried one aspidogastrean each. Amblema plicata individuals had intensities of 1.0,3.0, and a high of 18.8. Tritogonia verrucosa had a low intensity of 2.0. (Table V).

There were more mussel species (10) at the Little Kanawha River (at Grantsville, W. Va.) site than any other site visited during the course of this study, and yet none

were infested with aspidogastrid trematodes. Although 11 Little Kanawha Drainage sites were visited, clams infested by aspidogastrid trematodes were found only at five of those sites (Table IV). Hughes River sites had prevalence rates ranging from a low of 4.4% at South Fork Hughes River site number 1 to a high of 22.0% at North Fork Hughes River site number 1 (Table IV). Intensities for the five sites on the Hughes River where aspidogastreans were found ranged from 1.0 to 16.4 (Table V).

It was previously noted (Ohio River Drainage) that immature forms of A. conchicola were recovered from Lampsilis radiata luteola during July 1981. The following July in mussels from South Fork Hughes River site number 3, large numbers (>100) of A. conchicola immatures were also recovered from this drainage. Six of 74 mussels were infected thus prevalence rate was 8.1% (Table X). Mean number of A. conchicola per host never exceeded 2.5 (Table XI).

Aspidogastrid Trematodes--Guyandotte Drainage

Forty-three mussels were collected from three sites in the Guyandotte Drainage (Fig. 5). Only six of these mussels were infected by A. conchicola.

Prevalence rates for the Guyandotte Drainage ranged from a high of 100% for Pleurabema cordatum (1/1) and Tritogonia verrucosa carried a total of 119 A. conchicola individuals.

No C. insignis individuals were recovered from this drainage.

Aspidogastrid Trematodes--Kanawha River Drainage

As one can see in Table VII a total of 29 individual mussels from eight species plus the Asian clam, Corbicula fluminea, were examined from this area. All aspidogastrid trematodes collected from bivalves in the Kanawha River Drainage were C. insignis. Of the eight mussel individuals that carried C. insignis, four mussel species were represented. Interestingly enough, all of the infected bivalves were from Hurricane Creek. One Strophitus undulatus individual was infected with five C. insignis; this was the only time S. undulatus was found to carry aspidogastrid trematodes. Although 100% prevalence rates were recorded for A. grandis and Lampsilis ventricosa very few C. insignis were recovered. Quadrula quadrula had a prevalence of 75%, where 3 of 4 mussels were infected.

Table IX indicates intensities for bivalves in the Kanawha River Drainage. The highest intensity (14.3) was recorded for A. grandis. Next in order were: Strophitus undulatus with 5.0; Quadrula quadrula with 4.3; and Lampsilis ventricosa with 4.0.

Table XIII indicates the prevalence rates and mean number per host for aspidogastrid trematodes found in this study by mussel species.

Four mussel species recorded high prevalence rates (approximately 50%): Tritogonia verrucosa 6/13; Potamilus alata 10/20; Pleurabema cordatum 1/1; Amblema plicata (Table XIII). These high prevalence rates do not mean that much because of those four host mussels, three species had less than, or equal to, two mussel individuals collected for the entire study. Two mussel species had moderate prevalence rates (20-30%), Anodonta grandis (1/5), and Quadrula pustulosa (2/9). Two species had prevalence rates under 10%. They were Lampsilis radiata luteola 7.7%, and Lampsilis ventricosa 7.1%.

Intensity for mussel species carrying A. conchicola was also depicted in Table XIII. Highest mean number per host was recorded for P. alata with 39.5. Anodonta grandis had a mean number of A. conchicola per mussel of 20.0. Two mussel species had means of around 10; they were Tritogonia verrucosa (13.6), and Pleurobema cordatum (11.0), Amblema plicata (8.9), Lampsilis radiata luteola (7.12). Two mussel species had means less than 10 per host, Lampsilis ventricosa (4.0) and Quadrula pustulosa (2.0).

Four mussel species carried C. insignis individuals. They were: Anodonta grandis, Quadrula quadrula, Lampsilis radiata luteola, and Strophitus undulatus. High prevalence rates were recorded for Anodonta grandis; 3/5 and Quadrula quadrula 3/6 (Table XIII). Lampsilis radiata luteola individuals were recorded with a prevalence of 6/59, for C.

insignis. *Strophitus undulatus* individuals were at least infected, with a prevalence of 1/16.

Intensity for four mussel species with *C. insignis* individuals were: *Anodonta grandis*, 14.3; *Strophitus undulatus* 5.0; *Quadrula quadrula* 4.3; *Lampsilis radiata luteola* with an intensity of 2.0 per host.

Aquatic Mites -- All Drainage Areas combined

Of the 1032 mites recovered during the course of this study, only 176 could be accurately identified. The small number of identified mites as compared to unidentified mites was the result of technical problems. Most mites collected were either too damaged, or did not clear well enough in the methyl salicylate to allow for an accurate diagnosis.

One hundred and thirty-three *U. fossulata* individuals were recovered from seven mussel species that were distributed throughout all four drainages. *Unionicola formosa*, which also occurred in bivalves from all four drainage areas, was the second most common mite with 41 individuals identified. Five mussel species harbored *U. formosa*. *Najadicola ingens* was the least common species encountered, having been found in only two *Lampsilis radiata luteola* individuals, one collected from Spring Creek and the other from Twelvepole Creek (Table XII).

The author was unable to identify two well prepared mites that were found in two *L. r. luteola* individuals from Beech Fork Creek.

CHAPTER V

DISCUSSION

Sixty-two mussel individuals from all four drainages were infested with aspidogastrid trematodes giving bivalves a prevalence rate, for all drainages of 12.8%. Bakker and Davids (1973) collected 229 mussels (3 species) of which 37 were infected for a 16% prevalence rate. Rohde (1972) stated that the hosts of aspidogastrids were bivalves, gastropods, elasmobranchs, teleosts, and turtles. Michelson (1970) indicated the gastropods are true hosts of aspidogastrids.

It was reported by this author that 990 A. conchicola and 77 C. insignis individuals, were taken from ten bivalve species. This is approximately a 10 to 1 ratio of A. conchicola and 77 C. insignis. Kelly (1899) in his monograph of Unionid parasites--where 1614 mussels were examined from 11 sites in Illinois, Iowa, and Pennsylvania--suggested that A. conchicola was more common than C. insignis thus agreeing with the findings of this study. Najarian (1955) collected three mussel species: six A. grandis, 21 Ligumia subrostrata and one Uniomerus tetralasmus, and reported large numbers of C. insignis from Reelfoot Lake in Tennessee. He reported large numbers of worms, of which 212 were recovered from a single A. grandis. By comparison, only 43 C. insignis individuals were recovered from three A. grandis individuals from the

present investigation. Najarian (1955) reported no A. conchicola from Tennessee. Even though Najarian's paper does not agree with the present findings the samples could have easily been biased because his sample size was so small (28). Nelson et. al. (1975) indicated in his article on Oklahoma mussels that A. conchicola had an intensity equal to three times that of C. insignis. Kelly (1899) and Nelson (1975) had more A. conchicola than C. insignis individuals. Bakker and Davids (1973) usually found one to three aspidogastrids per clam. In this study, prevalence rates were low with 1064 aspidogastrids in 500 mussels which is only a little over two per host--similar to their results.

Intensities for various surveys were given as ranges and not ratios so only prevalence rates will be discussed when comparing other surveys to this one.

Kelly (1899) reported C. insignis from nine of ten collection sites. He recorded the presence of A. conchicola in six mussel species that were also found in the present investigation. Of Kelly's six mussel species, five were also recorded as hosts for C. insignis. Mussels found in common for both the present investigation and Kelly's investigation were: Lampsilis ventricosa; Anodonta grandis; Quadrula quadrula, and Lampsilis radiata luteola. Only two of this investigator's mussel species for the present investigation contained both A. conchicola and C. insignis, they were: Lampsilis radiata luteola and Anodonta grandis. Kelly (1899) reported both Aspidogaster and Coty-

laspis, from mussel hosts already listed. Other mussel species were: Lampsilis ventricosa, Quadrula pustulosa, and Strophitus undulatus.

Flook and Ubelaker (1972) showed less mussel species diversity (2 species), while the present study had ten host mussel species. Their study also had only one mussel species for each trematode parasite. Low prevalence rates were the rule for this study. Quadrula pustulosa. however, was 2/9 for the present investigation, and a prevalence of 5/14 was recorded by Flook and Ubelaker.

Najarian (1955) found that all of the Anodonta grandis averaging 97.5 trematodes from six adult individuals were infected. He found 20/21 Ligumia subrostrata individuals carried C. insignis. No Ligumia mussels were collected during the present study.

Nelson et al. (1975) had six mussel species in common with the present investigation (Table XIII). The author compared Nelson's results against the present study and all six mussel species had higher prevalence rates. Nelson reported a host record of 1545 A. conchicola individuals, in one Potamilus purpurata. Pauley and Becker (1968) collected western mussel species (Columbia River, Washington) that were not collected by the present investigator.

Hendrix (1968) collected five of the same mussel species that were collected by the present investigation. Four of those five mussel species had prevalence rates higher

than the present research effort despite having low numbers of hosts.

A Pearson Product-Moment correlation coefficient was run on Lampsilis radiata luteola individuals that carried Aconchicola. This was done to test for a relationship between mussel size and number of Aconchicola. Lampsilis radiata luteola males had a zero correlation, meaning no relationship existed between length of Lampsilis radiata luteola and A. conchicola had the same result.

Aspidogastrid Trematodes--Ohio River Drainage

Beechfork and Twelvepole Creek had more mussel species in common than any other streams in this investigation (all drainages). The six mussel species that they had in common are given in Table II. The prevalence rate for Beechfork without Corbicula fluminea is 2/54; prevalence rate for for Twelvepole Creek (4 sites combined) without Corbicula fluminea is 19/86. Thus the two sites had six mussel species in common and yet they had two quite different prevalence rates and intensities. Upon closer examination of this disparity one important piece of evidence must not be overlooked. Beechfork had only one individual each of: Lampsilis ventricosa, Potamilus alata, and Quadrula pustulosa. Where there has been no difference between Lampsilis ventricosa at Beechfork versus Twelvepole Creek since all 11 mussels (collected 5 and 6 mussels on two separate occasions) had no A. conchicola individuals. Potamilus

alata at Twelvepole Creek was quite different. Instead of no mussel infections (like BF) Twelvepole Creek had infections, 11 of those 14 mussel individuals were infected with trematodes. A similar result but not so exaggerated was observed for Quadrula pustulosa individuals. Only one Quadrula pustulosa at Beechfork had a prevalence rate of 2/31 while a closer look at Twelvepole Creek for Lampsilis radiata luteola individuals revealed 4/31 (two times the number at Beechfork). So one of the differences between these two sites can be seen as differences in infection rates of Potamilus alata and Lampsilis radiata luteola.

Sandy Creek had prevalence rates of 0/17 indicating low rates of parasitism for this site and maybe the entire study (Table II). Note in Table II that this site is well represented for number of mussel species. Only Beechfork and Twelvepole Creek had more species in this drainage. Mill Creek site number one had large numbers of mussels collected, but all 19 mussels were the same species. The prevalence rate was 20.9%. This may not be very accurate because of it having only one mussel species to comprise the site.

Potamilus alata and Anodonta grandis recorded high prevalence rates but Anodonta grandis had only two individual mussels recovered which would make Anodonta grandis less significant. Prevalence rates for mussel species ranged from 0 to 62%. Five mussel species from this drainage were

parasitized by aspidogastreans. Potamilus alata had 17 mussels recovered and 11 of them were infected by aspidogastreans. Corbicula fluminea and Fusconaia flava were of little consequence despite the numbers collected as none were infected (Table II). Tritogonia verrucosa had a prevalence rate of 25% in Ohio River Drainage, but there were only eight mussel individuals recovered so this species, due to the small number of clams may be less accurate statistically than Potamilus alata or Lampsilis radiata luteola. Perhaps the greatest number of individuals for a mussel species was Lampsilis radiata luteola since 96 individuals were recovered. Lampsilis radiata luteola prevalence rates were recorded at 10.5%. Throughout the drainage area a large portion of the mussels was not infested.

Throughout this study Potamilus alata was recorded having high intensity and prevalence rates, but every once in a while other species will have higher intensities. Lampsilis radiata luteola at Twelvepole Creek site number 4 had an intensity of 67.5, while Potamilus alata exhibited its highest intensity at 53.5.

Larval trematodes or immature forms were collected from Beechfork in July 1981. Immatures were again recorded from South Fork Hughes River site #3 in 18 July 1982. Two Lampsilis radiata luteola individuals harbored hundreds of immature aspidogastrean forms. In contrast to this somewhat apparent periodicity in egg and sperm production for

Aspidogaster one might expect larval forms to appear at certain times of the year. Steinberg (1931) found that the testis was enlarged in bivalves and active only at the beginning of June and the spermatozoa were produced in July. He continued, saying that oogenesis began in May and continued to mid July, at which time the ovary was at its maximum size. Steinberg's statement is compatible with the occurrence of this investigation's larval trematodes in July for two consecutive years (1981, 1982).

For C. insignis, Osborn (1903, 1905) stated that the testis was inactive in May and active in July.

Aspidogastrid Trematodes--Little Kanawha Drainage:

Although this drainage is the most diverse in terms of number of mussel species, only three mussel species carried A. conchicola individuals. Amblema plicata individuals were recorded with prevalence rates of 8/15. Number of mussel individuals collected were: 146 Lamp-silis radiata lutcola; Amblema plicata 25; and Lasmigona costata 9. All other species contained six or fewer individuals.

Aspidogaster conchicola was present on only seven occasions in the Little Kanawha Drainage (Table V). Mean numbers ranged from 1.0 to 18.8. Three of the mean numbers per host were 1.0, one was 1.5 and the other 3.0. Eight

Amblema plicata mussels were infected.

North Fork of Hughes River site #1 contained six mussel species recovered and three of them carried A. conchicola individuals.

Sites that had A. conchicola recovered from them were Hughes River (either South Fork or North Fork of Hughes River). Every site in Hughes River was represented by at least one A. conchicola individual. Hughes River sites, of mussel species diversity were comprised from two species, at South Fork Hughes River site #2, to six species of mussels at North Fork Hughes River site #1. One site contained six mussel species (NR1), two sites harbored five mussel species (NR2, SR3), one site had 4 mussel species (SR1), and SR2 revealed 2 mussel species. Compared to other drainages, the Hughes River was diverse in number of species. Kelly (1899) thought that the more mussel hosts, the larger the infestations and the more numerous and diverse the parasites tend to be. Hughes River had the only A. conchicola and C. insignis infec .tion for this drainage but also the only Cotylaspis insignis individuals were collected from the mussel Lampsilis radiata luteola at three different sites on the Hughes River (South Fork Hughes River site #2; South Fork Hughes River site #3; North Fork Hughes River site #1). Hughes River sites were represented by a large number of mussel species and as a result both aspidogastrean trematode species were recovered from Hughes River sites. No other

drainage had both species of aspidogastrids recovered from it. These data would seem to agree with Kelly's statement.

Aspidogastrid Trematodes--Guyandotte Drainage

Nine of the 43 bivalves collected were Corbicula fluminea individuals (Table IV). Those nine C. fluminea did not have any helminth or arthropod parasites. Throughout this investigation not a single C. fluminea individual contained a single parasite either aspidogastrid or acarine.

Mud River site number 2 had 14 Lampsilis radiata luteola individuals that were free of Aspidogaster parasites. Guyandotte drainage was characterized by a low number of mussel individuals collected and a high prevalence rate. Pleurabema cordatum 1/1, Tritogonia verrucosa 4/4 disagree with Kelly's hypothesis mentioned earlier in this paper because even though the number of mussel species was relatively high only Lampsilis radiata luteola individuals were collected from this site.

Intensities ranged from 11.0 to 75.0. Six host mussels contained 265 A. conchicola individuals from this drainage (Table VII). This author also believes that this disagrees with Kelly's hypothesis. Kelly (1899) suggested that whenever a given host is more plentiful, the infection is larger, and a greater variety of parasites occur.

Aspidogastrid Trematodes--Kanawha Drainage

Hurricane Creek is the most diverse site in terms of total numbers and number of mussel species in the Kanawha River Drainage (Table VIII). Eight mussel species were collected from Hurricane Creek and four of the eight carried C. insignis. In this drainage as with the previous drainage low numbers of mussel individuals were characteristic. Elk River mussels were not parasitized by aspidogastrid trematodes. The Kanawha River site had only two Corbicula flumincа which were not infested by trematodes of any type.

Prevalence rates for Hurricane Creek as a whole was 53.5% (8/15). Hurricane Creek contained more than half the total number of mussels collected from the Kanawha River Drainage.

While the number of individuals in Hurricane Creek was low, intensities were high. This would seem to disagree with Kelly's hypothesis. This characteristic mirrors the Guyandotte drainage. The highest number of C. insignis was recorded at 28.

Aquatic Mites--All Drainage Areas Combined

Five of the eight known mussel species identified as hosts for mites hold two species of mites: Unionicola

fossulata, and Unionicola formosa. Unionicola fossulata was the more common mite. According to Vindrine and Bereza (1979) U. fossulata is a common parasite of lampsiline mussels. Mitchell (1965) believed that mites occurred in groupings of two females to one male, the limiting factor for this ratio was not food but number of good oviposition sites. Vidrine & Bereza (1979) thought U. formosa had some host specificity for Anodonta but in this study U. formosa was found in Anodontoides ferruscianus, Lampsilis radiata luteola. Lasmigona complanata, Lasmigona costata, and Strophitus undulatus (Table XII). Mitchell (1955) found five mite species to inhabit the same mussel species L. radiata luteola, but due to different oviposition site little overlap between mites occurs. He discussed four mite species commonly found in Lampsilis radiata luteola. One of those mites U. fossulata, usually had less than ten specimens per mussel. He continued by saying that eggs appeared in early spring and oviposition continued through the early part of June. By late June most mussels were free of mite eggs. Mitchell (1955) described the lifecycle of mites. This author noticed female mites filled with eggs but no attempt to discern any periodicity was made. Humes and Jamnback (1950) discussed the large numbers of Najadicola ingens they collected from mussels of New England and southeastern Canada. They found N. ingens to principally parasitize two host clams Anodonta cataracta and Elliptio complanta and usually Lampsilis

radiata. This author collected his two N. ingens individuals from two Lampsilis radiata luteola individuals. Vidrine (1980) found very few N. ingens in his examinations but stated that in some sites N. ingens were quite common.

Figure 1. Collection sites for the entire study.

Twelvepole Creek site number 1	TP1
2	TP2
3	TP3
Beech Fork of Twelvepole Creek	BF
Mud River site number 1	MR1
2	MR2
3	MR3
Mill Creek site number 1	MC1
2	MC2
Sandy Creek	SC
Crooked Fork Sandy Creek	CSC
Tygart's Creek	TC
Worthington Creek	WoC
North Fork Hughes River 1	NR1
2	NR2
South Fork Hughes River 1	SR1
2	SR2
3	SR3
Sandstone Creek	SSC
Little Kanawha River	LK
West Fork Little Kanawha River	WK
Spring Creek	SpC
Elk River at Elkview	ERE
at Clendenin	ERC
at Queenshoals	ERQ
Kanawha River	KR
Little Coal River at Madison W. Va.	CB

Fig.1

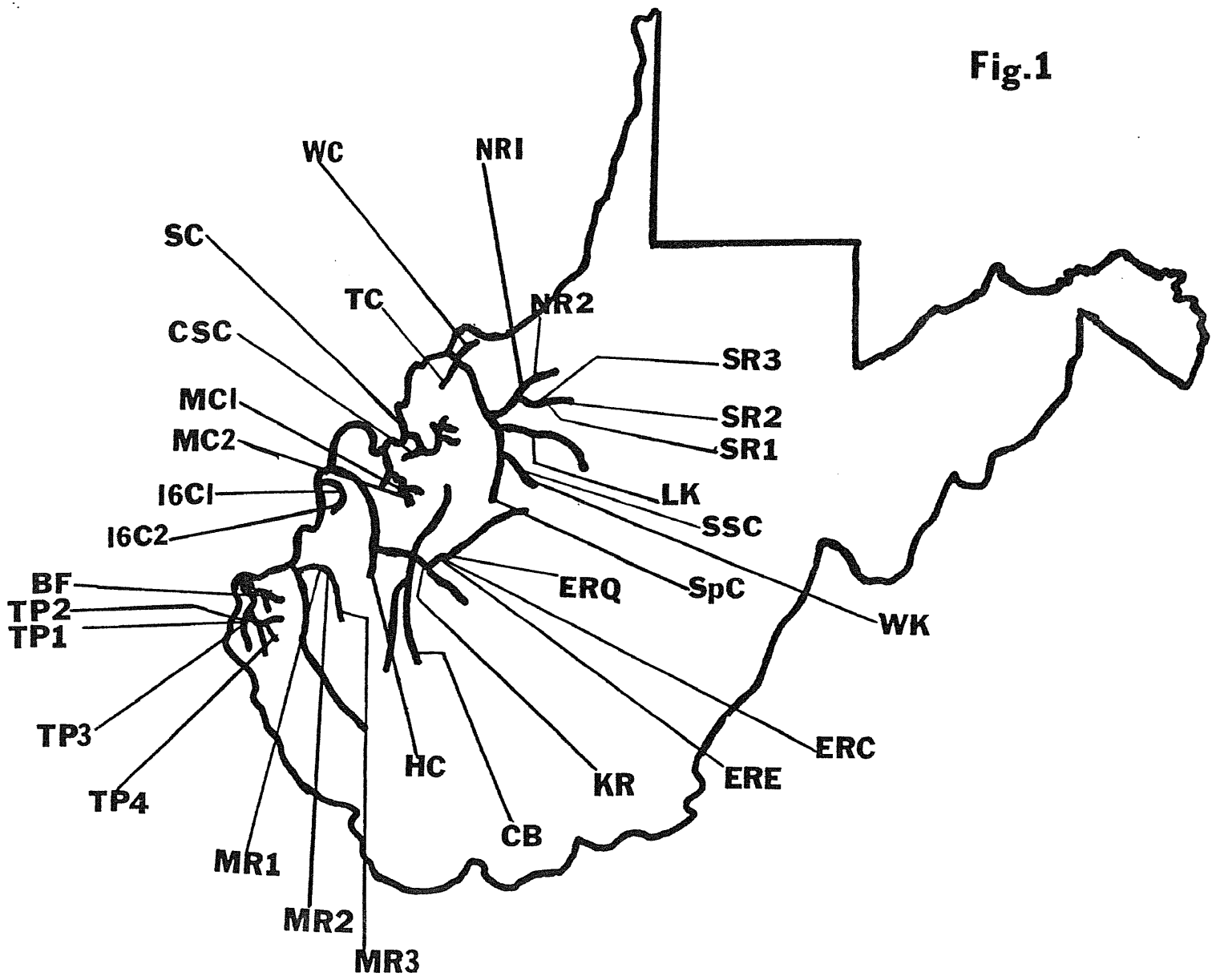
WC
NRI
SC
TC
NR2
CSC
SR3
MCl
SR2
MC2
SR1
I6Cl
LK
I6C2
SSC
BF
ERQ
SpC
TP2
TP1
WK
TP3
ERC
HC
KR
ERE
TP4
CB
MR1
MR2
MR3

Figure 2. Kanawha River Drainage collection sites.

Hurricane Creek	HC
Kanawha River	KR
Elk River at Elkview	ERE
Elk River at Clendinin	ERC
Elk River at Queenshoals	ERQ
Little Coal River near Madison W.Va.	CB

Numbers in parentheses are number of mussels collected at that site.

See Materials and Methods for specific site locations Pg. 15.

Fig. 2

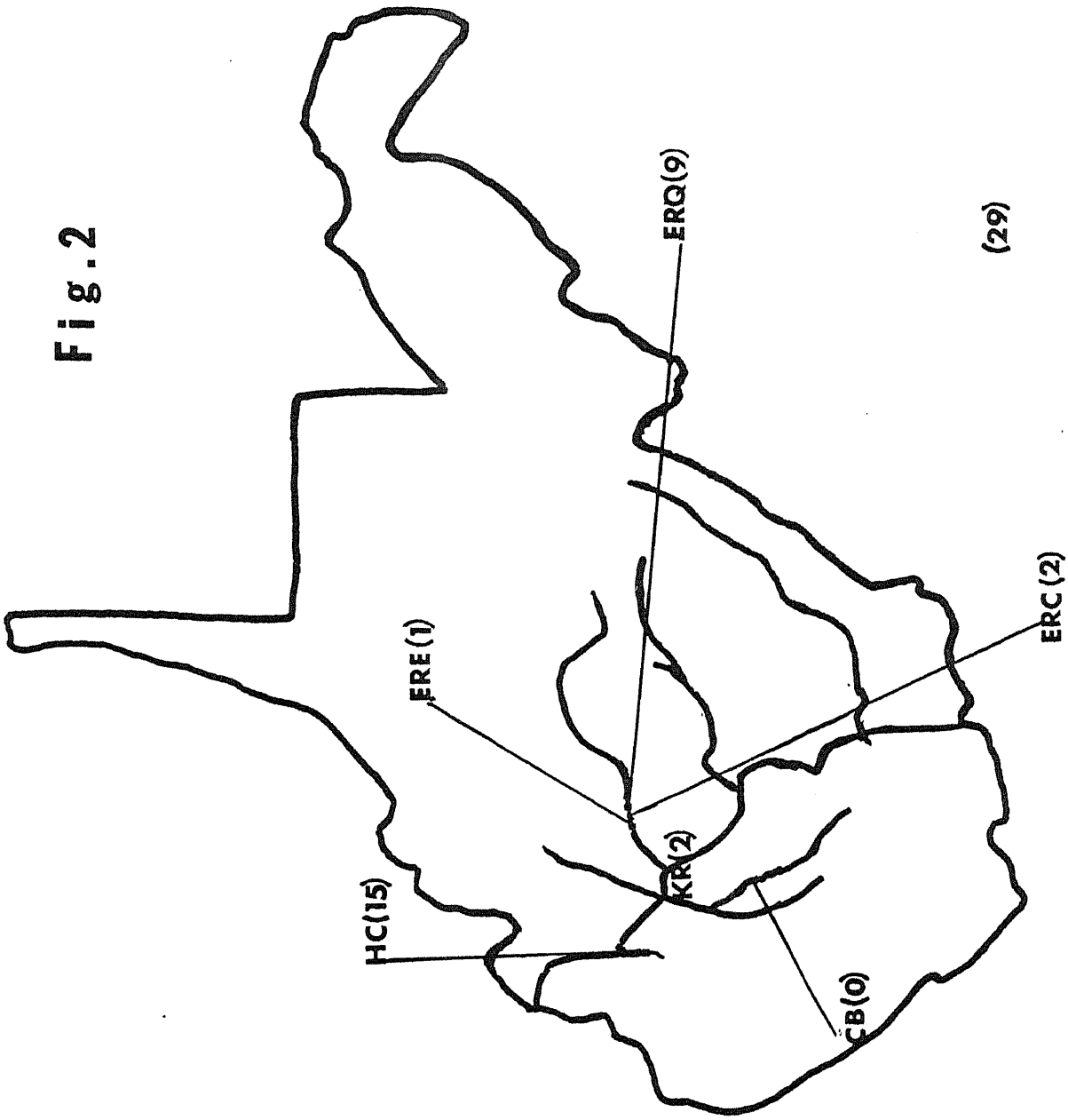

Figure 3. Little Kanawha River Drainage collection sites.

Tygart Creek site number 1	TC1
2	TC2
Spring Creek	SpC
West Fork Little Kanawha River	WK
Little Kanawha River	LK
Sandstone Creek	SSC
South Fork Hughes River site number 1	SR1
2	SR2
3	SR3
North Fork Hughes River site number 1	NR1
2	NR2
Worthington Creek	WoC

Numbers in parentheses are number of mussels collected for that site. Specific site locations can be found in Materials and Methods Pp. 13-14.

Fig. 3

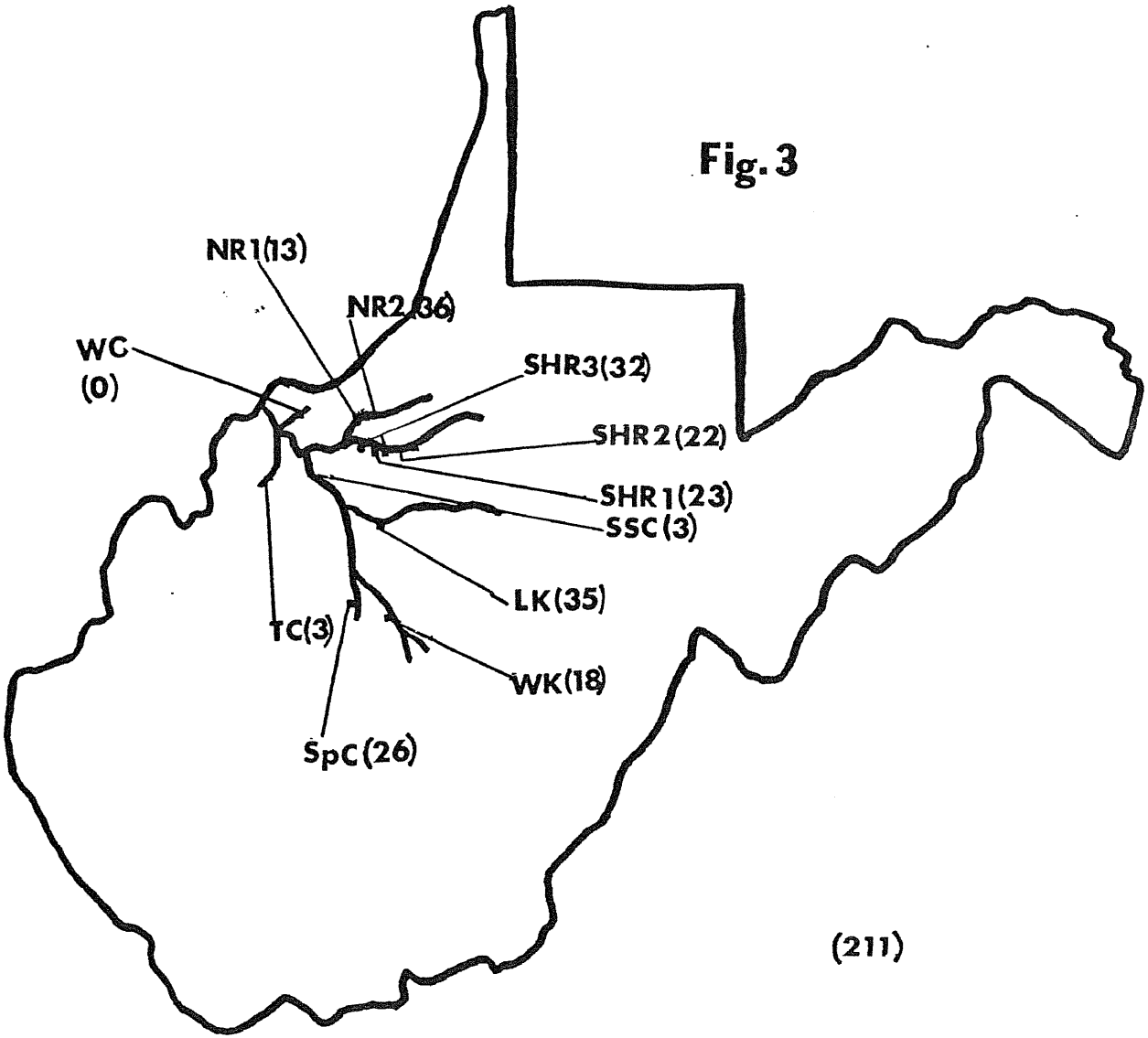
NR1(13)
NR2(36)
WC
(0)
SHR3(32)
SHR2(22)
SHR1(23)
SSC(3)
LK(35)
TC(3)
WK(18)
SpC(26)
(211)

Figure 4. Ohio River Drainage Collection sites.

Twelvepole Creek site number 1	TP1
2	TP2
3	TP3
4	TP4
Beech Fork Twelvepole Creek	BF
Sixteen Mile Creek site number 1	16C1
2	16C2
Mill Creek site number 1	MC1
2	MC2
Sandy Creek	SC
Crooked Run Sandy Creek	CSC
McClintic Wildlife Station Pond #6	P-6

Numbers in parentheses are number of mussels collected from that site. Specific site locations are in Materials and Methods Pg. 11-13.

Fig. 4

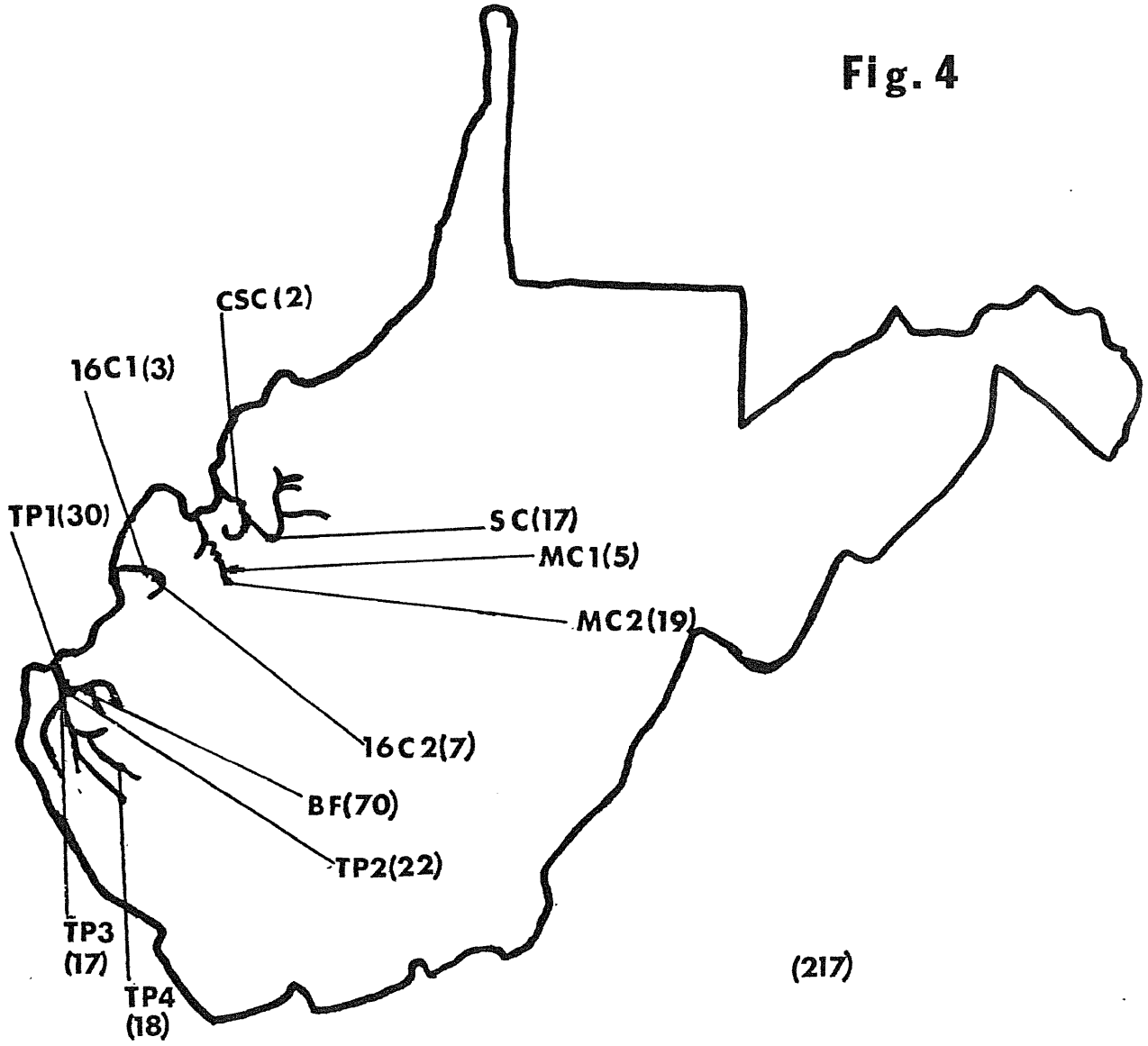
CSC(2)
16C1(3)
TP1(30)
SC(17)
MC1(5)
MC2(19)
16C2(7)
BF(70)
TP2(22)
TP3
(17)
TP4
(18)
(217)

Figure 5. Guyandotte River Drainage.

Mud River site number	1	MR1
	2	MR2
	3	MR3

Numbers in parentheses are numbers of mussels collected for each site. Specific site locations are in Materials and Methods Pg. 14-15.

Fig. 5

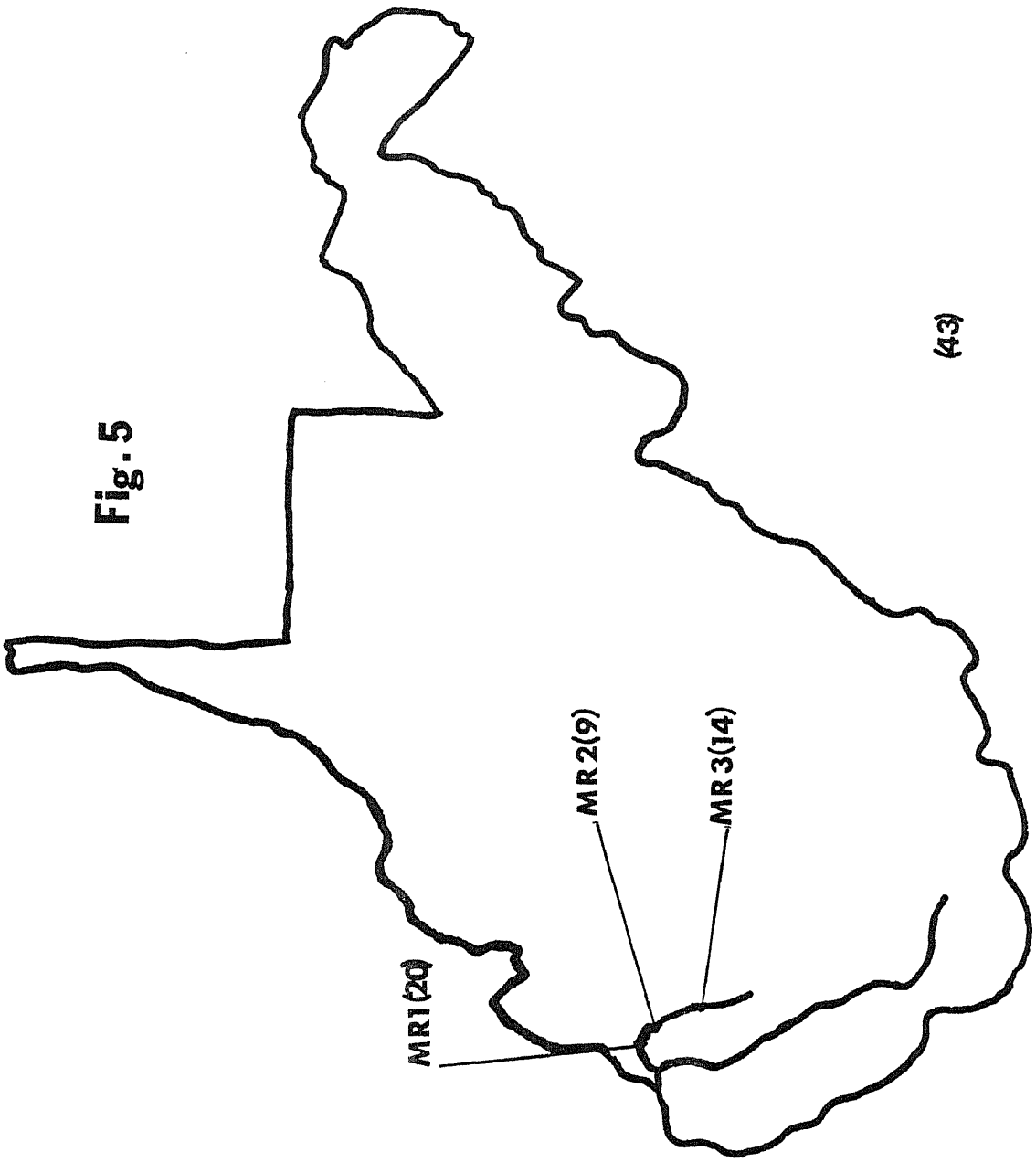

Table I. Aspidogastrid trematodes and their mussel hosts.

	Aspidogaster conchicola	*Cotylaspis insignis*
Amblema plicata	117	
Anodonta grandis	20	43
Lampsilis r. luteola	269	12
Lampsilis ventricosa		4
Pleurabema cordatum	11	
Potamilus alata	435	
Quadrula pustulosa	4	
Quadrula quadrula		13
Strophitus undulatus		5
Tritogonia verrucosa	134	
Totals	990	77

Table II. Prevalence of Lasidiopaster conchicola in 14 mussel species from 12 collection sites on the Ohio River Drainage.

	TP	TP1	TP2	TP3	TP4	OR1	OR1	OR2	OR11	OR12	R-6	OR9	Totals
Anodonta grandis						0/1	1/1						1/2
Anodontoides ferrussianus						0/8							0/8
Corbicula fluminea	0/16	0/1											0/17
Fusconaia flava	0/16	0/2											0/18
Lasmigona complanata						0/1	0/3			0/2			0/6
Lasmigona costata			0/1										0/1
Lampsilis r. luteola	0/32	1/8	1/10	1/8	2/6	0/7	0/1	4/19	3/3	1/4			12/98
Lasmosilis ventricosa	0/1	0/5			0/6								0/12
Potamilus alata	0/1	1/2	3/4	3/4	4/4							0/2	11/17
Quadrula pustulosa	0/1	0/5	0/1	1/1	1/1								2/9
Quadrula quadrula										0/1			0/1
Sphaerium sp.											0/7		0/7
Strophitus undulatus	0/3	0/3	0/5	0/2									0/13
Tritogonia verrucosa		0/4	0/1	1/2	1/1								2/8
Totals	0/70	2/30	4/22	6/17	8/18	0/17	1/5	4/19	3/3	1/7	0/7	0/2	29/217

Table III. Mean number of *A. conchicola* in 14 mussel species from 12 collection sites on the Ohio River Drainage.

	EF	TP1	TP2	TP3	TP4	SC1	KC1	MC2	16C1	16C2	P-6	CSC
Anodonta grandis						-*	20.0					
Anodontoides ferruscianus						-						
Corbicula fluminea	-	-										
Fusconaia flava	-	-										
Lasmigona complanata						-	-					
Lasmigona costata			-			-	-			-		
Lampsilis r. luteola	-	14.0	18.0	2.0	67.5	-	-	2.3	9.0	2.0		
Lampsilis ventricosa	-	-			-							
Potamilus alata	-	26.0	43.7	21.3	53.5							-
Quadrula pustulosa	-	-	-	1.0	3.0							
Quadrula quadrula										-		
Sphaerium sp.											-	
Strophitus undulatus	-	-	-	-								
Tritogonia verrucosa		-	-	6.0	7.0							

* - mussels were collected at this site but no *A. conchicola* were recovered.

Table IV. Prevalence of Aspidogaster conchicola in 15 mussel species in 11 collection sites on Little Nanawha Drainage.

	LN	ST1	SP2	SP3	NR1	UP2	WF	SpC	SS1	TC1	TC2	Totals
Actinonaias carinata	0/4			0/1		0/1						0/6
Amblema plicata	0/8	1/7			6/7	1/3						8/25
Elliptio crassidens	0/1											0/1
Elliptio dilitata	0/2						0/4					0/6
Fusconaia flava		0/1					0/1					0/2
Fusconaia maculata	0/2											0/2
Lampsilis r. luteola	0/12	0/14	2/21	2/28	0/24	0/1	0/13	0/25	0/3	0/1	0/1	4/146
Lampsilis vertricosa	0/1			0/1								0/2
Lasmigona complanata				0/1								0/1
Lasmigona costata			0/1	0/1	0/1	0/3		0/1				0/9
Obovaria subrotunda					0/2							0/2
Potamilus alata		0/1				0/1					0/1	0/3
Ptychobranchus fasciolaris	0/2											0/2
Quadrula quadrula	0/1											0/1
Strophitus undulatus	0/1				0/1							0/2
Tritogonia verrucosa					1/1							1/1
Totals	0/34	1/23	2/22	2/32	7/36	1/14	0/18	0/26	0/3	0/1	0/2	13/211

Table V. Mean number per host of *A. conchicola* in 15 mussel species in 11 collection sites in Little Yanawha Drainage.

	LMR	SR1	SR2	SR3	NR1	NR2	WMR	SpC	SSC	TC1	TC2
Actinonaias carinata	-			-							
Amblema plicata	-	3.0			18.0	1.0					
Elliptio crassidens	-										
Elliptio dilitata	-						-				
Fusconaia flava		-					-				
Fusconaia maculata	-										
Lampsilis r. luteola	-	-	1.0	1.5	1.0	-	-	-	-	-	-
Lampsilis ventricosa	-			-							
Lasmigona costata			-	-	-	-		-			
Obovaria subrotunda					-						
Potamilus alata		-				-					-
Ptychobranchus fasciolaris	-										
Quadrula quadrula	-										
Strophitus undulatus	-										
Tritogonia verrucosa					2.0						

Table VI. Prevalence rates of *Aspidogaster conchicola* in 4 mussel species on the Guyandotte River Drainage.

	MR1	MR2	MR3	Totals
Corbicula fluminea			0/9	0/9
Lampsilis r. luteola	1/11	0/14	0/4	1/29
Pleurabema cordatum			1/1	1/1
Tritogonia verrucosa	3/3		1/1	4/4
Totals	4/14	0/14	2/15	6/43

Table VII. Mean number per host of *A. conchicola* in 5 collection sites of Guyandotte Drainage.

	HD1	HD2	HD3
Corbicula fluminea			-
Lampsilis r. luteola	75.0	-	-
Pleurabema cordatum			11.0
Tritogonia verrucosa	32.6		21.0

Table VIII. Prevalence for Cotylasmis insignis in Kanawha River Drainage. Five sites were collected in Kanawha River Drainage.

	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Totals
Anodonta grandis				3/3		3/3
Corbicula fluminea					0/2	0/2
Fusconaia flava				0/1		0/1
Lampsilis F. luteola	0/1	0/2	0/9	0/1		0/13
Lampsilis ventricosa				1/1		1/1
Lasmigona complanata				0/4		0/4
Lasmigona costata				0/1		0/1
Quadrula quadrula				3/3		3/3
Strophitus undulatus				1/1		1/1
Totals	0/1	0/2	0/9	8/15	0/2	8/29

Table IX. Mean number of Cotylaspis insignis per host in the Kanawha River Drainage.

	ERE	ERC	ERQ	HC	KR
Anodonta grandis				14.3	
Corbicula fluminea					-
Fusconaia flava				-	
Lampsilis r. luteola	-	-	-	-	
Lampsilis ventricosa				4.0	
Lasmogona complanata				-	
Lasmogona costata				-	
Quadrula quadrula				4.3	
Strophitus undulatus				5.0	

Table X. Prevalence of Cotylaspis insignis in a single species of mussel from three collection sites in the Little Wanawha River Drainage.

	SR2	SR3	NR1	Totals
Lampsilis r. luteola	4/21	1/28	1/24	6/74

Table XI. Mean number of C. insignis individuals per host from three different collection sites in the Little Wanawha River Drainage.

	SR2	SR3	NR1
Lampsilis r. luteola	2.5	1.0	1.0

Table XII. Identified aquatic mites, broken down by their hosts. Only 178 mites could be identified out of a total of 1132 mites recovered.

	Unionicola fossulata	*Unionicola formosa*	*Najadicola ingens*	Unidentified sp.
Amblema plicata	3			
Anodontoides ferruscianus	1	7		
Lampsilis r. luteola	86	12	2	2
Lampsilis ventricosa	1			
Lasmigona complanata	4	12		
Lasmigona costata	1	5		
Strophitus undulatus		1		
Tritogonia verrucosa	12			
Unknown hosts	25	4		
Totals	133	41	2	2

Table XIII. Prevalence and mean number of aspidogastrid trematodes (intensity) for bivalves in western West Virginia.

HOST	*Aspidogaster conchicola*		*Cotylaspis insignis*	
	Prevalence	Intensity	Prevalence	Intensity
Amblema plicata	8/27	14.6		
Anodonta grandis	1/5	20.0	3/5	14.3
Lampsilis r. luteola	18/283	14.9	6/283	2.0
Lampsilis ventricosa			1/14	4.0
Potamilus alata	11/20	39.5		
Pleurabema cordatum	1/1	11.0		
Quadrula pustulosa	2/9	2.0		
Quadrula quadrula			3/6	4.3
Strophitus undulatus			1/16	5.0
Tritogonia verrucosa	7/13	19.1		

LITERATURE CITED

Baer, J. G. and C. Joyeaux. 1961. Classe des trematodes in grasse, traite de Zoologie 4 (not seen; fide Rohde 1972).

Bakker, J. G. and C. Davids. 1973. Notes on life history of Aspidogaster conchicola Baer 1826 (Trematoda: Aspidogastridae). Journal of Helminthology 47(3): 269-276.

Burmeister, H. 1856. Zoonomische Briefe. Allegemeine Darste llung der thierischen Organisation II Leipzig. (fide Rohde 1972).

Cheng, T. C. 1973. Parasitology. Academic Press. New York.

Cunningham, J. T. 1887. On Stichocotyle nephropis, a new trematode. Trans. R. Soc. Edinburgh. 32:273-280. (not seen; fide Rohde 1972).

Davids, C. 1973. The relations between mites of the genus Unionicola and the mussels Anodonta and Unio. Hydrbio logia 41(1): 37-44.

Flook, J. M. and J. E. Ubelaker. 1972. A survey of metazoan parasites in Unionid Bivalves of Garza-Little Elm Reservoir, Denton County, Texas. Tex. Journal of Science 23: 381-392.

Fulhage, I. 1954. The occurrence of Cotylaspis insignis Leidy, (Aspidogastridae) in clams and turtles of Lake Texoma. Proc. Okla. Acad. Sci. 67-68.

Gordon, M. J., B. K. Swan, and C. G. Paterson. 1979. The biology of Unionicola formosa (Dana and Whelpley): a water

mite parasitic in the unionid bivalve, Anodonta cataracta (Say), in a New Brunswick Lake. Can J. Zool. 57(9): 1748-1756.

Halton, D. W. and R. A. W. Lyness. 1971. Ultrastructure of the tegument and associated structures of Aspidogaster conchicola (Trematoda: Aspidogastrea) J. Parasit. 57(6) :1198-1110.

Hendrix, S. S. 1968. New host and locality records for two Aspidogastrid trematodes, Aspidogaster conchicola and Cotylaspis insignis. J. Parasit. 54 (1):179.

Huehner, M. K. and F. J. Etges. 1971. A new aspidogastrid host for Aspidogaster conchicola. J. Parasit. 57(6): 1255.

_____. 1972. A new aspidogastrid trematode Cotylogasteroides sp. n., from freshwater mussels of Ohio. J. Parasit. 58(3): 467-470.

_____. 1977. The lifecycle and development of Aspidogaster conchicola in the snails Viviparous malleatus and Goniobasis livescens. J. Parasit. 63 (4): 669-674.

_____. 1981. Encapsulation of Aspidogaster conchicola (Trematoda: Aspidogastrea) by unionid mussels. J. Invert. Path. 37:123-128.

Humes, A. G. and H. A. Jamnback. 1950. Najadicola ingens (Koenike), a water mite parasitic in fresh-water clams. Psyche. 57(3): 77-87.

Kelly, H. M. 1899. A statistical study of parasites of the Unionidae. Ill. State Lab. Nat. Hist. 5: 399-418.

Kofoid, C. A. 1899. On specific identity of Cotylaspis insignis Leidy and Platyaspis anodontae Osborn. Zool. Bull 2:179-185.

Koenike, F. 1895. Nordamerican Hydrachniden, Abh natur wiss. Ver. Bremen. 13(2): 167-226. (not seen; fide Vidrine 1981).

Leidy, J. 1858. Contributions to helminthology. Proc. Acad. Nat. Sci. Phila. 10:110-112.

MacInnis, A. J. 1980. Instructions to Authors. J. Parasit. 66(5): 865-880.

Margolis, L. G. W. Esch, J. C. Holmes, A. M. Kuris, and G. A. Shad. 1982. The use of ecological terms in parasitology (Report of an adhoc committee of the American Society of Parasitologists) J. Parasit. 68(1): 131-133.

Marshall, R. 1924. Water mites of Alaska and Canadian north west. Trans. Amer. Micros. Soc. 43: 236-255, (not seen; fide Vidrine 1981).

Michelson, E. H. 1970. Aspidogaster conchicola from freshwater gastropods in the United States J. Parasit. 53(4): 709-712.

Mitchell, R. D. 1955. Anatomy, lifehistory, and evolution of the mites parasitizing freshwater mussels. Mus. Zool. U. Mich. Misc. Publ. No. 89, 1-27.

_____ 1965. Population regulation of a water mite parasitic on Unionid mussels. J. Parasit. 51:990-996.

Murray, H. D. 1965. Unionicolidae (Acarina) parasitizing Unionidae (Mollusca) in Kansas. Trans. Kan. Acad. Sci. 68(4): 584-585.

Najarian, H. H. 1955. Notes on aspidogastrid trematodes and hydracarina from some Tennessee mussels. J. Tenn. Acad. Sci. 30(1): 11-14.

Nakana, P. 1950. Natural history and distribution of water mites Genus Unionicola, in Anodonta grandis (Say), Lampsilis siliquoidea (Barnes), and Ligumia nasuta (Say). J. Ala. Acad. Sci. 30(1):8.

Nelson, E. N., J. K. Richardson, H. H. Bailey. 1975. Aspects of the occurrence of Aspidobothrid parasites (Trematoda: Aspidobothria) in Oklahoma naiads (Pelecypoda: Unionidae)

Osborn, H. L. 1905. Habits and structure of Cotylaspis insignis (Leidy) from Lake Chautauqua, N. Y. Zool. Jahr. 211-242.

Pauley, G. B. and C. D. Becker. 1968. Aspidogaster conchicola in mollusks of the Columbia River system with comments on the hosts pathological response. J. Parasit. 54(5): 917-920. John Wiley and Sons. New York.

Pennak, R. W. 1978. Freshwater Invertebrates of the United States.

Rohde, K. 1972. The aspidogastrea, especially Multicotyle purvisi Dawes 1941. Advances in Parasitology 10: 78-145.

Steinberg, D. 1931. Die Geschlechtsorgane von Aspidogaster conchicola Baer and ihr Jhrcyclus (Vorlaufige Mitteilung). Zool. Anz. 94: 153-170.

Stunkard, H. S. 1917. Studies on North American polystomidae, Aspidogastridae, and Paramphistomidae. Ill. Biol. Monogr. 3:1-114.

Taylor, R. W. 1980. A survey of the freshwater mussels of the Ohio River from Greenup Locks and Dam to Pittsburgh, Pa. Huntington/Pittsburgh Districts, U.S.A. Corps of Engineers. 71 pp.

Thorn, M. D. 1980. Introductory Statistics for Psychology Duxburg Press, North Scituate, Massachusetts.

Van Cleave, H. J. and C. O. Williams. 1942. Maintenance of a trematode, Aspidogaster conchicola, outside the body of its natural host. J. Parasit. 28: 127-130.

Williams, C. O. 1942. Observations of the lifehistory and taxonomic relationships of the trematode Aspidogaster conchicola J. Parasit. 28: 467-475.

Vidrine, M. F. 1979. Unionicola (Pentatax) fossulata (Koenike 1895) (Arthropoda: Acarina: Unionicolidae) in eastern North American freshwater mussels. (Mollusca: Bivalvia: Unionacea: Unionidae: Lampsilinae: Lampsilini). Proc. La. Acad. Sci. 42:84.

Vidrine, M. F. 1981. Systematics and coevloution of Unionicolid water-mites and their unionid mussel hosts in the eastern United States. Doctoral Dissertation University South western Louisiana, Lafayette La., 661 p.

Voeltskow, H. E. 1888. Aspidogaster conchicola. Arb. Zool. Zootom. Inst. Wurzburg. 8:249-289. (not seen; fide Vidrine 1981).

Wolcott, R. 1898. New American species of the genus Atax. (Fab.) Bruz. Zool. Bull. 1: 279-285. (not seen; fide Vidrine 1981).

Yamaguti, S. 1965. Systema Helminthum. Vol. IV. John Wiley and Sons, New York. 699 p.