Chambers

Recovery Plan

FILE COPY

Tuberculed-blossom Pearly Mussel
Epioblasma (=*Dysnomia*) *torulosa torulosa*

Turgid-blossom Pearly Mussel
Epioblasma (=*Dysnomia*) *turgidula*

&

Yellow-blossom Pearly Mussel
Epioblasma (=*Dysnomia*) *florentina florentina*

RECOVERY PLAN FOR THE

Tuberculed-blossom Pearly Mussel
Epioblasma (=*Dysnomia*) *torulosa torulosa* (Rafinesque, 1820)

Turgid-blossom Pearly Mussel
Epioblasma (=*Dysnomia*) *turgidula* (Lea, 1858)

Yellow-blossom Pearly Mussel
Epioblasma (=*Dysnomia*) *florentina florentina* (Lea, 1857)

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DISCLAIMER

THIS IS THE COMPLETED RECOVERY PLAN FOR THE TUBERCULED-BLOSSOM, TURGID-BLOSSOM AND YELLOW-BLOSSOM PEARLY MUSSELS. IT HAS BEEN APPROVED BY THE U.S. FISH AND WILDLIFE SERVICE. IT DOES NOT NECESSARILY REPRESENT OFFICIAL POSITIONS OR APPROVALS OF COOPERATING AGENCIES, AND IT DOES NOT NECESSARILY REPRESENT THE VIEWS OF ALL INDIVIDUALS WHO PLAYED A ROLE IN PREPARING THIS PLAN. THIS PLAN IS SUBJECT TO MODIFICATION AS DICTATED BY NEW FINDINGS, CHANGES IN SPECIES STATUS, AND COMPLETION OF TASKS DESCRIBED IN THE PLAN. GOALS AND OBJECTIVES WILL BE ATTAINED AND FUNDS EXPENDED CONTINGENT UPON APPROPRIATIONS, PRIORITIES, AND OTHER CONSTRAINTS.

THE RECOVERY PLANS FOR THE MUSSEL AND FISH SPECIES OF THE TENNESSEE RIVER VALLEY HAVE BEEN DEVELOPED ON A SPECIES-BY-SPECIES BASIS. FOR IMPLEMENTATION PURPOSES, THE PLANS WILL BE CONSOLIDATED ON A WATERSHED BASIS, AND THE NEEDS OF ALL LISTED SPECIES IN THAT SYSTEM WILL BE ADDRESSED.

This plan was prepared under contract by Steven Ahlstedt, Tennessee Valley Authority, Norris, Tennessee.

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CONTENTS

Page

PART I

INTRODUCTION 1

DISTRIBUTION 3

Historical 3

Present 9

ECOLOGY AND LIFE HISTORY 10

Epioblasma torulosa torulosa 11

Epioblasma turgidula 13

Epioblasma florentina florentina 15

REASONS FOR DECLINE AND/OR EXTINCTION 20

Impoundment 21

Siltation 22

Pollution 23

PART II

RECOVERY 26

Recovery Objectives 26

Step-Down Outline 27

Narrative Outline 27

BIBLIOGRAPHY 30

PART III

IMPLEMENTATION SCHEDULE 37

APPENDIX - List of Reviewers 39

TABLE

1. Historical records for *Epioblasma* (=*Dysnomia*) *torulosa torulosa* prior to 1970 with archaeological specimens recorded to 1983 4

CONTENTS
(continued)

Page

2. Historical records for Epioblasma (=Dysnomia) turgidula prior to 1970 with archaeological specimens recorded to 1982 7

3. Historical records for Epioblasma (=Dysnomia) florentina florentina prior to 1970 with archaeological specimens recorded to 1982 8

FIGURE

1. Typical Naiad Life Cycle Depicting the Various Stages 19

PHOTOGRAPHS

1. Photograph of *E. t. torulosa* 12

2. Photograph of *E. turgidula* 14

3. Photograph of *E. f. florentina* 16

PART I

INTRODUCTION

Freshwater mussels (naiades) are known to occur in every temperate and tropical climate. Approximately one-half of the extant species of freshwater mussels occur in North America. These species occur in what has been recognized as six faunal zones or regions which include: (1) North Atlantic Slope, (2) Pacific coastal, (3) Mississippian, (4) Ozarkian, (5) Cumberlandian, and (6) Ohioan Regions (Johnson, 1980). Eastern North America still contains the most diverse freshwater molluscan fauna known in the world. Stansbery (1970) reported that fauna numbers over a thousand species of bivalves and gastropods combined. Unique among all freshwater mussels is a genus of Unionidae Epioblasma (=Dysnomia), known for their high degree of sexual dimorphism. Of this group, eight species reported earlier this century are presumed extinct. The extinction of this group appears to be symptomatic of a general synecological problem that exists between Epioblasma and environmental changes that have occurred in many streams and rivers throughout North America. Stansbery (1971) reports that all members of this group, without exception, are characteristic riffle or shoal species inhabiting parts of those streams which are shallow with sandy-gravel substrate and rapid currents. The elimination of these species has been attributed to impoundments, barge canals, and other flow alteration structures that have eliminated riffle and shoal areas.

Twenty-three freshwater mussels in the United States are listed as endangered by the U.S. Department of Interior. Of these, eight species are members of the genus Epioblasma (=Dysnomia). Three of these species, (1) tuberculed-blossom pearly mussel Epioblasma torulosa torulosa, (2) turgid-blossom pearly mussel Epioblasma turgidula, and (3) yellow-blossom pearly mussel Epioblasma florentina florentina were all proposed for listing in September, 1975 (Federal Register 40(188):44329-44333) and listed in June, 1976 (Federal Register 41(115):24062-24067). Due to the scarcity of recent information concerning each of these species, recovery plans for all three species will be combined into one document.

Epioblasma t. torulosa was described by Rafinesque (1820) as Amblema torulosa from the Ohio and Kentucky Rivers. For clarification of nomenclatorial changes in this group refer to Bogan and Parmalee (1983). Vanatta (1915) also reported the type specimen as coming from the Kentucky River. All records for this species (including various named forms or subspecies) indicate that it was widespread in the larger rivers of eastern United States and southern Ontario, Canada.

Epioblasma turgidula was described by Lea (1858) as Unio turgidulus from the Cumberland River, Tennessee, and Florence, Alabama (Tennessee River). The female of this species was later described by Reeve (1864) as Unio deviatus (Stansbery, 1976a). Call (1885) further listed the distribution as the Cumberland and Duck Rivers, Tennessee. The Cumberland River, Tennessee, record in the original description is questionable in that the lower Tennessee River was often referred to as the Cumberland River in earlier years (Stansbery, 1976a). Epioblasma turgidula is a medium to large river Cumberlandian type reported from the Ozarks. Ortmann (1925) postulated that this distribution pattern suggests a former connection of the Ozarks with the Cumberland Plateau.

Epioblasma f. florentina was described by Lea (1857) as Unio florentinus from the Tennessee River, Florence and Lauderdale Counties, Alabama, and the Cumberland River, Tennessee. *Epioblasma f. florentina* was a large river Cumberlandian type found throughout the Tennessee and Cumberland River drainages. One apparently related headwaters form, *Epioblasma walkeri* occurs in the headwater tributaries of these drainages while another apparently related form, *Epioblasma florentina curtisi*, is endemic to the Ozarkian Region of Missouri.

DISTRIBUTION

Historical

Epioblasma torulosa (including forms or subspecies) once was widespread in the Tennessee, Cumberland, Ohio, and St. Lawrence river drainages. The inflated big river form, *Epioblasma t. torulosa* was found throughout the Tennessee River system including the Elk, Duck, and Nolichucky Rivers. Based on the amount of material observed by the author, Stansbery (1976a), and Bogan and Parmalee (1983) from archaeological Indian shell middens along the banks of the Tennessee River, *E. t. torulosa* was a relatively common species in the Tennessee River. *Epioblasma t. torulosa* was also reported from the Cumberland River but must have been very rare based on the lack of records from the Cumberland River for this species. Ortmann (1925) reported hesitantly that *E. t. torulosa* occurred in the Cumberland River. However, archaeological specimens of *E. t. torulosa* are reported from the Cumberland by Parmalee et al., (1980) and Bogan and Parmalee (1983). *Epioblasma t. torulosa* is also reported from the Ohio and Kentucky Rivers, and the Scioto and Kanawha Rivers (Stansbery, 1961, 1972, 1980; Johnson, 1978; Clarke, 1982; Taylor, 1983). Table 1 lists known historical records prior to 1970 with archaeological specimens recorded to 1983.

Table 1. Historical records for *Epioblasma* (=*Dysnomia*) *torulosa torulosa* prior to 1970 with archaeological specimens recorded to 1983.

River	Source
Tennessee River	Rafinesque (1820) Conrad (1834) Lewis (1876) Call (1885) Hinkley (1904, 1906) Ortmann (1918, 1920, 1925) van der Schalie (1939) Stansbery (1964, 1976b) Warren (1975) Parmalee et al. (1980) archaeological specimens Bogan and Parmalee (1983) archaeological specimens
Elk River	Ortmann (1925) van der Schalie (1939) Stansbery (1964) Isom et al. (1973) Johnson (1978) Ahlstedt (1983) relict specimens observed
Duck River	Bogan and Parmalee (1983) specimens collected by Athearn
Nolichucky River	Johnson (1978)
Cumberland River	Ortmann (1926) Parmalee et al. (1980) archaeological specimens Bogan and Parmalee (1983) archaeological specimens
Ohio River	Rafinesque (1820) Call (1900) Ortmann and Walker (1922) Ortmann (1925) Parmalee (1960, 1967) La Roque (1967) Stansbery (1970) Johnson (1978)
Kentucky River	Rafinesque (1820) Vanatta (1915) Danglade (1922) Ortmann and Walker (1922) Johnson (1978, 1980)

Table 1. Continued.

River	Source
Kanawha River, W. Virginia	Stansbery (1972) archaeological specimens Stansbery (1980) Clarke (1982) relict specimens Taylor (1983)
Scioto River, Ohio	Higgins (1858) Stansbery (1961)

Epioblasma turgidula was historically relatively widespread with a disjunct distribution occurring in both the Cumberlandian and Ozarkian Regions (Johnson, 1978). This Cumberlandian form has been reported from the Tennessee River and tributary streams including Shoal and Bear Creeks, Elk, Duck, Holston, Clinch, and Emory Rivers (Ortmann, 1918, 1924, 1925; Stansbery, 1964, 1970, 1971, 1976a; Johnson, 1978). Additional records are also reported from the Cumberland River (Ortmann, 1918; Clench and van der Schalie, 1944; Johnson, 1978). This species is also reported from the Ozark Mountain Region including Spring Creek, Black and White Rivers (Simpson, 1914; Johnson, 1978). Table 2 lists known historical records prior to 1970 with archaeological specimens recorded to 1982.

Epioblasma f. florentina is a Cumberlandian type historically widespread in the Tennessee and Cumberland Rivers and tributaries to the Tennessee River. *Epioblasma f. florentina* was reported from Hurricane, Limestone, Bear, and Cypress Creeks, all tributary streams to the Tennessee River in northern Alabama (Ortmann, 1925; Bogan and Parmalee, 1983). This species was reported from larger tributary streams of the lower and upper Tennessee River including the Flint, Elk, and Duck Rivers (Marsh, 1885; Isom et al. 1973; Bogan and Parmalee, 1983) and the Holston, Clinch, and Little Tennessee Rivers (Ortmann, 1918; Stansbery, 1970; TVA, 1972a). Specimens were also reported from Citico Creek, a tributary to the Little Tennessee River (Bogan and Parmalee, 1983). *Epioblasma f. florentina* apparently occurred throughout the Cumberland River (Wilson and Clark, 1914; Ortmann, 1918, 1925; Shoup et al. 1941; Neel and Allen, 1964; Parmalee et al. 1980). Table 3 lists known historical records prior to 1970 with archaeological specimens recorded to 1982.

Table 2. Historical records for Epioblasma (=Dysnomia) turgidula prior to 1970 with archaeological specimens recorded to 1982.

River	Source
Spring Creek, Arkansas	Simpson (1914)
Black River, Arkansas	Johnson (1978) specimens reported early 1900's
White River, Missouri and Arkansas	Johnson (1978) specimens reported early 1900's
Tennessee River	Lea (1857, 1858) Lewis (1876) Call (1885) Simpson (1900, 1914) Ortmann (1918, 1924) Stansbery (1964) Johnson (1978) Parmalee et al. (1982) archaeological specimens
Shoals Creek, Alabama	Hinkley (1906) Ortmann (1918, 1925) Johnson (1978)
Bear Creek, Alabama	Ortmann (1918, 1924, 1925) Johnson (1978)
Elk River	Stansbery (1970, 1971) Johnson (1978)
Duck River	Marsh (1885) Call (1885) Ortmann (1918, 1924) Stansbery (1976a)
Holston River, Tennessee	Ortmann (1918, 1924) Johnson (1978)
Clinch River, Tennessee	Johnson (1978)
Emory River, Tennessee	Ortmann (1918, 1924)
Cumberland River	Lea (1858) Call (1885) Simpson (1900, 1914) Ortmann (1918) Clench and van der Schalie (1944) Johnson (1978)

Table 3. Historical records for *Epioblasma* (=*Dysnomia*) *florentina florentina* prior to 1970 with archaeological specimens recorded to 1982.

River	Source
Tennessee River	Lea (1857) Hinkley (1906) Lewis (1876) Ortmann (1918, 1925) Parmalee et al. (1982) archaeological specimens Morrison (1942) Simpson (1900, 1914) Stansbery (1964, 1976b)
Flint River, Alabama	Bogan and Parmalee (1983)
Hurricane Creek, Alabama	Bogan and Parmalee (1983)
Limestone Creek, Alabama	Bogan and Parmalee (1983)
Bear Creek, Alabama	Bogan and Parmalee (1983)
Cypress Creek, Alabama	Ortmann (1925)
Elk River	Isom et al. (1973)
Duck River	Marsh (1885)
Holston River	Ortmann (1918)
Little Tennessee River, Tennessee	TVA (1972a) specimens collected by Athearn 1962, 1963, 1965
Citico Creek, Tennessee	Bogan and Parmalee (1983) Athearn collected specimens in 1957
Clinch River	Stansbery (1971)
Cumberland River	Lea (1861) Ortmann (1918, 1925) Wilson and Clark (1914) Shoup et al. (1941) Neel and Allen (1964) Simpson (1900, 1914) Parmalee et al. (1980) archaeological specimens Sickel (1982) relict specimens

Present

Epioblasma t. torulosa was collected fresh-dead (one specimen) in 1969 from the Kanawha River, West Virginia, below Kanawha Falls (Stansbery, 1980). To date, this represents the only record of this species from the Kanawha River. Stansbery reported that no living specimens of *E. t. torulosa* have ever been collected from the Kanawha River. Recent studies of the Kanawha River by Clarke (1982) and Taylor (1983) found no evidence of *E. t. torulosa*. Clarke (1982) recommended that a detailed scuba search be conducted below Kanawha Falls to determine this species' status in the Kanawha. Taylor (1983) concluded that this species no longer occurs in the drainage. Stansbery (1976b) and Jenkinson (1981) consider this species to be "probably extinct."

Epioblasma turgidula was last reported in the mid-1960's from the Duck River near Normandy, Tennessee (Stansbery, 1976a). With the completion of Normandy Dam on the Duck River by TVA in 1976, the three locations where specimens of *E. turgidula* were collected are now either impounded or affected by the operation of Normandy Dam. This species has not been found in recent freshwater mussel surveys conducted on the Duck River (TVA, 1972b, 1979; Ahlstedt, 1980), nor has it been reported from any other stream or river system. Stansbery (1971) and Jenkinson (1981) consider this species to be extinct.

Stansbery 1971, 1976b) reported that *E. f. florentina* has not been seen or collected in over a half century and thus considers this species extinct. However, Athearn collected specimens of *E. f. florentina* from the Little Tennessee River in the mid 1960's and from Citico Creek in 1957 (TVA, 1972a; Bogan and Parmalee, 1983).

ECOLOGY AND LIFE HISTORY

Freshwater mussels (naiades), are benthic animals that normally remain buried in the substrate with only the most posterior margin of the shell and siphons exposed to the water column. Freshwater mussels are found in a variety of habitats ranging from mud and sand between bedrock ledges, to rubble and gravel substrates. The majority of freshwater mussel species are usually found in riverine conditions in relatively firm rubble, gravel, and sand substrate swept-free of siltation. Typically, most mussel species are found buried in the substrate in relatively shallow areas called riffles or shoals. Freshwater mussels in the genus *Epioblasma* are characteristic riffle or shoal species inhabiting those parts of streams which are shallow with sandy gravel substrate and rapid currents (Stansbery, 1971). The eight species presumed extinct were, with few exceptions, recorded from riffles of our largest rivers. This type of habitat has nearly been eliminated by impoundment of the large rivers. Of these eight species, Stansbery lists *E. f. florentina* and *E. turgidula* as extinct. *Epioblasma f. florentina* has not been seen in over half a century and the last known population of *E. turgidula* in the Duck River were apparently destroyed. Neel and Allen's (1964) survey of the upper Cumberland Basin documented an almost total elimination of the genus *Epioblasma* (=*Dysnomia*) presumably due to mine wastes.

Epioblasma torulosa torulosa (photo 1)

Epioblasma t. torulosa is a larger, more inflated form of Epioblasma torulosa gubernaculum (Reeve, 1865) which occurs only in headwater tributaries of the Tennessee River above Knoxville, Tennessee, (as per Ortmann, 1918). Epioblasma t. torulosa exhibited considerable ecophenotypic variation in sculpture and obesity. Ball (1922) demonstrated the relationships between shell inflation and tuberculation with streamsize in this species. Previously, Ortmann (1918) noted that the typical big river form E. t. torulosa from the Tennessee River had a row of prominent knobs across the middle of the shell but, further upstream, the knobs become reduced and finally disappear, thus passing into the form E. t. gubernaculum. Epioblasma t. torulosa also appeared to grade into another form Epioblasma torulosa rangiana (Lea, 1838) of the Ohio River system (Ortmann, 1913; Johnson, 1978; Bogan and Parmalee, 1983). Johnson (1978) provides the following description of the shell:

> Shell of medium size, reaching almost 90 mm in length. Outline irregularly ovate, elliptical or obovate. Valves inequilateral, subinflated to inflated, solid. Anterior end regularly rounded, posterior end of male slightly produced; more broadly rounded in females. Ventral margin slightly curved. Dorsal margin curved forming an indistinct angle with the obliquely descending posterior margin. Hinge ligament short. Posterior ridge of the male rather low, narrowly rounded, separated from a similar medial ridge by a broad furrow of varying depth that ends in an emargination between the somewhat produced ridges. Both the ridges and the furrow vary from being smooth to having elevated knobs. The marsupial swelling in the female is sometimes marked by a number of small radial furrows, but the ridges become obscure. The rounded marsupial swelling extended from the middle of the base

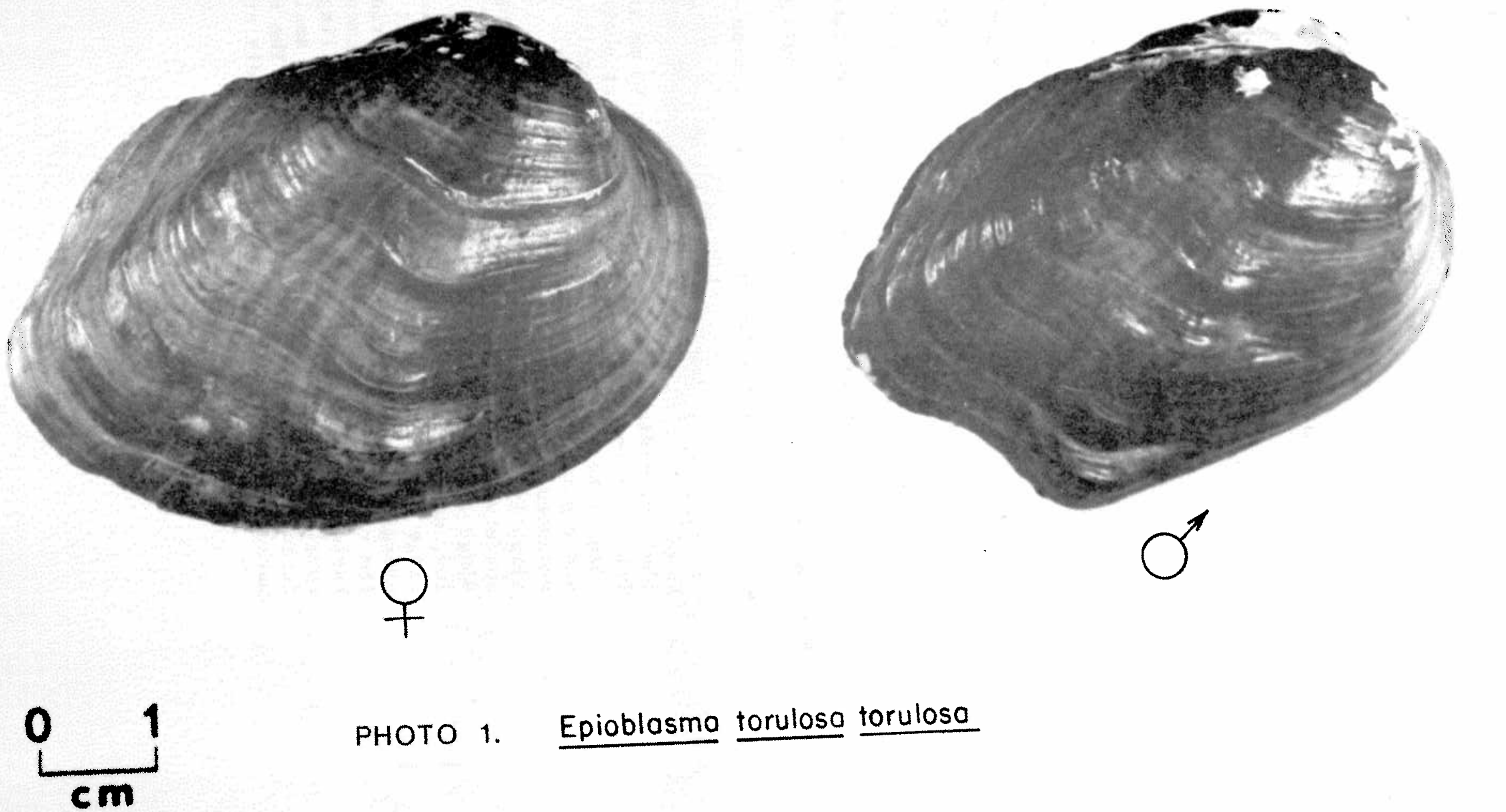

PHOTO 1. Epioblasma torulosa torulosa

to the upper part of the posterior end. Umbos full, somewhat turned over a small lunule, located toward the anterior third of the shell, sculpture feeble and corrugated. Surface of the shell with many distinct growth lines. Periostracum smooth and shiny, tawny, yellowish green, or straw colored, usually with numerous green rays.

Left valve with two triangular pseudocardial teeth; slight interdentum. Two long, almost straight, lateral teeth. Right valve with one large pseudocardinal tooth with a smaller tooth before it. One lateral tooth, sometimes with a vestigial tooth below. Umbonal cavity shallow. Anterior and posterior adductor muscle scars and pallial line, well impressed. The shell is thin in the marsupial region of the female especially toward the margin. Nacre white to salmon-red.

Male shells are generally irregularly ovate with a rather wide radial furrow of varying depth ending in a broad sinus, often bluntly pointed behind.

Female shells are generally obovate, larger than the male, having a large, flattened, rounded marsupial swelling extending from the middle of the base to near the upper part of the posterior end, which is thin and often a darker green than the rest of the shell.

Epioblasma turgidula (photo 2)

Epioblasma turgidula is a small-sized Cumberlandian type found both in the Cumberlandian and Ozarkian Plateau regions. As with other members of this genus, this species is sexually dimorphic. Male specimens of E. turgidula were originally described by Lea (1858) while Reeve (1864) later described the female as Unio deviatus. Walker (1910) in his paper on Truncilla first recognized the two sexes as being the same species since he includes Truncilla deviatus in his keys to both male and female specimens. Ortmann (1918) also correctly identified U. deviatus as the female of U. turgidulus. Stansbery (1976a) and Johnson (1978) report that E. turgidula closely resembles E. biemarginata and is superficially similar to all the members of the subgenus Capsaeformis. A detailed description of E. turgidula is given by Johnson (1978) and is presented below:

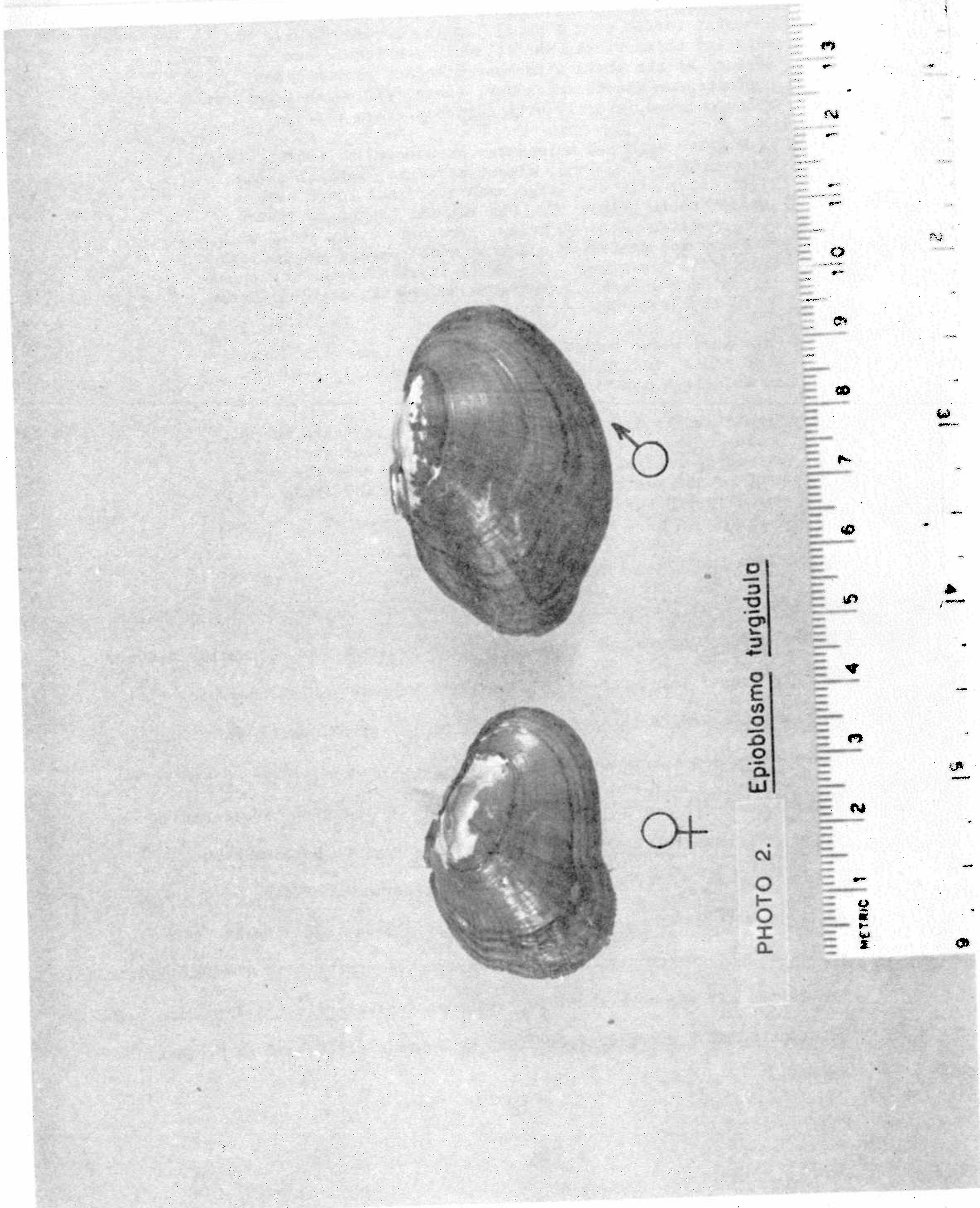

PHOTO 2. *Epioblasma turgidula*

Shell rather small, seldom reaching more than 40 mm in length. Outline elliptical, ovate, or obovate. Valves inequilateral, solid, slightly inflated. Anterior and regularly rounded; posterior end of male rather pointed, of female more broadly rounded. Ventral margin curved in males, almost straight in females before the marsupial swelling. Dorsal margin slightly curved forming an indistinct angle with the obliquely descending posterior margin. Hinge ligament short. Posterior ridge of the male, double, somewhat raised, ending posteriorly in a slight biangulation. The ridges of the female fade out on the marsupial swelling. Dorsal slope slightly concave. The male has a rather wide, shallow, radial furrow, which ends in an emargination. The medial ridge is only slightly developed, and both it and the radial furrow are obscured in females by marsupial swelling. Umbos moderately full and elevated, located in the anterior third of the shell; umbonal sculpture not observed. Surface of the shell with irregular growth lines, which are especially strong on the female posteriorly. Periostracum rather shiny, yellowish green, with numerous fine green rays over the entire surface.

Left valve with two small, rough, subcompressed pseudocardinal teeth. No interdentum. Two short, straight, lateral teeth. Right valve with one small, triangular, pseudocardinal tooth, with a second tiny tooth before it that is parallel to the hinge line. One lateral tooth. Umbonal cavities shallow. Anterior adductor muscle scars well impressed; posterior scars faint. Pallial line distinct anteriorly. Nacre bluish white. Shell heavier anteriorly, posterior end of females especially thin and irridescent.

Male shells are elliptical or ovate, with a distinct raised double posterior ridge, which ends in a biangulation near the base. Before the ridge is a wide shallow radial furrow and faint medial ridge.

The female is somewhat obovate, and while the marsupial swelling obliterates the radial furrow and the medial and posterior ridges, there is a tendency for the shell to be somewhat concave in the region of the posterior ridges. The surface of the marsupial swelling is not different from the rest of the shell, the feeble green rays are rather evenly distributed in both sexes.

<u>Epioblasma florentina florentina (photo 3)</u>

<u>Epioblasma</u> <u>f</u>. <u>florentina</u> is a medium-sized Cumberlandian type found both in the Cumberlandian and Ozarkian regions. This species is represented in the Ozarkian region by <u>E</u>. <u>f</u>. <u>curtisi</u> (Utterback, 1915)

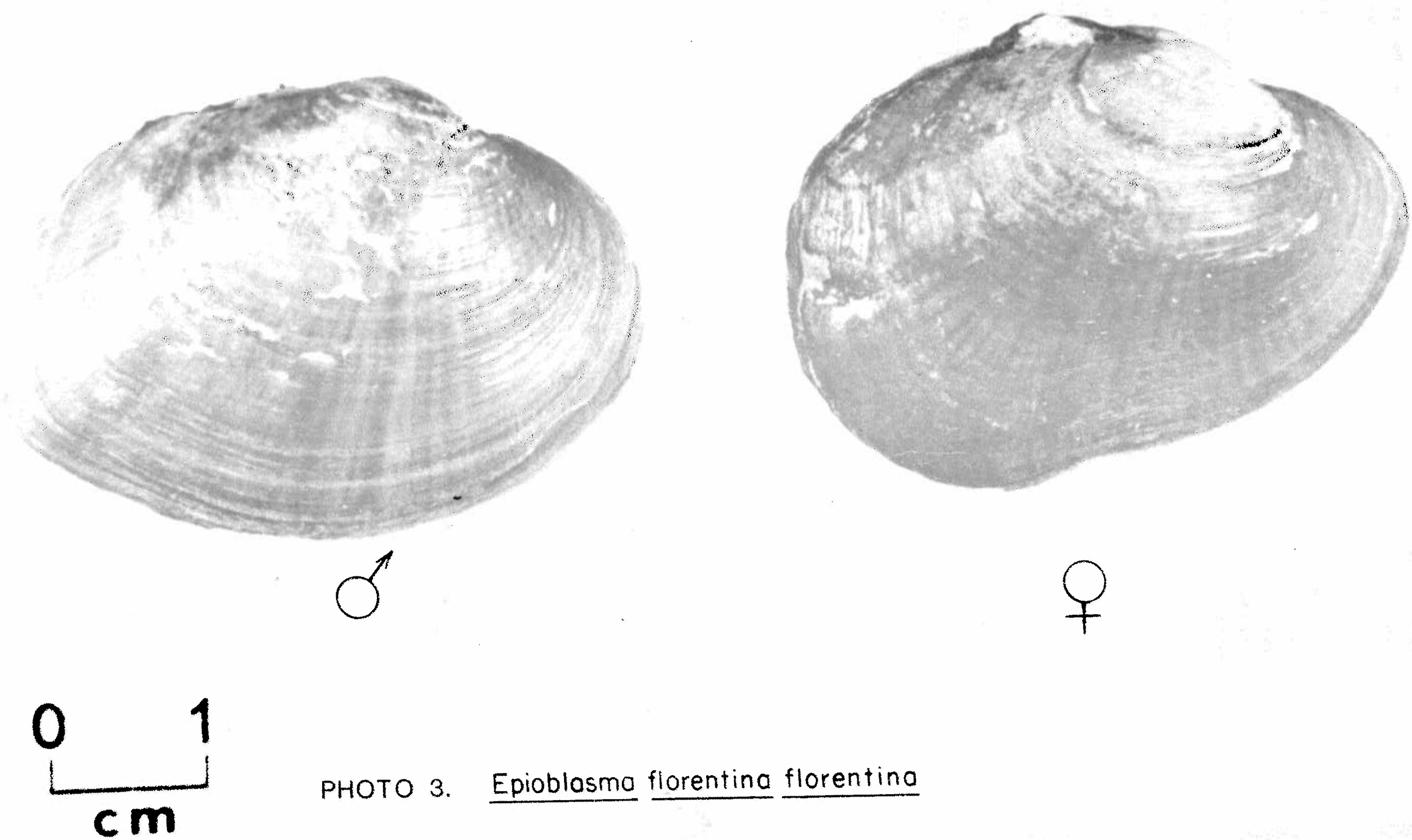

PHOTO 3. Epioblasma florentina florentina

which is being evaluated in a separate recovery plan. *E. f. florentina* represents the big-river form of this species which may grade into the smaller, headwaters form *E. f. walkeri* (Wilson and Clark, 1914; Ortmann, 1918 and 1924). As with *E. turgidula*, *E. f. florentina* is superficially similar to all the members of the subgenus *Capsaeformis*. The detailed description of *E. f. florentina* given by Johnson (1978) is as follows:

> Shell of medium size, seldom reaching over 60 mm in length. Outline elliptical or irregularly obovate. Valves somewhat inequilateral, subinflated, subsolid. Anterior end regularly rounded, posterior end of male slightly produced; posterior more broadly rounded in females. Ventral margin slightly but uniformly curved in the male; almost straight in females to the sulcus, behind which the marsupial swelling extends well below the base. Dorsal margin straight, forming an angle with the obliquely descending posterior margin. Hinge ligament short. Posterior ridge of the male, double, but faint, ending in a slight biangulation posteriorly; ridge scarcely visible in females. There is a wide shallow radial depression in front of the full, lower posterior ridge in the male. The considerable marsupial swelling of the female is usually marked by a sulcus before and behind and is sometimes finely toothed on the margin.
>
> Umbos quite full and elevated, located slightly anterior of the middle in the male, and in the anterior third of the shell in the female, umbonal sculpture not observed. Surface of the shell with uneven growth lines. Periostracum subshiny, yellow, honey yellow, brownish yellow, or whitish with numerous green rays more or less uniformly distributed over the entire surface.
>
> Left valve with two chunky triangular pseudocardinal teeth; slight interdentum. Two short slightly curved lateral teeth. Right valve with one large triangular pseudocardinal tooth, usually with a smaller tooth before it that is parallel to the hinge line. One lateral tooth, sometimes with a vestigial tooth below. Umbonal cavities shallow. Anterior adductor muscle scars well impressed, posterior ones shallow. Pallial line distinct anteriorly. Nacre bluish white. Shell heavier anteriorly, posterior end of females especially thin and irridescent.

> Male shells irregularly elliptical, with a double posterior ridge that ends in a slight bimargination near the median. There is a wide, shallow, radial depression in front of the full, lower posterior ridge.
>
> Female shells irregularly obovate with a thin, slightly inflated marsupial swelling, which may be considerably produced and extended well below the base, often marked by two distinct sulci, toothed on the margin.

The life histories of E. t. torulosa, E. turgidula, and E. f. florentina are probably similar to those of most naiades and are briefly illustrated in Figure 1. Males produce sperm which are discharged into the surrounding water and dispersed by water currents. Females downstream from the males obtain these sperm during the normal process of siphoning water while feeding and respiration (Stein, 1971). Fertilization of the eggs by sperm occurs within the gills of the female. In the genus Epioblasma fertilized eggs are retained in the posterior section of the outer gills which are modified as brood pouches. Based on the position of the genus Epioblasma (=Dysnomia) in the subfamily Lampsilinae, it is assumed that only the outer two demibranches serve as ovisacs (Heard and Guckert, 1970).

The family Unionidae are separated into two groups based on the length of time glochidia remain in the female (Ortmann, 1919). By Ortmann's definitions, bradytictic bivalves (long-term breeders) breed from midsummer through fall or early winter. Embryos develop in the female over winter and are released the following spring or summer. Tachytictic bivalves (short-term breeders) breed in spring and release glochidia by mid- to late-summer of the same year. Data for other Epioblasma species (Ortmann, 1919; Bogan and Parmalee, 1983) would suggest that Epioblasma t. torulosa, E. turgidula, and E. f. florentina are long-term breeders.

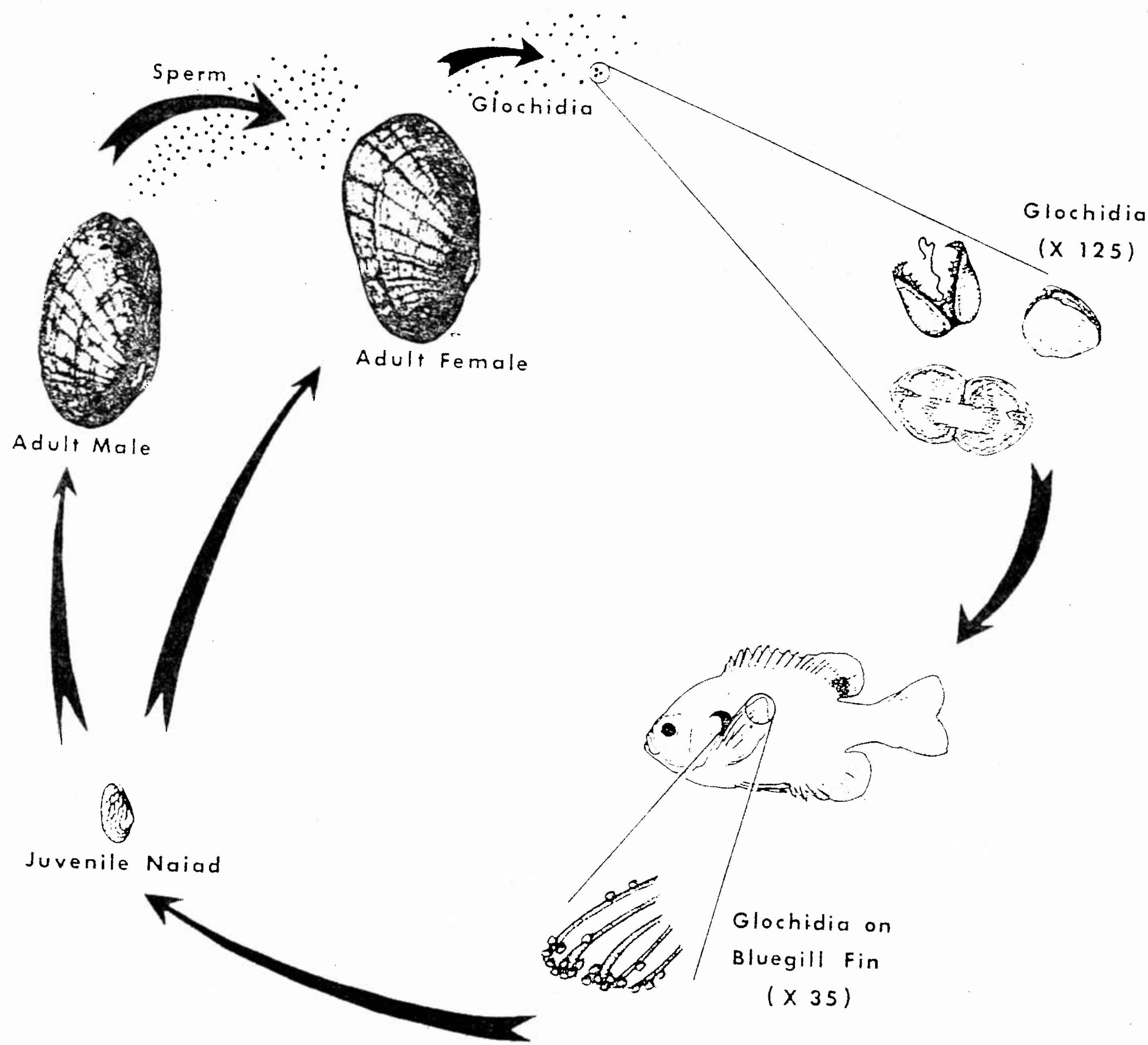

Figure 1. Typical naiad life cycle depicting the various stages. The life cycle for most species of naiades is very similar to that depicted here (Grace and Buchanan 1981).

Glochidial releases by some bradytictic species have also been observed during fall and winter (Zale, 1980). Upon release into the water column, mature glochidia attach to the gills or fins of appropriate host fishes to encyst and metamorphose to the juvenile stage. The glochidia of most Epioblasma species are bean-shaped and hookless. Hookless glochidia typically have a more spoon-shaped delicate shell and are most frequently parasitic on gill filaments of fish (Lefevre and Curtis, 1910; Coker and Surber, 1911). The fish host(s) for E. t. torulosa, E. turgidula, and E. f. florentina are unknown.

REASONS FOR DECLINE AND/OR EXTINCTION

The genus Epioblasma (=Dysnomia) as a whole is becoming rarer because all members of this genus are riverine and typically found in streams which are shallow with sandy-gravel substrate with rapid currents (Stansbery, 1971). Eight Epioblasma species are presumed extinct and were, with few exceptions, recorded from riffles or shoals of our largest rivers. The reasons for the extinction of these species and the decline of the remaining Epioblasma species are not totally understood; however, these species or their fish host(s) may be reacting to levels or types of impacts that are not killing other species in the same habitat. Due to the longevity of most mussel species--up to 50 years--and their sedentary nature, they are especially vulnerable to stream perturbations such as impoundments, siltation, and pollution.

Impoundment

Possibly the single greatest factor contributing to the decline of freshwater mussels, not only in the Tennessee Valley but other regions as well, is the alteration and destruction of stream habitat due to impoundments for flood control, navigation, hydroelectric power production, and recreation. Ortmann's (1918) monograph on the naiads of the upper Tennessee River is the most significant work on that region's freshwater mussel fauna prior to construction of impoundments on many of these streams. At the time of Ortmann's survey, a total of 66 species of mussels occurred in the Tennessee River between Chattanooga and Knoxville, Tennessee. Pardue (1981) reported only 23 species of mussels living in the Tennessee River during a survey conducted in 1978. Publications by Wilson and Clark (1912, 1914) and Neel and Allen (1964) on the mussels of the Cumberland River and its tributaries also offer an excellent historical account of that fauna prior to impoundment and extensive coal mining. A total of 79 species of freshwater mussels was reported by Wilson and Clark (1914) and 59 species were later reported by Neel and Allen (1964).

Since the early 1930's and 1940's, the Tennessee Valley Authority, Aluminum Company of America (Alcoa), and the U.S. Army Corps of Engineers have constructed 51 impoundments throughout the Tennessee and Cumberland River systems alone. Stream impoundments affect species composition by eliminating those species not capable of adapting to reduced flows, altered temperature regimes, and anoxic conditions. Tributary dams typically have hypolimnial discharges that cause the stream below the dam (reservoir tailwater) to differ significantly from both preimpoundment conditions and from upstream river reaches. Hypolimnial discharges include: altered temperature regimes, extreme water level fluctuations, reduced turbidity, seasonal oxygen deficits, and high concentrations of certain heavy metals (TVA, 1980). Biological responses attributable to these environmental changes typically include reductions in the fish and benthic macroinvertebrate communities (Isom, 1971). Hickman (1937) recorded numerous species of mussels and snails in the vicinity of the Norris Dam construction site prior to the impoundment of that reach of the Clinch River and predicted that the Norris Dam flood control project would have a deteriorating effect on the molluscan fauna. A. R. Cahn (1936) collected 45 mussel species and nine river snail species in the dewatered riverbed following closure of Norris Dam. In a return visit to the area 4 months later, he could not find a single live mussel. Ortmann (1925) witnessed the most famous and unique locality for mussels (Muscle Shoals, Alabama), destroyed by the construction of Wilson Dam on the Tennessee River.

Siltation

Siltation is another factor that has severely affected freshwater mussels. In rivers and streams, the greatest diversity and abundance of mussels are usually associated with gravel and/or sand substrates. These substrates are most common in running water (Hynes, 1970). Increased silt transport into our waterways due to strip mining, coal washing, dredging, farming, logging, and road construction are some of the more obvious results of human alteration of the landscape. Hynes (1974) states that there are two major effects of inorganic sediments introduced into aquatic ecosystems. The first is an increase in the turbidity of the water with a consequent reduction in the depth of light penetration, and the second is a blanketing effect on the substrate. High turbidity levels due to the presence of suspended solids in the water column have a mechanical or abrasive action which can irritate, damage, or clog the gills or feeding structures of mollusks (Loar et al. 1980). Additionally, high levels of suspended solids may reduce or inhibit feeding by filter-feeding organisms, such as mussels, causing nutritional stress and mortality (Loosanoff, 1961). Freshwater mussels are quite long lived and rather sedentary by nature; many species are unable to survive in a layer of silt greater than 0.6 centimeters (Ellis, 1936). Since most freshwater mussels, especially the Cumberlandian types and the genus Epioblasma, are typically riverine species that require clean, flowing water over stable, silt-free rubble, gravel, and sand shoals, the smothering action of silt is often severe. Fuller (1977) reported that siltation associated with poor agricultural practices and deforestation of much of North America was probably the most significant factor impacting mussel communities. Mussel life cycles can be affected indirectly from siltation by impacting host-fish populations by smothering fish eggs or larvae, reducing food availability, or filling of interstitial spaces in gravel and rubble substrate, thus eliminating spawning beds and habitat critical to the survival of young fishes (Loar et al. 1980).

Pollution

A third factor which must be considered is the impact caused by various forms of pollutants. An increasing number of streams throughout the United States receive municipal, agricultural, and industrial waste discharges. The damage suffered varies according to a complex of interrelated factors, which includes the characteristics of the receiving stream and the nature, magnitude, and frequency of the stresses being applied. The degradation can be so severe and of such duration that the streams are no longer considered valuable in terms of their biological resources (Hill et al. 1974). These areas will not recover if there are residual effects from the pollutants, or if there is an inadequate pool of organisms for recruitment or recolonization (Cairns et al. 1971).

The absence of freshwater mussels can be an indication of environmental disruption only when and where their former presence can be demonstrated (Fuller, 1974). It is very rare that the composition and size of the mussel fauna can be quantitatively and/or qualitatively correlated with a specific disruption, be it chemical or physical (Ingram, 1956). However, some data are available concerning the adverse impacts of some pollutants on freshwater mussels along with other components of the ecosystem. Neel and Allen (1964) reported that coal mine acids in headwater tributaries of the Cumberland River have practically eliminated the most diverse known assemblage of Epioblasma (= Dysnomia) species. A combination of toxic wastes, gravel dredging, and increased fertilizer and pesticide use has reduced the freshwater mussel fauna in the Stones River from 45 to 30 species (Schmidt, 1982). Ortmann (1918), in his studies of the freshwater mussels in the upper Tennessee drainage, reported numerous streams to be already polluted and the mussel fauna gone. These streams included the Powell River, for a certain distance below Big Stone Gap, Virginia (wood extracting plant); the North Fork Holston River for some distance below Saltville, Virginia (salt and plaster of Paris industries); French Broad River at Asheville, North Carolina; Big Pigeon River from Canton, North Carolina, all the way to its mouth (wood pulp and paper mill); and the Tellico River below Tellico Plains, Tennessee (wood pulp and extracting mill).

PART II

RECOVERY

A. Recovery Objectives

The ultimate goal of this recovery plan is to locate, maintain, and enhance any known populations of *E. t. torulosa*, *E. turgidula*, and *E. f. florentina*. Based on the information provided in this document and the opinions expressed by numerous experts, it appears that all three of these species may already be extinct. Stansbery (1971) listed eight *Epioblasma* species presumed to be extinct, including *E. turgidula* and *E. f. florentina*. In 1976, Stansbery reported that *E. t. torulosa* may also be extinct. A survey by TVA biologists (Jenkinson, 1981) found no reason to believe that *E. f. florentina*, *E. turgidula*, and *E. t. torulosa* might be found alive. The extinction of these species appears to be symptomatic of a general synecological problem that exists between *Epioblasma* and chronic environmental changes that have occurred and are continuing to occur in most major river systems. Based on the recent decline for other endangered species of this group, including *E. walkeri* (Neves, 1984), *E. t. gubernaculum* (Ahlstedt, 1984), and *E. sampsoni* (Clarke, 1981), it is highly improbable, if and when live specimens of any one of the three subject species are found that (1) populations can be restored to other rivers within its historic range, or (2) the species can ever recover to the point of delisting. Nevertheless, recovery efforts for each species will be reevaluated when the following criteria are met:

1. A reproducing population of either _E. t. torulosa_, _E. turgidula_, or _E. f. florentina_ are found in any stream or river system.
2. Each species and its habitat are protected from present and foreseeable anthropogenic and natural events that may interfere with the survival of the population.

B. Step-Down Outline

Prime Objective: Determine the current status for each of these species, and provide protection for any populations located.

1. Conduct intensive surveys for each species.
   - 1.1 Identify essential habitat and specific areas in need of protection.
   - 1.2 Utilize existing legislation and regulations to protect the species and its habitat.
2. Determine present and foreseeable threats to the species and strive to minimize and/or eliminate them.
3. Assess overall status for species listed in this recovery plan.

C. Narrative Outline

1. Conduct intensive surveys for each species. Intensive dive/float surveys using scuba-equipped divers, snorkelers, and/or commercial mussel fishermen are recommended for attempting to locate living populations of each species:

   Epioblasma t. torulosa--Freshwater mussel surveys are recommended for the lower Ohio River below Owensboro, Kentucky, and the Kanawha River, West Virginia, below Kanawha Falls (KRM 95.5-81.0).

Epioblasma turgidula--Freshwater mussel surveys are recommended for Shoal and Bear Creeks, Alabama; Emory River, Tennessee; Spring Creek, Arkansas; Black River, Arkansas; and White River, Missouri and Arkansas.

Epioblasma f. florentina--Freshwater mussel surveys are recommended for Hurricane and Bear Creeks, Alabama; upper Little Tennessee River above Tellico Reservoir; Citico Creek, Tennessee; and the Big South Fork Cumberland River.

1.1 Identify essential habitat and specific areas in need of protection. If individuals are found, the extent of the population must be delineated.

1.2 Utilize existing legislation and regulations to protect the species and its habitat. Prior to and during implementation of this recovery plan the species will be protected by the full enforcement of existing laws and regulations.

2. Determine present and foreseeable threats to the species and strive to minimize and/or eliminate them. All local, state, and federal development and enforcement agencies and land use groups will be notified of the sensitivity of certain areas with known populations of these species. Since these areas will probably represent the only known location(s) for these species, every effort will be made to prevent any modification or impact which might prove harmful to the species and its habitat. These impacts typically include dredging, strip

mining, industrial development, road and bridge construction, installation of sewage treatment plants and their operation, and the use of herbicides along roads and powerline corridors as well as pesticides and fertilizers for farm crops.

3. Assess overall status of each species. This recovery plan must be evaluated periodically to determine the current status of these 3 species. If freshwater mussel surveys fail to locate live specimens of *E. t. torulosa*, *E. turgidula*, and *E. f. florentina*, these species will be recommended for removal from the federal endangered species list due to extinction.

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KEY TO IMPLEMENTATION SCHEDULE COLUMNS 1 AND 4

General Category (Column 1):

Information Gathering - I or R (research)

1. Population status
2. Habitat status
3. Habitat requirements
4. Management techniques
5. Taxonomic studies
6. Demographic studies
7. Propagation
8. Migration
9. Predation
10. Competition
11. Disease
12. Environmental contaminant
13. Reintroduction
14. Other information

Acquisition - A

1. Lease
2. Easement
3. Management agreement
4. Exchange
5. Withdrawal
6. Fee title
7. Other

Other - O

1. Information and education
2. Law enforcement
3. Regulations
4. Administration

Management - M

1. Propagation
2. Reintroduction
3. Habitat maintenance and manipulation
4. Predator and competitor control
5. Depradation control
6. Disease control
7. Other management

Priority (Column 4):

1 - Those actions absolutely necessary to prevent extinction of the species.

2 - Those actions necessary to maintain the species' current population status.

3 - All other actions necessary to provide for full recovery of the species.

Tuberculed-blossom Pearly Mussel (Epioblasma (=Dysnomia) torulosa torulosa)
Turgid-blossom Pearly Mussel (Epioblasma (=Dysnomia) turgidula), and Yellow-blossom Pearly Mussel (Epioblasma (=Dysnomia) florentina florentina)

Part III Implementation Schedule

*1 General Category	Plan Task	Task Number	Priority	Task Duration	Responsible Agency *2 FWS Region	FWS Program	Other	Estimated Fiscal Year Costs *3 FY 1	FY 2	FY 3	Comments/Notes
I1,2	Conduct intensive surveys for each species.	1	1	3 yr.	3,4, 5	SE	TWRA, THP, TVA, KDFWR, KNPC, WVDNR, ADCNR, AGFC, ANHC, MDC, MDR, IDC, INPC	25,000	25,000	25,000	*1. See general categories for Implementation Schedules. *2. Other agencies' responsibility would be of a cooperative nature or projects funded under a contract or grant program. In some cases contracts could be let to universities or private enterprises. *3. Note: Task costs have not been estimated for this plan. This species' present/historic distribution coincides with that of other listed species. Thus, a task aimed at this species will benefit others. Rather than attempting to apportion the costs to each species, recovery tasks will be estimated at a later date when the plans are combined on a watershed basis for implementation.
I3,M3, 02-4	If populations are found, identify essential habitat and specific areas in need of protection and protect with existing legislation and regulations.	1.1 and 1.2	1 (if populations are found)	Continuous	3,4, 5	SE,ES LE	Same as above	1,000	1,000	1,000	
M1-7, 01	If populations are found, determine present and foreseeable threats and strive to minimize and/or eliminate them.	2	1 (if populations are found)	Unknown	3,4, 5	SE,ES	Same as above	Unknown	Unknown	Unknown	
04	Assess overall status of species.	3	2	Continuous until delisted	3,4, 5	SE,ES	Same as above	500	500	500	

Abbreviations:

SE - Endangered Species
ES - Ecological Services
LE - Law Enforcement
TWRA - Tennessee Wildlife Resources Agency
THP - Tennessee Heritage Program
TVA - Tennessee Valley Authority
KDFWR - Kentucky Department of Fish and Wildlife Resources
KNPC - Kentucky Nature Preserves Commission
WVDNR - West Virginia Department of Natural Resources
ADCNR - Alabama Department of Conservation and Natural Resources
AGFC - Arkansas Game and Fish Commission
ANHC - Arkansas Natural Heritage Commission
MDC - Missouri Department of Conservation
MDNR - Missouri Department of Natural Resources
IDC - Illinois Department of Conservation
INPC - Illinois Nature Preserves Commission

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