# Unionid Mollusca (Bivalvia) from Little South Fork Cumberland River, with Ecological and Nomenclatural Notes

LYNN B. STARNES

*Tennessee Valley Authority,*
*450 Evans Building, Knoxville, Tennessee 37902*

AND

ARTHUR E. BOGAN

*Department of Malacology,*
*Academy of Natural Sciences of Philadelphia,*
*19th and the Parkway, Philadelphia, Pennsylvania 19103*

*ABSTRACT.*— A mollusk survey of the Little South Fork of the Cumberland River in southern Kentucky from 1977 to 1981 yielded 24 species of Unionidae, one species of Corbiculidae, and 5 species of aquatic gastropods. Pertinent taxonomic notes on unionids are made herein. A series of quantitative surveys in riffles in the lower third of the river (an area designated a Kentucky Wild River) revealed average unionid densities ranging from 2.87 to 7.53 individuals per square meter. Approximately five percent of the river contains optimal riffle habitat. Average corbiculid densities ranged from 10.75 to 46.59 individuals per square meter.

## INTRODUCTION

The Little South Fork of the Cumberland River (herein referred to as Little South Fork) originates in Pickett County, Tennessee, meanders through the Interior Low Plateau physiographic province, and confluences with the Big South Fork of the Cumberland River approximately 110 stream kilometers (64 air km) from its source (Fig. 1) (Fenneman 1938). Little South Fork changes from a high gradient stream south of the Kentucky-Tennessee border to a moderate gradient stream with well developed riffles and increasingly larger pools downstream.

Throughout its length little South Fork has eroded through Pennsylvanian shale and sandstone to Mississippian limestone. Water quality data reported by Harker et al. (1979, 1980) indicate that the Kidder and Ste. Genevieve Limestone Members of the Monteagle Limestone, exposed in the streambed, strongly influence water chemistry.

Development within the Little South Fork watershed is limited and approximately 65% of the drainage area forested (Harker et al. 1980.) Agriculture is primarily limited to floodplains. The watershed in the vicinity of Mt. Pisgah and Parmleysville has historically been and remains an area of oil production. Harker et al. (1980) reported oil slicks, and we noted hydrogen sulfide odors, in the river in this area. Surface mining of coal deposits associated with the Breathitt Formation

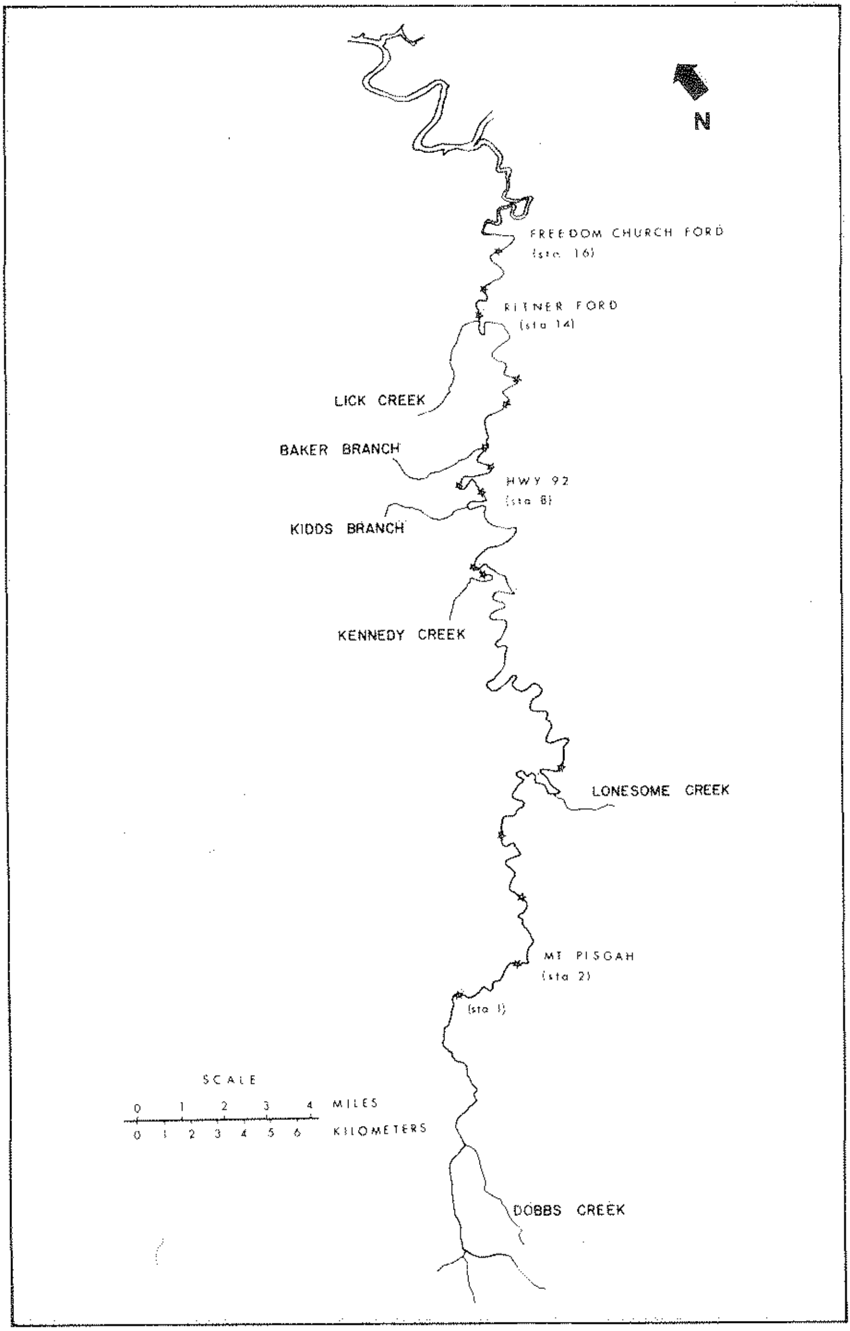


Fig. 1. Little South Fork of the Cumberland River, indicating major tributaries, sampling stations, and approximate distances.

beneath the Rockcastle Sandstone Member of the Lee Formation began in the 1970s. As of March 1981 there were 11 active and 4 inactive surface mines in the watershed.

While the fauna of Little South Fork has never been thoroughly surveyed, historical records from the Cumberland River and its tributaries provide information about which species had potential access to Little South Fork. Wilson and Clark (1914) documented the distribution, relative abundance and habitat of mussel resources in the Cumberland River and the lower Big South Fork of the Cumberland River (Table 1) from a commercial standpoint. Shoup and Peyton (1940) provided data on unionids collected from the Tennessee section of Big South Fork. Neel and Allen (1964) surveyed the upper Cumberland River in Kentucky from 1947 to 1949, especially the area above Wolf Creek Dam prior to impoundment. Two of the stations collected by Neel and Allen were on Big South Fork — one above Burnside, which corresponds to a Wilson and Clark locality, and the other at Yamacraw (Tables 1 and 2).

Ortmann (1924, 1925, 1926) provided taxonomic and distributional information pertaining to unionids of the Cumberland River. Williamson (1905) reported a limited fauna in the Rockcastle River, a major tributary located in the eastern headwaters of the Cumberland River. Stansbery (1969) reviewed naiad faunal changes at Cumberland Falls based on surveys of Wilson and Clark (1914) and Neel and Allen (1964).

Recent reports of the naiad fauna of Little South Fork include the work on *Pegias fabula* by Starnes and Starnes (1980) and the species lists provided by Harker et al. (1979, 1980). Their collection stations, which are from sites that approximate our stations 4, 5, 6, 7, 8, 14, and 16, have been combined with our data in Table 3. B. Branson and G. Schuster, Eastern Kentucky University (EKU), in 1980 surveyed the lower part of Little South Fork from the Highway 92 crossing downstream to Freedom Church Ford at approximately our stations 8, 11, 12, 14, and 16. Their unpublished unionid data have been combined with our data in Table 3.

## MATERIALS AND METHODS

In 1977 we initiated qualitative surveys to establish a list of mussel species. Our efforts in 1979 centered around collecting live specimens, determining species assemblages, and estimating upstream distribution limits of unionids. Independently, in 1978 the Kentucky Nature Preserves Commission (KNPC) began comprehensive water quality and biological surveys in the Little South Fork (Harker et al. 1979, 1980). In 1981 we conducted a quantitative and qualitative survey of the lower Little South Fork. Ten-square foot (0.1 $m^2$) samples were taken along three transects at stations 8, 13, and 16, using a metal frame placed over

Table 1. Historical taxonomy of the naiads of the Big South Fork of the Cumberland River, with the taxonomy used in this study.

| Wilson and Clark (1914) | Neel and Allen (1964) | This study |
|---|---|---|
| *Pleurobema crudum* (Lea, 1871) | | *Fusconaia barnesiana* (Lea, 1838) |
| *Quadrula subrotunda* (Lea, 1831) | *Fusconaia subrotunda* | *Fusconaia subrotunda* |
| *Quadrula cylindrica* (Say, 1817) | *Quadrula cylindrica* | *Quadrula cylindrica* |
| *Quadrula pustulosa* (Lea, 1831) | *Quadrula pustulosa* | *Quadrula pustulosa* |
| *Quadrula tritigonia* (Ortmann, 1909) | *Tritigonia verrucosa (Rafinesque, 1829)* | *Tritigonia verrucosa* |
| *Quadrula tuberculata* (Rafinesque, 1820) | *Cyclonaias tuberculata* | *Cyclonaias tuberculata* |
| *Unio crassidens* (Lamarck, 1819) | *Elliptio crassidens* | *Elliptio crassidens* |
| *Unio gibbosus* (Barnes, 1823) | *Elliptio dilatatus* (Rafinesque, 1820) | *Elliptio dilatatus* |
| *Lastena lata* (Rafinesque, 1820) | *Lastena lata* | *Hemistena lata* |
| *Pleurobema clava* (Lamarck, 1819) | *Pleurobema oviforme* (Conrad, 1834) | *Pleurobema oviforme* "complex" |
| *Quadrula obliqua* (Lamarck, 1819) | *Pleurobema cordatum cordatum* (Rafinesque, 1820) | *Pleurobema cordatum* |
| *Quadrula coccinea* (Conrad, 1836) | *Pleurobema cordatum coccineum* | *Pleurobema coccineum* |
| *Quadrula pyramidata* (Lea, 1834) | *Pleurobema cordatum pyramidatum* | *Pleurobema pyramidatum* |
| *Alasmidonta truncata* (Wright, 1898) | *Alasmidonta marginata* (Say, 1819) | *Alasmidonta marginata* |
| *Alasmidonta minor (Lea, 1845)* | *Alasmidonta minor* | *Alasmidonta viridis* (Rafinesque, 1820) |
| *Pegias fabula* (Lea, 1836) | | *Pegias fabula* |
| *Anodonta grandis* (Say, 1829) | | *Anodonta grandis* |
| *Anodonta imbecillis* (Say, 1829) | | *Anodonta imbecillis* |
| *Symphynota costatas* (Rafinesque, 1820) | *Lasmigona costata* | *Lasmigona costata* |
| *Strophitus edentulus schaefferinana* (Lea, 1852) | *Strophitus rugosus* (Swainson, 1822) | *Strophitus undulatus* (Say, 1817) |
| *Lampsilis ligamentina gibba* (Simpson, 1914) | *Actinonaias carinata gibba* | *Actinonaias ligamentina gibba* |
| *Lampsilis perdix* (Lea, 1834) | *Actinonaias pectorosa* (Conrad, 1834) | *Actinonaias pectorosa* |
| *Lampsilis glans* (Lea, 1834) | | *Toxolasma lividus* (Rafinesque, 1831) |
| *Truncilla arcaeformis* (Lea, 1831) | | *Plagiola arcaeformis* |
| *Truncilla brevidens* (Lea, 1834) | *Dysnomia brevidens* | *Plagiola interrupta* (Rafinesque, 1820) |
| *Truncilla capsaeformis* (Lea, 1834) | *Dysnomia capsaeformis* | *Plagiola capsaeformis* |
| *Truncilla walkeri* (Wilson & Clark, 1914) | *Dysnomia florentina walkeri* | *Plagiola florentina walkeri* |

| | | |
|---|---|---|
| *Truncilla haysiana* (Lea, 1833) | *Dysnomia haysiana* | *Plagiola haysiana* |
| *Truncilla triquetra* (Rafinesque, 1820 | *Dysnomia triquetra* | *Plagiola triquetra* |
| *Plagiola securis* (Lea, 1829) | *Plagiola lineolata* (Rafinesque, 1820) | *Ellipsaria lineolata* |
| *Lampsilis multiradiata* (Lea, 1829) | *Lampsilis fasciola* (Rafinesque, 1820) | *Lampsilis fasciola* |
| *Lampsilis ovata* (Say, 1817) | *Lampsilis ovata* | *Lampsilis ovata* |
| *Lampsilis ventricosa* (Barnes, 1823) | *Lampsilis ovata ventricosa* | *Lampsilis ovata cardium* (Rafinesque, 1820) |
| *Lampsilis gracilis* (Barnes, 1823) | *Leptodea fragilis* (Rafinesque, 1820) | *Leptodea fragilis* |
| *Lampsilis recta* (Lamarck, 1819) | *Ligumia recta latissima* (Rafinesque, 1820) | *Ligumia recta latissima* |
| *Medionidus conradicus* (Lea, 1834) | *Medionidus conradicus* | *Medionidus conradicus* |
| *Obovaria circula* (Lea, 1829) | *Obovaria subrotunda* (Rafinesque, 1820) | *Obovaria subrotunda* |
| *Lampsilis alata* (Say, 1817) | *Proptera alata* | *Potamilus alata* |
| *Plagiola donaciformis* (Lea, 1828) | *Truncilla donaciformis* | *Truncilla donaciformis* |
| *Plagiola elegans* (Lea, 1831) | *Truncilla truncata* (Rafinesque, 1820) | *Truncilla truncata* |
| | *Micromya nebulosa* (Conrad, 1834) | *Villosa iris* (Lea, 1830) |
| *Lampsilis picta* (Conrad, 1834) | *Micromya picta* | *Villosa taeniata picta* |
| *Lampsilis punctata* (Lea, 1865) | | *Villosa taeniata punctata* |
| *Lampsilis trabalis* (Conrad, 1834) | *Micromya trabalis* | *Villosa trabalis* |
| *Lampsilis vanuxemensis* (Lea, 1838) | *Micromya vanuxemensis* | *Villosa vanuxemensis* |
| *Obliquaria reflexa* (Rafinesque, 1820) | *Obliquaria reflexa* | *Obliquaria reflexa* |
| *Dromus dromas caperatus* (Lea, 1845) | *Dromus dromas* (Lea, 1834) | *Dromus dromas caperatus* |
| *Ptychobranchus phaseolus* (Hildreth, 1828) | *Ptychobranchus fasciolare* (Rafinesque, 1820) | *Ptychobranchus fasciolare* |
| *Ptychobranchus subtentus* (Say, 1825) | | *Ptychobranchus subtentum* |

the area to be sampled. To avoid wind ripples or sun glare, mask and snorkel was used to observe the substrate while each rock was removed from within the frame. All mollusks recovered from the square were retained for identification.

Specimens collected by KNPC were identified by D. H. Stansbery and deposited at Ohio State University. Collections by G. Schuster and B. Branson are at EKU. Most of our specimens have been deposited in the Department of Anthropology Zooarchaeology Collection, University of Tennessee (UT), Knoxville. Additional smaller collections have been deposited at the Department of Malacology, Academy of Natural Sciences of Philadelphia (ANSP), and in the senior author's collection.

## TAXONOMY

Approximately 70% of the taxa recorded from Big South Fork, confluent with Little South Fork, has undergone taxonomic revisions since 1914; therefore, we feel that Table 1 and the following discussion are essential to a general understanding of historical and modern unionid taxonomy of Cumberland River tributaries. Table 1 compares our nomenclature with that reported in Wilson and Clark (1914) and Neel and Allen (1964). Synonyms were traced by using Bogan and Parmalee (in press), Burch (1975), Clarke (1981), Haas (1969), Ortmann (1917, 1918), Ortmann and Walker (1922), and Simpson (1914). Of the 78 total unionid species found in the Cumberland River, 24 have been documented in Little South Fork.

The *Pleurobema clava* of Wilson and Clark (1914) is here called the *P. oviforme* "complex". Ortmann (1924) suggested that *P. clava* from the Upper Cumberland and Big South Fork may be *P. oviforme*. We have identified *Fusconaia subrotunda* reported in Starnes and Starnes (1980) to be *Pleurobema oviforme*. Stansbery (OSU) identified KNPC materials from the Rockcastle and Little South Fork rivers as *P. oviforme*. Some specimens from Little South Fork approach *P. clava* in shell shape, hence our use of "complex".

Wilson and Clark (1914) listed both *Alasmidonta minor* and *A. truncata* from Big South Fork (Table 1). Clarke (1981) included both *A. minor* and *A. truncata* as synonyms of *A. calceolus*, which he placed as a junior synonym of *A. viridis* (Rafinesque 1820).

Taxa reported in the genera *Carunculina*, *Truncilla*, and *Dysnomia* require clarification. Both Wilson and Clark (1914) and Neel and Allen (1964) reported *Carunculina*, but not the taxon *C. lividus*, from Big South Fork. Stansbery (1976) observed that *Villosa vanuxemensis* was absent from the Rockcastle River and that the purple-nacred *Toxolasma* was *T. lividus*. This suggests that the identification of *V. vanuxemensis* by both Wilson and Clark (1914) and Neel and Allen (1964) was in fact a confusion with specimens of *T. lividus*. Morrison (1969) listed *Toxolasma* Raf. 1831 as an earlier available name for *Carunculina* Simpson in Baker, 1898. Johnson (1978) moved taxa from *Epioblasma* (= *Dysnomia)*, formerly placed in *Truncilla*, to the genus *Plagiola*, and recognized the lectotype of *Plagiola interrupta* Raf., 1820 (Johnson and Baker 1973). If the Poulson Collection of Rafinesque's types (see Vanatta 1916; Walker 1916) is accepted, then Johnson's revision based on the type of *Plagiola interrupta* (= *Dysnomia brevidens* [Lea, 1934]) is accurate. Our examination of the lectotype of *P. interrupta* confirms that it is a female *Epioblasma brevidens*.

Rafinesque's types also affect two other taxa. *Lampsilis ovata cardium* Raf., 1820 (= *L. o. ventricosa* Barnes, 1823) is based on Rafinesque's type from the Poulson Collection (Johnson and Baker 1973; Walker 1916; Vanatta 1916). The use of *Potamilus (= Proptera)* may be argued on the basis of priority, i.e., *Potamilus* Raf., 1818 versus *Proptera* Raf., 1819.

## RESULTS

In the combined 1977-1981 surveys, 24 species of Unionidae and one species of Corbiculidae were collected (Table 3). This table represents the compilation of distribution data from our surveys, the KNPC collections, and unpublished data from Schuster. Observed live specimens of each species are indicated by an asterisk. There is a relatively high correlation between species occurring historically in Big South Fork and species currently occurring in Little South Fork. However, 15 species are conspicuously absent (Table 2). Some species, such as *Elliptio crassidens*, may have been excluded by preferences for a larger river habitat. However, the majority of species, such as *Fusconaia barnesiana* and *Hemistena lata*, are normally associated with other rivers the size of Little South Fork. Comparable rivers, such as the Stones (Wilson and Clark 1914), upper Powell (Ahlstedt and Brown 1980), middle Duck (Ahlstedt 1981), upper Holston (Stansbery 1972; Stansbery and Clench 1974, 1975, 1978), and the Rockcastle (Williamson 1905) all contain taxa absent from Little South Fork. It seems probable that the requirements of the 15 absent species are similar to those of the documented species in Big South Fork and Little South Fork.

Table 3 is a compilation of molluscan collections at respective stations on Little South Fork. There is a pattern of longitudinal diversity, with species being added as one moves downstream from Station 2.

From January 1980 to October 1981 there was a 37 cm shortage from mean average rainfall. Due to this prolonged dryness, during our quantitative sampling the entire river downstream from Station 13 (approximately 3 km above Ritner Ford) entered a sandy pool and fil-

Table 2. Comparison of mollusk fauna reported from Big South Fork of the Cumberland River and that found in Little South Fork.

| Taxa | Wilson and Clark (1914) Above Burnside | Wilson and Clark (1914) Parkers Lake | Neel and Allen (1964) Above Burnside | Recent Collections, Little South Fork: Present | Recent Collections, Little South Fork: Absent |
|---|---|---|---|---|---|
| *Fusconaia barnesiana* | X | X | | | X |
| *Fusconaia subrotunda* | X | X | | | X |
| *Quadrula cylindrica* | X | X | | | X |
| *Quadrula pustulosa* | | X | X | | X |
| *Tritigonia verrucosa* | X | | | | X |
| *Cyclonaias tuberculata* | X | X | X | X | X |
| *Elliptio crassidens* | X | X | X | | X |
| *Elliptio dilatatus* | X | X | X | X | |
| *Hemistena lata* | X | | | | X |
| *Pleurobema oviforme* "complex" | X | X | | X | |
| *Pleurobema cordatum* | ? | | | | |
| *Pleurobema coccineum* | X | X | | | |
| *Pleurobema pyramidatum* | X | | | | |
| *Alasmidonta marginata* | X | | | X | |
| *Alasmidonta viridis* | | | | X | |
| *Pegias fabula* | | | | X | |
| *Anodonta grandis* | | | | X | |
| *Anodonta imbecillis* | | | | X | |
| *Lasmigona costata* | X | X | | X | |
| *Strophitus undulatus* | X | X | | X | |
| *Actinonaias ligamentina gibba* | X | X | X | X | |
| *Actinonaias pectorosa* | X | | X | X | |
| *Toxolasma lividus* | | | | X | |
| *Plagiola arcaeformis* | X | | | | |
| *Plagiola interrupta* | X | X | | | X |

| | | | | | |
|---|---|---|---|---|---|
| *Plagiola capsaeformis* | X | X | X | | X |
| *Plagiola florentina walkeri* | | | ? | | |
| *Plagiola haysiana* | X | X | X | | |
| *Ellipsaria lineolata* | X | | | | |
| *Lampsilis fasciola* | X | X | X | X | |
| *Lampsilis ovata* | X | X | | | |
| *Lampsilis ovata cardium* | | | X | X | |
| *Leptodea fragilis* | | X | | X | X |
| *Ligumia recta latissima* | X | X | X | | X |
| *Medionidus conradicus* | | X | | X | |
| *Obovaria subrotunda* | | X | | X | |
| *Potamilus alata* | X | X | X | X | |
| *Truncilla donaciformis* | | | X | | |
| *Truncilla truncata* | X | | | | X |
| *Villosa iris* | | | | X | |
| *Villosa taeniata picata* | X | | | | |
| *Villosa taeniata punctata* | X | X | | X | |
| *Villosa trabalis* | | X | | X | |
| *Villosa vanuxemensis* | | | X | | X |
| *Obliquaria reflexa* | X | | | | |
| *Dromus dromas caperatus* | X | X | | | X |
| *Ptychobranchus fasciolare* | X | X | X | X | |
| *Ptychobranchus subtentum* | X | X | | X | |
| *TOTAL TAXA* | 33 | 27 | 16 | 24 | 15 |

Table 3. Recent molluscan collections from Little South Fork Cumberland River, indicating stations and river miles where taken. (X = specimens collected by authors; O = records of KNPC; = are records of EKU; * =live specimens observed.)

| TAXA | Sta. 1 35.5 | Sta. 2 33.6 | Sta. 3 31.3 | Sta. 4 28.5 | Sta. 5 24.8 | Sta. 6 17.0 | Sta. 7 16.9 | Sta. 8 14.2 | Sta. 9 13.7 | Sta. 10 13.3 | Sta. 11 12.5 | Sta. 12 10.4 | Sta. 13 9.6 | Sta. 14 7.5 | Sta. 15 7.5 | Sta. 16 3.8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Cyclonaias tuberculata* | | | | | | | | | | | = | | | | | |
| *Elliptio dilatatus* | | | | | | | | = | X | X | X | = | X* | X | X | X* |
| *Pleurobema oviforme* "complex" | | | X | O | O | O | O | X | | | X | | X* | X | | O |
| *Alasmidonta marginata* | | | | | | | | X* | X | | X* | | X | X | X | |
| *Alasmidonta viridis* | | | | O | | | O | | | | | | | | | |
| *Pegias fabula* | | | | | | | O | X* | X* | X* | X* | = | X* | X* | X | X* |
| *Anodonta grandis* | | | | | | | | = | | | | | | = | | |
| *Anodonta imbecillis* | | | | | | | | X | | X | | | | X | | |
| *Lasmigona costata* | | | | | O | | O | X* | | X* | X* | X | X* | X* | X* | O |
| *Strophitus undulatus* | | | | * | | | O | | | | | | | O | | |
| *Actinonaias ligamentina gibba* | | | | | | | | | | | =* | = | | | | |
| *Actinonaias pectorosa* | | | | | | | | | | | | | X | | | |
| *Toxolasma lividus* | | | | O | | O | O | X | X | X | | X | X* | X | | X |
| *Lampsilis fasciola* | | | X | X* | O | O | O | X* | X* | X | X* | X* | X | X | X | X* |
| *Lampsilis ovata cardium* | | | | O | O | O | O | X | | X | X* | X | | X | X | X* |
| *Leptodea fragilis* | | | | | | | | = | | X* | X* | X* | X | X | X | |
| *Medionidus conradicus* | | | | X* | O | O | O | X | X | X | X* | X | X | X | X | X* |
| *Obovaria subrotunda* | | | | X | | O | O | X* | X | X* | X | X | X | O | X | X* |
| *Potamilus alata* | | | | | | | | X* | | X* | X* | X* | X* | O | X* | X* |
| *Villosa iris* | | | X | X* | | O | O | X | X | X | X | = | X | X | X | X |
| *Villosa taeniata punctata* | | X | X | X | O | O | O | X | X | X | X* | X | X | X* | X | X |
| *Villosa trabilis* | | X | X | X | O | O | O | X* | | X* | X | = | X | O | | X |
| *Ptychobranchus fasciolare* | | | | X | | | O | X* | X* | X* | X* | X | X* | O | X* | X* |
| *Ptychobranchus subtentum* | | | | O | | O | O | X* | X* | X | X* | X | X | X | X | X* |
| *Corbicula fluminea* | | | | | | | | X* | X* | X* | X* | X* | X* | O* | X* | O* |
| *TOTAL TAXA* | 0 | 2 | 5 | 13 | 7 | 10 | 15 | 20 | 12 | 17 | 19 | 17 | 18 | 21 | 15 | 16 |

tered underground to enter subterranean channels in the Ste. Genevieve limestone. The streambed was dry for approximately one kilometer, after which the river emerged at the base of limestone bluffs. Below the point of resurgence the water was cooler and had greater clarity, and there were long, deep pools.

A sampling transect at Freedom Church Ford (Sta. 16) yielded an average 2.87 unionid individual/$m^2$, compared with 7.53 and 7.17 individuals/$m^2$ at upstream stations 8 and 13, respectively (Table 4). Decreases in abundance at Station 16 were probably related to decreases in optimal habitat. G. Schuster (pers. comm.) reported sedimentation at Ritner Ford in spring 1981. Although these sediments were gone by fall 1981, mussel populations are incapable of withstanding repeated or extended siltation. Limestone outcrops and bedrock, which increasingly dominated the substrate in the river below Station 13, may also reduce the amount of optimal habitat. At Freedom Church (Sta. 16) the ford is a continuous sheet of limestone, 30 m wide and 20 m long, and unionids are restricted to gravel accumulated above and below the bedrock outcrops.

Within the river, certain general habitat preferences were apparent. Without heavy spring rains in 1981, deep pools were covered with 2 to 10 cm of organic detritus. No live unionids were collected in these areas. Neither unionids nor *Corbicula* occurred along stream margins where water willow, *Justicia americana*, is abundant. However, in 1980 and 1981 these areas were exposed or in shallow water. In pool areas, heaviest concentrations of unionids, especially *Potamilus alata*, occurred along current-swept banks. No live *Corbicula* were recorded in deep, sluggish pools except at inflow areas, while shallow pools contained occasional live specimens.

Unionids were not recorded in water less than 10 cm deep, but *Corbicula* was found in water 3 cm in depth. Greatest unionid densities occurred in water from 10 to 25 cm deep. With the exception of *Lampsilis ovata* and *Pegias fabula*, all unionids could be found with the anterior end protruding slightly from the substrate. *Lampsilis ovata* was uncovered in gravel with the anterior end approximately 5 cm below the normal substrate surface. *Pegias fabula*, previously reported by Starnes and Starnes (1980) at the interface between pool and riffle, was also collected live from the shallower, current-swept areas in the riffle proper. During low flow periods, *Pegias* was observed reclining upon the substrate between gravel and cobbles, with a somewhat more horizontal than vertical orientation. In higher spring flows, *Pegias* anchored into the substrate with more typical unionid orientation. *Ptychobranchus subtentum* was ubiquitous in riffle areas in water 10 to 25 cm deep and in all but the swiftest current. *Medionidus conradicus* was restricted

Table 4. Molluscan species collected in quantitative samples taken in River.

| | | *Elliptio dilatatus* | | | *Pegias fabula* | | | *Lampsilis fasciola* | | | *Lampsilis ovata* | | | *Medionidus conradicus* | | | *Obovaria subrotunda* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Transects | | | | | | | | | | | | | | | | | |
| | Sample | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| Sta. 8 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| | 7 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 8 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 9 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 10 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Subtotals | 0 | 0 | 0 | 1 | 4 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 |
| Average number of individuals/ $m^2$ | | | | | | | | | | | | | | Unionidae 7.53 | | | | | |
| Sta. 13 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| | 5 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 9 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 10 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Subtotals | 0 | 0 | 2 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 1 | 0 |
| Average number of individuals/ $m^2$ | | | | | | | | | | | | | | Unionidae 7.17 | | | | | |
| Sta. 16 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| | 6 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 10 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Subtotals | 0 | 0 | 0 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| Average number of individuals/ $m^2$ | | | | | | | | | | | | | | Unionidae 2.87 | | | | | |

three transects at stations 8, 13, and 16, Little South Fork Cumberland

| *Potamilus alata* | | | *Villosa iris* | | | *Villosa taeniata* | | | *Ptychobranchus fasciolare* | | | *Ptychobranchus subtentum* | | | *Corbicula fluminea* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 3 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 4 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 0 |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 5 | 9 | 5 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 9 | 5 | 8 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 4 | 7 |
| 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 12 | 3 | 1 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 5 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 12 | 2 |
| 1 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 2 | 4 | 1 | 33 | 62 | 35 |
| | | | | | | | | | | | | Corbiculidae 46.59 | | | | | |
| 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 2 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 8 | 2 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 4 | 15 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 7 | 18 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 2 | 1 | 1 | 1 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 5 | 1 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 6 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 8 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 15 |
| 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 0 | 1 | 2 | 0 | 2 | 4 | 20 | 30 | 72 |
| | | | | | | | | | | | | Corbiculidae 43.73 | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 1 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 3 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 5 | 1 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 10 | 17 | 3 |
| | | | | | | | | | | | | Corbiculidae 10.75 | | | | | |

to these deeper, swift areas, anchored between rocks or in sand-filled cracks in bedrock.

Populations of *Corbicula* were widespread and four to six times as dense as unionid populations, with 10.75, 43.73, and 46.59 individuals/$m^2$ at the three quantitatively sampled stations (Table 4). Relict *Corbicula* shells were found in great numbers along banks and in pools. While muskrats harvest both unionids and *Corbicula*, the ratio of *Corbicula* to unionid shells in 1981 seemed disproportionately high, indicating possible changes in *Corbicula* populations.

Gastropods identified from Little South Fork included: *Goniobasis semicarinata* (Say, 1829), *G. ebenum* (Lea, 1941), *Pleurocera acuta* (Rafinesque, 1831), *Physella* sp., and *Campeloma crassulum* (Rafinesque, 1819). *Campeloma rubrum* is widely distributed, yet relatively uncommon in the river outside of its preferred habitat. Live specimens were restricted to mud (loamy) banks. Consequently, *Campeloma* was not collected in quantitative surveys. The upstream limit for gastropods was not determined; however, at the uppermost collecting locality their numbers were significantly lower, ranging from 0 to 8 individuals/$m^2$. Densities of gastropods ranged from 1 to 25 individuals/$m^2$ at Station 4, from 5 to 38 individuals/$m^2$ at Station 8, and from 0 to 12 individuals/$m^2$ at Station 16.

## DISCUSSION AND CONCLUSIONS

The Little South Fork of the Cumberland River contains perhaps one of the last extant representative populations of the Cumberlandian mollusk fauna in Kentucky. A total of 24 unionid, one corbiculid, and 5 gastropod species are reported in these surveys. After clarification of unionid taxonomy, recent Little South Fork samples were compared with historical Big South Fork records, revealing that approximately one-third of Big South Fork species are absent from Little South Fork. We can only speculate on the factor(s) responsible for the absence of these 15 species. Along these lines, Stansbery and Clench (1975, 1978) listed factors possibly limiting molluscan populations, including available nutrients, stable substrate or dissolved calcium. Unionid distributions in Little South Fork are most likely limited by a combination of factors, including the possible absence of the proper fish host.

Unionid densities were greatest in current-swept substrates. Optimal habitat was riffles with a relatively coarse substrate, in water 10 to 25 cm deep. Downstream density decreases were related to increases in percentage of bedrock in pools and riffles, which reduced available habitat.

Distribution of the naiad fauna is curtailed where the river gradient increases from 1.2 m/km to 1.8 m/km before reaching the 3.8 m/km

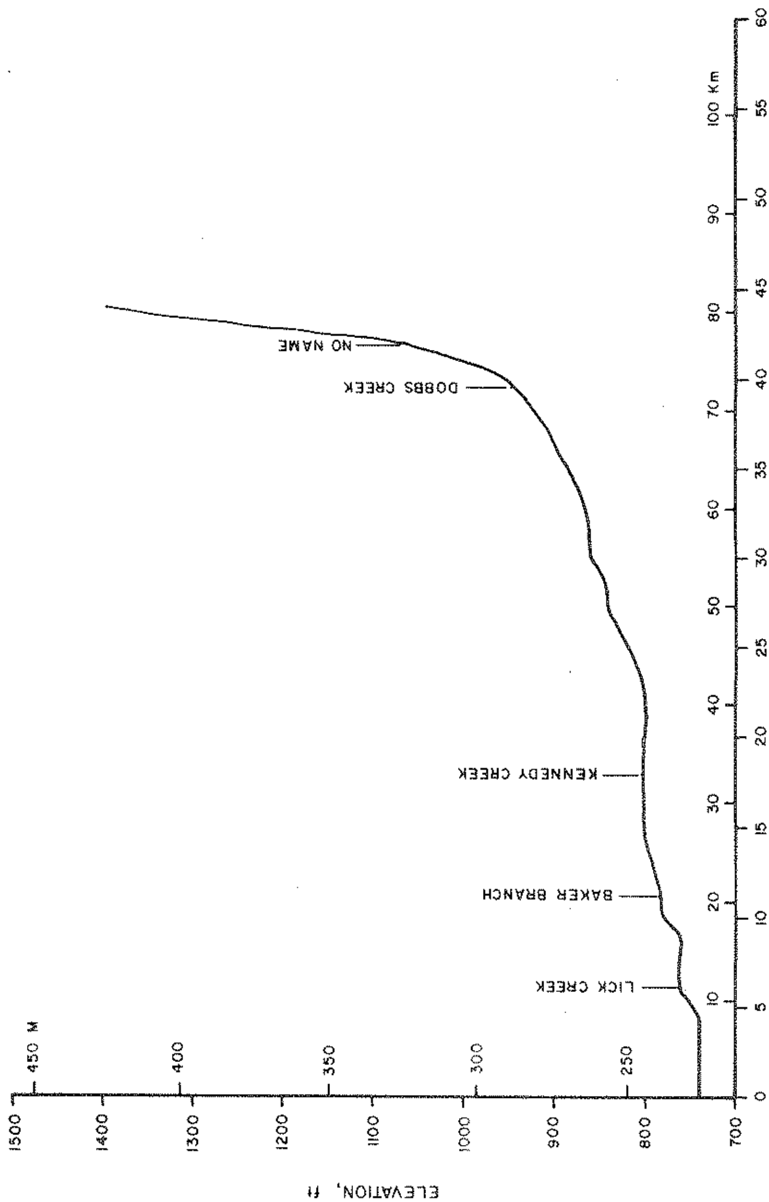


Fig. 2. Schematic showing altitudinal changes with river mile in Little South Fork of the Cumberland River.

gradient in the headwaters. Elevation changes in Little South Fork are shown in Figure 2. Above Parmleysville (Sta. 4), where 12 species occur, there is a relatively rapid decline in species diversity. The last species encountered as we progressed upstream (Sta. 2) were *Villosa taeniata* and *V. trabalis*, with all species absent at Station 1, 11 km above Station 4. In the headwaters above Mt. Pisgah there is an average gradient of 3.75 m/km; below this area it decreases to 1.2 m/km. The abrupt change in stream gradient with associated physical changes is an effective faunal barrier (Fig. 2), as noted by Masnik (1975) for fish in the upper Clinch River system. From the headwaters to the river area just above Mt. Pisgah there is a faunal transition zone: gradient sharply decreases, substrate shifts from boulder and bedrock to cobble and sand, and river velocity decreases.

The section of the river at Mt. Pisgah is apparently a major physical barrier to naiad distribution farther into the headwaters. Similar distributional limitations have been noted in other Tennesseee River tributary streams. Apparently at and above this section of the river, the unionids are not able to become established for any of several reasons: change in fish fauna (lack of suitable host fish), lack of suitable substrate, lack of nutrients, and thermal fluctuations. The observed faunal barrier above Mt. Pisgah was anticipated by the work on unionid distribution in the headwaters of the Tennessee River by Stansbery (1972), Stansbery and Clench (1974, 1975, 1978), Ahlstedt and Brown (1980), Ahlstedt (1982), and the work on fish distribution by Masnik (1975). A similar increase in stream gradient and corresponding faunal changes was also observed in the Little River, Blount County, Tennessee (Bogan and Starnes 1982). The small assemblage of species found in the rivers just below the zone of increased gradient is one typical of small streams (e.g., *Lasmigona holstonia, Medionidus conradicus, Villosa iris, V. taeniata, Pleurobema oviforme, Alasmidonta viridis*).

Current surface coal mining regulations (Kentucky Permanent Regulatory Program, and the Surface Mining Control and Reclamation Act of 1977) are designed to protect aquatic resources. However, even if roads and silt control structures are properly designed, constructed, and maintained, we are uncertain as to the survival of sensitive unionid populations. Multiple mines, whose impacts on the watershed will be combined or cumulative, characteristically will locate within coal-rich watersheds. To preserve water quality and protect the unionid fauna, the number of permits issued within both Little South Fork and individual tributaries should be limited, and an annual monitoring program to evaluate the status of the unionid populations should be initiated. Survival of this river's unionid fauna possibly will be directly related to compliance with and enforcement of the Act by inspection and enforcement personnel of Kentucky and the Office of Surface Mining.

*ACKNOWLEDGMENTS.* — We acknowledge the field, lab, and editorial assistance of Wayne C. Starnes and Cindy Bogan. Special appreciation is expressed to Jerry and Christine Louton for field assistance, especially in an unexpected portage of canoes and samples. For providing specimens, identifications, collection records, and observations we acknowledge the assistance of: B. A. Branson and G. A. Schuster (EKU), Paul W. Parmalee (UT), David H. Stansbery (OSU), Melvin L. Warren, Jr. (KNPC), and Sam M. Call (Kentucky Division of Water). An anonymous reviewer provided helpful questions and comments.

## LITERATURE CITED

Ahlstedt, Steven A. 1981. The molluscan fauna of the Duck River between Normandy and Columbia dams in central Tennessee. Bull. Am. Malacol. Union Inc. for 1980:60-62.

_________. 1982. The molluscan fauna of Copper Creek (Clinch River System) in southwestern Virginia. Bull. Am. Malacol. Union Inc. for 1981: 4-6

_________, and S. R. Brown. 1980. The naiad fauna of the Powell River in Virginia and Tennessee (Bivalvia: Unionacea). Bull. Am. Malacol. Union Inc. for 1979:40-43.

Bogan, Arthur E., and P. W. Parmalee. In press. Endangered and threatened mollusks of Tennessee. Tenn. Wildl. Resour. Agency.

_________, and L. B. Starnes. 1982. The unionid fauna of the Little River and some observations on unionid biogeography. Presentation annual meeting American Malacological Union, New Orleans.

Burch, John B. 1975. Freshwater Unionacean clams (Mollusca: Pelecypoda) of North America. Malacological Publications, Hamburg, MI. 204 pp.

Clarke, Arthur H. 1981. The Tribe Alasmidontini (Unionidae: Anodontinae), Part I: *Pegias, Alasmidonta,* and *Arcidens*. Smithson. Contrib. Zool. No. 326. 101 pp.

Fenneman, Neville M. 1938. Physiography of Eastern United States. McGraw-Hill, New York. 691 pp.

Haas, Fritz. 1969. Superfamilia Unionacea. Das Tierreich *88*:1-663

Harker, Donald F., Jr., S. M. Call, M. L. Warren, Jr., K. E. Camburn and P. Wigley. 1979. Aquatic biota and water quality survey of the Appalachian Province, eastern Kentucky. Techn. Rep. Ky Nature Preserves Comm., Vol. 1. Frankfort. 522 pp.

_________, M. L. Warren, Jr., K.E. Camburn, S. M. Call, G. J. Fallo and P. Wigley. 1980. Aquatic biota and water quality survey of the Upper Cumberland River Basin. Techn. Rep. Ky. Nature Preserves Comm., Vol. 2. Frankfort. 409 pp.

Johnson, Richard I. 1978. Systematics and zoogeography of *Plagiola (=Dysnomia=Epioblasma)* an almost extinct genus of freshwater mussels (Bivalvia: Unionidae) from middle North America. Bull. Mus. Comp. Zool. *148*(6):239-321.

———, and H. B. Baker. 1973. The types of Unionacea (Mollusca: Bivalvia) in the Academy of Natural Sciences of Philadelphia. Proc. Acad. Nat. Sci. Phila. *125*(9):145-186.

Masnik, Michael T. 1975. Composition, longitudinal distribution, and zoogeography of the fish fauna of the upper Clinch River system in Tennessee and Virginia. Unpubl. Ph. D. dissert. Va. Polytech. Institute State Univ., Blacksburg. 401 pp.

Morrison, Joseph P. E. 1969. The earliest names for North American naiads. Am. Malacol. Union Inc. Annu. Rep. 1969:22-24.

Neel, Joe K., and W. R. Allen. 1964. The mussel fauna of the upper Cumberland basin before its impoundment. Malacologia *1*(3):427-459.

Ortmann, Arnold E. 1917. A new type of nayad-genus *Fusconaia*. Group of *F. barnesiana* Lea. Nautilus *31*(2):58-64.

———. 1918. The naiades (freshwater mussels) of the upper Tennessee drainage, with notes on synonymy. Proc. Am. Philos. Soc. *57*:521-626.

———. 1924. The naiad fauna of Duck River in Tennessee. Am. Midl. Nat. *9*(1):18-62.

———. 1925. The naiad-fauna of the Tennessee River system below Walden Gorge. Am. Midl. Nat. *9*(8):321-372.

———. 1926. The naiades of the Green River drainage in Kentucky. Ann. Carnegie Mus. *17*:167-188.

———, and B. Walker. 1922. On the nomenclature of certain North American naiades. Occas. Pap. Mus. Zool. Univ. Mich. No. 112. 75 pp.

Shoup, Charles S., and J. H. Peyton. 1940. Collections from the drainage of the Big South Fork of the Cumberland River in Tennessee. J. Tenn. Acad. Sci. *15*(1):106-116.

Simpson, Charles T. 1914. A descriptive catalogue of the naiades, or pearly freshwater mussels. Bryant Walker, Detroit. 1540 pp.

Stansbery, David H. 1969. Changes in the naiad fauna of the Cumberland River at Cumberland Falls in eastern Kentucky. Am. Malacol. Union Inc. Annu. Rep. 1969:16-17.

———. 1972. The mollusk fauna of the North Fork Holston River at Saltville, Virginia. Bull. Am. Malacol. Union Inc. for 1971:45-46.

———. 1976. Status of endangered fluviatile mollusks in central North America: *Toxolasma cylindrellus* (Lea, 1868). Ohio State Univ. Res. Foundation. Report to Bur. Sport Fish. Wildl., USFWS, USDI, Columbus. 7 pp.

———, and W. J. Clench. 1974. The Pleuroceridae and Unionidae of the North Fork Holston River above Saltville, Virginia. Bull. Am. Malacol. Union Inc. for 1973:33-36.

———, and ———. 1975. The Pleuroceridae and Unionidae of the Middle Fork Holston River in Virginia. Bull. Am. Malacol. Union Inc. for 1974:51-54.

———, and ———. 1978. The Pleuroceridae and Unionidae of the Upper South Fork Holston River in Virginia. Bull. Am. Malacol. Union Inc. for 1977:75-78.

Starnes, Lynn B., and W. C. Starnes. 1980. Discovery of a new population of *Pegias fabula* (Lea) (Unionidae). Nautilus *94*(1):5-6.

Vanatta, Edward G. 1916. Rafinesque's types of *Unio*. Proc. Acad. Nat. Sci. Phila. *67*:549-559.

Walker, Bryant. 1916. The Rafinesque-Poulson unios. Nautilus *30*(4):43-47.

Williamson, E. B. 1905. Odonata, Astacidae and Unionidae collected along the Rockcastle River at Livingston, Kentucky. Ohio Nat. *5*(6):309-312.

Wilson, Charles B., and H. W. Clark. 1914. The mussels of the Cumberland River and its tributaries. Bur. Fish. Doc. 781:1-63.

*Accepted 6 December 1982*