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Natural History and Distribution of the Upland Chorus Frog, Pseudacris feriarum Baird, in West Virginia

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by

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Abstract

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Chapter 1 is a literature review of *Pseudacris feriarum*, largely based on published *P. triseriata* Complex species accounts. Chapter 2 presents the natural history of *P. feriarum* in West Virginia and compares some parameters with other *Pseudacris* species. Chapter 3 looks at the phenology of a wetland in eastern West Virginia. Chapter 4 examines the current range of *P. feriarum* and compares it with the historical range in the state. Finally, hypotheses are given as to why Upland Chorus Frogs have declined in West Virginia. All information obtained from this study should be used to create a management plan for the conservation of all present and future *P. feriarum* populations.

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Study Site Description

This study took place in Berkeley Springs, Morgan County, West Virginia. Average temperature is -1.1˚C in January, 0˚C in February, 5.5˚C in March, 10˚C in April and 15.5˚C in May. Average humidity in January ranges from 75 to 58% (from morning to afternoon), 75 to 54% in February, 75 to 52% in March, 75 to 48% in April and 80 to 55% in May. Average precipitation is 7.1 cm in January, 5.6 cm in February, 8.1 cm in March and April and 10.2 cm in May. Average snowfall is 19.1 cm in January, 16.5 cm in February, 10.2 cm in March, 1.3 cm in April and 0.0 cm in May (City-Data.com).

The macrohabitat can be described as a marshy, mostly-ephemeral wetland located on an open meadow approximately 120 by 185 meters with a water trench running through the middle. The northern end is bordered by a house while the southern end is bordered by a horse field. The western end is met by a road and the eastern side leads into a forested area. The northern end of the water channel is typically present during all seasons while the southern end is more temporary with its edge receding about 15 m during the spring. Average water depth ranged from 0.05 to 0.3 m (shallowest to deepest). The type of water bottom is silt and is occluded by emergent vegetation. The prominent vegetation is *Carex* sp. (Sedges), *Cyperus* sp. (Sedges), *Chara* sp. (Muskgrasses), *Juncus effusus* (Common Rush), *Potamogeton* sp. (Pondweeds), *Phalaris arundinacea* (Reed Canary Grass) and *Ludwigia palustris* (Marsh Purslane) (Figures 1 through 4). Prior to this study, this area was used for agricultural purposes. This site was used to study the natural history of

Pseudacris feriarum in West Virginia and for determining phenology and species richness in an eastern West Virginia wetland.

Figure 1. Digitized Aerial Photograph of Study Site

- Gray denotes Creek Road
- Blue denotes wetland
- Black denotes 200 feet silt drift fence
- White denotes landmarks (house and barn)
- Maroon denotes minnow traps

Figure 2. Berkeley Springs Study Site (looking at the southern end)

(Photograph by Zachary Loughman)

Figure 3. Berkeley Springs Study Site (western edge of water trench)

(Photograph by Zachary Loughman)

Figure 4. Berkeley Springs Study Site (*Juncus effusus*): *Pseudacris feriarum* typically heard calling from vegetation along water

(Photograph by Zachary Loughman)

Chapter 1: Literature Review

Pseudacris Phylogenetic Relationships

Genus *Pseudacris* (Chorus Frogs) is only found in North America and presently contains 15 species. Members include: *brachyphona, brimleyi, cadaverina, clarkii, crucifer* (two subspecies: *c. crucifer* and *c. bartramiana*), *feriarum, illinoensis, kalmi, maculata, nigrita* (two subspecies: *n. nigrita* and *n. verrucosa*), *ocularis, ornata, regilla* (seven subspecies: *r. cascadae, r. curta, r. hypochondriaca, r. pacifica, r. palouse, r. regilla* and *r. sierra*), *streckeri* and *triseriata* (Collins and Taggart, 2002; Conant and Collins, 1998). All *Pseudacris* names throughout this paper are based on Moriarty and Cannatella (2004).

Prior to 1975, overall similarity of morphology or calls was used to taxonomically group *Pseudacris* and other Holarctic (extra-tropical North American and Eurasian regions) hylids. Because chorus frogs are "morphologically conservative," taxonomic uncertainty has been widespread and several studies have been performed to help elucidate this ambiguity (Moriarty and Cannatella, 2004).

Until recently, subspecies of *P. triseriata* included: *P. t. triseriata,* P*. t. feriarum, P. t. maculata* and *P. t. kalmi* (collectively called Striped Chorus Frog). These subspecies were first characterized using color pattern and morphological variation (*i.e*. tibia/body length ratios) across their geographic distribution (Harper, 1955; Smith and Smith, 1952). Platz and Forester (1988) and Platz (1989) elevated all subspecies to full species status based on differences in

advertisement calls and morphometrics. However, more population sampling must be completed to determine true geographic limits (Moriarty and Cannatella, 2004). To date, there is still much controversy regarding species status within *Pseudacris*. For example, *illinoensis* was recognized as a full species by Collins and Taggart (2002) but *illinoensis* taxonomic status is still considered "ambiguous" by Moriarty and Cannatella (2004). Also, *P. kalmi* is still considered a subspecies of *feriarum* by some (Crother, 2000).

Pseudacris feriarum Distribution and Habitats

Upland Chorus Frogs are found from northern New Jersey to northern Florida; west to east Texas and southeastern Oklahoma; and isolated populations in coastal South Carolina and southeast Georgia (Figure 5); they are among the most widely distributed anurans in North America (Conant and Collins, 1998). Within their range, Upland Chorus Frogs are found in a variety of habitats including swampy areas of broad valleys, grassy swales, moist areas of woodlands and borders of heavily vegetated ponds (Green and Pauley, 1987). In West Virginia, *P. feriarum* are largely found in the Ridge and Valley province. Historically, they were also found south along the Virginia border in Greenbrier, Monroe and Summers counties (Green and Pauley, 1987) (Figure 5) but they have not been observed or heard calling in these areas since the late 1980s (T.K.P., personal communication).

West Virginia Pseudacris species

In West Virginia, *P. feriarum* may be confused with 2 other members of *Pseudacris*: *P. brachyphona* (Mountain Chorus Frog) and *P. c. crucifer* (Northern Spring Peeper) (Figure 6). There are several simple ways to deduce which *Pseudacris* species is being observed or heard (Figure 6, Table 1).

Northern Spring Peepers are often found calling in the same areas as Mountain and Upland Chorus Frogs (usually in mid to late February but later at higher elevations) and are about the same size (up to 3.8 cm). However, *P. c. crucifer* is found state wide in West Virginia and has more toe webbing and larger toe pads than the 2 other species. *P. c. crucifer* also lays eggs singly (both *P. brachyphona* and *P. feriarum* lay eggs in clumps). Their call is very easy to recognize: “peep, peep” and usually ceases by midsummer. On the other hand, *P. feriarum* are only found in the Ridge and Valley Province while *P. brachyphona* are only found in the Allegheny Plateau. Both *P. feriarum* and *P. brachyphona* lay eggs in clumps (around 1000 for *P. feriarum* and around 300 to 900 for *P. brachyphona*). *P. feriarum* emerge slightly earlier, select more heavily vegetated ponds for breeding, are more secretive, call more frequently during the day and have a shorter breeding season (Green and Pauley, 1987).

Morphologically, all three species are ventrally cream-colored and dorsally pinkish to tan to brown. *P. feriarum* and *P. brachyphona* tend to have a dark triangle on the head while *P. brachyphona has* some yellow in the groin area. *P. feriarum* is the only one that has a dorsal pattern of lines or dots that do not cross

(in *P. brachyphona*, the pair of lines may cross and often do in *P. c*. *crucifer*) (Green and Pauley, 1987) (Figure 5).

Another difference between *P. brachyphona* and *P. feriarum* pertains to the speed and strength of their calls. *P. brachyphona*'s call has a "rake…rake" sound which is rapidly repeated over and over; it sounds like a raspy and drawn out monosyllable (Barbour, 1971). *P. feriarum* have a lower pitch and are slower than Mountain Chorus Frogs with *P. brachyphona's* pulse 4 times faster (Green and Pauley, 1987).

Pseudacris feriarum Phenotypic Characteristics

Upland Chorus Frogs are a diminutive species; they may attain a SVL of 3.8 cm (Figure 6). Dorsal color pattern varies from gray to tan to greenish-brown and a dark stripe on each side of the body extends from the snout, through the eye, to the groin area. A white line is present on the head, above the upper lip. Dorsally, there are 3 longitudinal lines which may be complete or broken into spots and a triangular spot on the head usually connects with the middle stripe (Green and Pauley, 1987) but some individuals may lack dorsal markings altogether (Johnson, 2000). Tops of the legs are covered with spots or bars while ventral surfaces are cream or white colored with black flecks. Both ventrally and dorsally, the skin is slightly rough. The hindlegs are longer than the forelegs and their long hind toes have slight webbing at the base and there are small toe pads. Sexual size dimorphism is present with females being significantly larger. On average, males reach 24.9 mm snout-urostyle length

(SUL) and females reach 28.7 mm SUL. Another way to sex individuals during the breeding season is by the males' dark, yellow vocal sacs (Hulse *et al*., 2001).

Because there is little published information on *P. feriarum*, the following life history accounts are largely based on published P*. triseriata* Complex literature.

Pre-breeding (Hibernation)

Because they are freeze-tolerant, hibernating sites include leaf-filled depressions beneath rotting logs or bark and holes under rocks made by small mammals (Green and Pauley, 1987; Storey and Storey, 1987). As a whole, chorus frogs are not good diggers, so it is unlikely they are found deep in the soil below the frost line (25 cm). If there is a severe winter and soil freezes, ice crystals can enter the bodily fluids of hibernating frogs and cause mortality. To combat this, glucose is produced in freeze-tolerant frogs (Edwards *et al*., 2000). Storey and Storey (1987) have shown that frogs from northern populations produce and accumulate cryptoprotectant (glucose) within their cells via the metabolism of liver glycogen stores. The purpose of the cryoprotectant is to stabilize cellular structure and function and to limit dehydration while animals are in a frozen state. Respiration, blood flow and heartbeat are stopped while in this condition. After emergence, frogs are able to withstand short bouts of below-zero temperatures. However, this freeze tolerance and the amount of cryptoprotectant decrease as spring proceeds (Storey and Storey, 1987). This probably has enabled this species to reside at higher elevations. On the other hand, *P. streckeri* seems to be intolerant of freezing, which is likely why they are

only found at lower elevations. However, *P. streckeri* are better diggers which may explain why they are only found in sandy soil at the northernmost limit of their distribution (Jablonski, 1998).

Breeding

One does not discover these frogs often, and when one does, it is usually during the breeding season when their calls are most noticeable. They are usually found on the ground near ephemeral water during this time (Hulse *et al*., 2001). Temperature over several weeks prior to emergence is an important determining factor as to when hibernation is over (Hulse *et al*., 2001). There is a breeding migration from overwintering sites to the breeding pools (Whitaker, 1971). In West Virginia, some may appear during warm spells in January but typically the breeding season begins in mid to late February to early March (Green and Pauley, 1987). Generally, the breeding activity peaks in April and drops off by the end of May (Hulse *et al*., 2001). During extremely cold winters, the breeding season may not begin until late March or even early April (Hulse *et al*., 2001). Landreth and Ferguson (1966) explained how chorus frogs may use both auditory (other sympatric males calling) and visual cues (reference points, celestial events) to orient themselves to their breeding site.

Breeding adults prey upon spiders, snails, and some caterpillars and fly larvae (Whitaker, 1971). This is in contrast to *P. c. crucifer* who fast during the breeding season (Oplinger, 1967). Whitaker (1971) found 61.6% of frogs were infected with nematodes and/or trematodes. Adult *P. triseriata* become infected when they eat infected snails that possess larval stages called cercaria.

Tadpoles become infected when free-swimming cercaria enter the spiracle (Whitaker, 1971).

Striped Chorus Frogs may breed in association with *Ambystoma laterale, A. tigrinum nebulosum, Bufo americanus, B. boreas, B. cognatus, B. woodhousii, Gastrophyrne olivacea, Hyla chrysoscelis, Notophthalmus viridescens, P. crucifer, Rana areolata, R. catesbeiana, R. clamitans, R. palustris, R. pipiens, R. septentrionalis, Rana sylvatica,* and *Spea bombifrons* (underlined species are found in West Virginia) (Blair, 1951a; Green and Pauley, 1987; Jacobs, 1950; Mitchell, 1990; Roble, 1985; Smith, 1983; Skelly, 1996; Whitaker, 1971).

Amplexus and Egg Deposition

Large aggregates of males gather in shallow pools along slopes and valley floors for 6 to 10 weeks (Whitaker, 1971). Most females arrive only for a few nights for communal breeding (Pollio and Kilpatrick, 2002; Whitaker, 1971). Generally, males call females from a hidden, grassy area or from an exposed area in shallow water or vegetation in a deeper body of water (Crenshaw and Blair, 1959; Landreth and Ferguson, 1966; Lord and Davis, 1956). During peak breeding times, males call both day and night (Landreth and Ferguson, 1966).

Females swim toward males in groups and as soon as contact is made, amplexus occurs (Hulse *et al*., 2001). Amplexus usually occurs at night on grassy stems, twigs and leaves (Gosner and Rossman, 1959). However, *P. kalmi* have been seen amplexing during the day (Gosner and Rossman, 1959). Females deposit 500 to 1,500 eggs but clutch number varies geographically (Gosner and Rossman, 1959; Wright and Wright, 1949). Eggs are deposited in

clumps of 40 to 60 (Green and Pauley, 1987) and are usually attached to vegetation 5 to 10 cm below the surface in water 15 to 50 cm deep (Whitaker, 1971). Depending on water temperature, eggs hatch between 4 and 46 days (Whitaker, 1971). In West Virginia, eggs hatch between 3 and 13 days (Green and Pauley, 1987). Average SVL for newly hatched tadpoles is between 4.8 and 6.1 mm (Whitaker, 1971).

Tadpoles

During the short period until metamorphosis, survival rates are low for tadpoles. Reasons include predators and feeding times that may be limited by weather (Hoppe and Pettus, 1984). One benefit of breeding in temporary water is that tadpoles can develop in an area that is relatively predator-free. A disadvantage is that tadpoles must find sufficient resources (*i.e*. food) to complete transformation before the water dries up. This may have a negative impact on the developing tadpole's larval period and size at metamorphosis (Britson and Kissell, 1996). Bridges (2002) reported that species who scavenge less for food can experience a reduction in size at metamorphosis and have a longer larval period. This, in turn, can have strong consequences for adult fitness. When amphibians are larger in size at metamorphosis, they are usually larger in size at sexual maturity, have increased fertility and a higher chance of reaching maturity. It has been thought that amphibian larvae can vary the length of their larval period in declining environments by making trade-offs between growth and development (Bridges, 2002).

However, rapid development through embryonic stages could be advantageous, particularly in areas with widely fluctuating temperatures. Frog tadpoles become more tolerant to temperature extremes with increasing embryonic age. It has been reported that more “northern” species have a higher survival rate because they have been exposed to lower temperatures following egg deposition (Hoppe and Pettus, 1984). This appears to be an adaptation to minimize the amount of time spent in this vulnerable form while anurans are metamorphosing (Wassersug and Sperry, 1977). Because many factors can affect behavior, it is important to examine how these can influence trade-offs and contribute to their evolutionary consequences (Bridges, 2002).

Rosenberg and Pierce (1995) found that *P. clarkii* tadpoles demonstrated significantly lower body growth at a lower pH (4.0). Survival at a higher pH (7.0) was elevated; however, body mass should be taken into account when considering acid tolerance and survivorship. Lower growth rates at a lower pH may be due to lower rates of feeding due to being more sluggish, lowered food quality due to exposure to low pH or a higher metabolism due to lower pH.

It has been shown that UV-B light damages neural tubes in amphibian larvae. Even though amphibian eggs and embryos are somewhat protected from UV light by melanin and jelly coatings, excess UV-B may be capable of causing damage in these stages (Jablonski, 1998). There are several factors that determine how amphibians may be affected by ambient UV-B radiation. Levels of cloud cover, haze, pollution, breeding site location, oviposition site and depth, seasonal time of breeding, melanin concentrations of embryos, capacity of DNA

repair and light-transmitting characteristics of the jelly coat are just a few examples (Starnes *et al*., 2000). Because *P. triseriata* deposit eggs in sunny places, usually at or right under the surface of clear water, it is suspected that these species are susceptible to ambient UV-B radiation. Effect of increased UV-B radiation to global amphibian declines will become more evident as we determine the sensitivity of amphibians to ambient UV-B at test sites worldwide (Starnes *et al*., 2000).

Larval period lasts from 6 to 13 weeks; usually 6 weeks in West Virginia (Green and Pauley, 1987; Jacobs, 1950; Smith 1983; Whitaker, 1971). Tadpoles are generalized suspension feeders; eating algae, protozoa, diatoms, decomposed plants and fecal pellets (Britson and Kissell, 1996; Whitaker, 1971). They tend to congregate in warm, shallow water where they may escape to leaf litter or vegetation in deeper water when predators emerge (E.C.M., personal observation *in* Moriarty and Lannoo, 2005). Most metamorphose by mid-July and hibernate by early September (Green and Pauley, 1987). Average SVL ranges from 7 to 12 mm for 2 populations of *P. maculata* in Colorado (Blair, 1951a). Whitaker (1971) showed recently metamorphosed froglets feed mainly on mites and spring tails (both readily available at water sources). Newly metamorphosed frogs migrate to upland feeding areas (E.C.M., personal observation *in* Moriarty and Lannoo, 2005).

It has been reported that metamorphosing frogs may be more susceptible to *Thamnophis* predation than tadpoles or fully metamorphosed frogs due to hindrance of locomotion via their intermediate body form (Wassersug and Sperry,

1977). Adult dytiscid beetles and dragonfly naiads are also known to prey upon chorus frog tadpoles (Smith, 1983; Skelly, 1996).

Smith (1987) found age at sexual maturity to be between the first and second year after metamorphosis, with larger individuals reaching sexual maturity first. Caldwell (1987) found longevity to be between 1 and 3 years for *P. nigrita* (a closely related species).

Post-breeding (Adults)

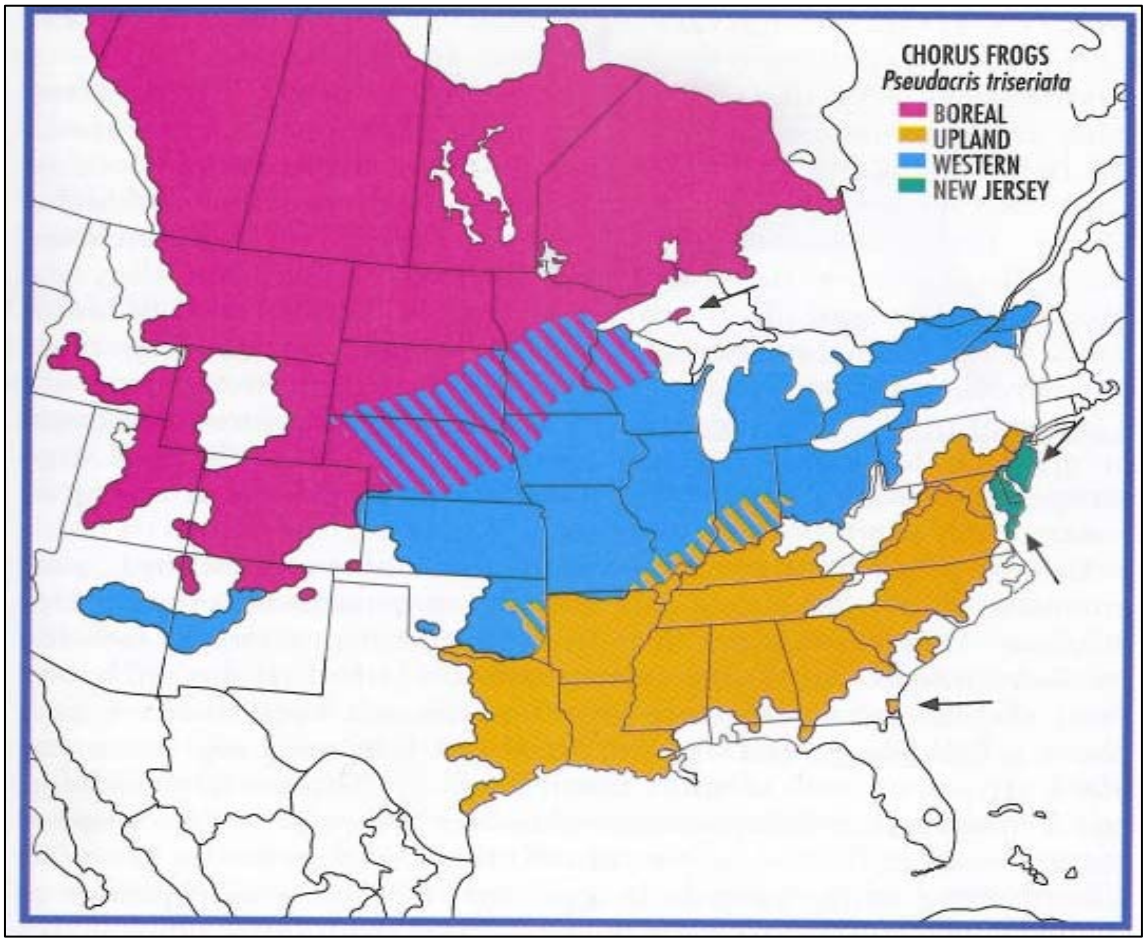
Outside the breeding season (summer, fall and winter), chorus frogs are terrestrial, with the exception of *P. c. crucifer* who are partly arboreal. Also during this time period, chorus frogs exhibit nocturnal activity; however, in higher and cooler altitudes, they may be more diurnal in activity (Blair, 1951b; Matthews and Pettus, 1966; Kramer, 1973). Adults may be found under vegetation, cracks in the ground, under logs, in crayfish burrows or under woody debris (Kramer, 1973). These microhabitats allow for more moisture to avoid desiccation (Kramer, 1973). Non-breeding adults feed on spiders, ants, slugs, beetles and a mixture of other invertebrates (Whitaker, 1971).

Diurnally, these frogs are hard to locate due to their small size and because they are well camouflaged (Lord and Davis, 1956). Other means frogs use to avoid predation include coming out at night to avoid diurnal predators (Wassersug and Sperry, 1977), using aquatic environments to escape terrestrial predators and *vice versa* (Landreth and Ferguson, 1966). However, there have been several documented predators on these adult frogs, including fishing spiders, gray jays and garter snakes (Matthews and Pettus 1966, Mitchell, 1990;

Smith, 1983; Wassersug and Sperry, 1977; Whitaker, 1971). Fishes and water snakes are probable predators as well (Whitaker, 1971).

Kramer (1973) determined post-breeding movements of *P. triseriata*. He recaptured marked individuals over 200 m from breeding pools with the majority occurring within 100 m of the pools. The minimum area home-range of 9 males was estimated to be between 641 and 6,024 m^2 (Kramer, 1974). It is generally unknown whether these frogs have territories; however, Roble (1985) noted instances of nonspecific satellite males associated with calling males with no antagonistic behavior. Satellite males have been observed in a number of anuran species. Generally, these are males that do not call, who "lie in wait" for vacated calling sites or they "steal" a mating by intercepting a breeding female en route to the calling male (Arak, 1983; Wells, 1977a, b). In some instances, satellite males alternate between calling and not calling (satellite role) which appears to be advantageous in terms of conserving energy. This behavior has been seen in Striped Chorus Frogs without any size difference in calling versus satellite males (Stebbins and Cohen, 1997).

Figure 5. *Pseudacris triseriata* Complex Ranges



(Modified from Conant and Collins, 1998)

Figure 6. West Virginia *Pseudacris* Species

P. feriarum (Morgan County)

(Photograph by Teresa Fogus)

P. c. crucifer (Fayette County)

(Photograph by Mark Watson)

P. brachyphona (Harrison County)

(Photograph by Mark Watson)

Table 1. West Virginia *Pseudacris* species Natural History Characteristics

Species	WV Range	Morphological Characteristics	Egg Composition & Number	Egg Length	Larval Length	Breeding Habitat	Non-breeding Habitat	Breeding Season
P. brachyphona (Mountain Chorus Frog)	Allegheny plateau	Dorsally: cruciform shape that usually does not cross and tan to brown, heel reaches middle of eye when leg is extended, longer 4th toe, ¼ toe webbing, yellow around groin area, smaller toe pads	Laid in clumps (10-50 eggs/mass) attached to vegetation under water(~300-900/ female)	~3-4 days	~60 days	Road ruts, roadside ditches	Woodland species, commonly found in shrubs and thickets	March through April (later at higher elevations or longer winters)
P. crucifer (Northern Spring Peeper)	County-wide	Dorsally: "X" shape and tan to brown, ½ toe webbing, somewhat larger toe pads, about 1.5 inches long	Laid singly attached to vegetation under water or on pond floor (100s)	~3-4 days	~90 days	Permanent and temporary pools, swamps, roadside ditches and puddles, open areas	Woodland species, commonly found in shrubs and thickets	February through June (through July at higher elevations or longer winters)
P. feriarum (Upland Chorus Frog)	Ridge & Valley	Dorsally: 3 lines or rows of spots on back and tan to brown, heel does not reach eye when leg is extended, longer 4th toe, ¼ toe webbing, white line above upper lip, smaller toe pads, smallest of all three *Pseudacris* species	Laid in clumps (40-60 eggs/mass) attached to vegetation under water(~1000 per female)	~3-4 days	~60 days	Heavily vegetated areas of roadside ditches, swamps and pond edges	Moist woodlands	Mid-late February through April (later at higher elevations or longer winters), slightly earlier than *P. brachyphona*

(Green and Pauley, 1987)

Chapter 2. Natural History of *Pseudacris feriarum* in West Virginia

Abstract

Natural history is the study of the natural development of an organism. My study looked at the natural history of *Pseudacris feriarum* in West Virginia. Other *Pseudacris* spp. natural history parameters are presented and some characteristics are compared to *P. feriarum*'s natural history in the state. Drift fences with pitfall traps were used to sample amphibians present. *P. feriarum* probably emerge in early March in West Virginia. Their breeding season is short, lasting only 34 days. In the laboratory, most eggs hatched in 8 days; other egg length ranges in literature are 3 to 4 days and 3 to 17 days. Size at metamorphosis ranges from 6.3 to 9.2 mm in West Virginia; this range is larger than ranges reported in other states and could be due to differences in temperatures, nutrient levels and total egg complements in *P. triseriata* (a closely related species). Larval period is 5.1 weeks; this is close to the 6-week period cited in the literature for West Virginia and Virginia. Morphological measurements from the field were compared to laboratory measurements. It was found most measurements were significantly different; this is probably because it is less accurate to measure animals in the field who are trying to escape. Currently, there is little literature pertaining to *P. feriarum*; hence, more detailed species accounts need to be studied and published in hopes of discovering which species are declining and why others appear secure.

Introduction

Natural History

Natural history is a broad term that encompasses many aspects of an organism. In this case, it is the study of the natural development of an amphibian—a frog. Natural history studies of this kind hope to answer questions such as time of emergence, when males start calling, time of amplexus, time of egg deposition, egg lengths, larval period lengths, when froglets leave the breeding site and where juveniles and adults can be found outside the breeding season. Other natural history parameters include: breeding habitat, distribution, range, clutch size, size at metamorphosis, adult size, age at sexual maturity, tadpole and adult diets and expected lifespan. The objectives of this study were to determine the natural history of *Pseudacris feriarum* in West Virginia, how they compare with Green and Pauley (1987) and how they compare with other *Pseudacris* species.

Amphibian Sampling

Literature documenting amphibian declines highlights the importance and need for standardized methods for inventorying and monitoring amphibians worldwide. Systematic observations, automated recording of calling anurans, drift fences, pitfall traps and aquatic funnel trapping are some of the methods used to accomplish the above (Willson and Dorcas, 2004).

Materials and Methods

2004 and 2005 Weather Comparisons

Historical weather data was obtained (Weather Underground, 2005) and analyzed using Sigma Stat 2.03.

Field versus Laboratory Morphological Measurements for Pseudacris feriarum

Preserved *P. feriarum* specimens were measured from WVBS collection (all specimens came from Hardy and Mineral counties). Laboratory means (n=35) were compared to field means (n=72). Morphological parameters measured were thumb width (TW), thumb length (TL), eye diameter (ED), tympanic membrane diameter (TMD), snout width (SW), head width (HW), tibia length (TibL), length of longest toe (LLT) and SVL. Data was analyzed using Sigma Stat 2.03.

Trapping

Terrestrial drift fences work by blocking the movement of an animal while guiding them into traps alongside the fence in order to increase capture rates. Aquatic drift fences work in the same way and have been used successfully for other taxa including fishes and turtles. Willson and Dorcas (2004) found traps with fencing captured significantly more species (of all life stages) per trap than unfenced traps, twice as many animals as the control group (without aquatic fencing) and significantly larger numbers of larval salamanders. They used rectangular funnel traps alongside fencing instead of

the traditional cylindrical traps because these can be placed flush with the fencing allowing less space for animals to swim around the traps.

In order to collect and study *P. feriarum* (along with other species) in West Virginia, state scientific collecting permits were obtained through West Virginia Division of Natural Resources (WVDNR) (2004.120 and 2005.166). Forty-two collapsible, rectangular minnow traps by Promar™ were used to sample animals at my site. Traps were constructed of nylon mesh and were 46 X 25 X 25 cm. A zippered pocket was located on top in order to remove animals easily. Sixty-one meters of silt drift fence was used in conjunction with minnow traps to sample amphibians present. Fencing was placed centrally in the water channel with 12 traps distributed approximately every 5 m along the west side of the fence and 13 traps approximately every 4.5 m on the east side. Traps were placed so they would not be next to each other on either side of the fence. Metal staples were used to keep fencing in the ground. These 25 traps were placed flush with the fence. Twelve traps were randomly distributed away from the fence on the west side while an additional 4 traps were placed in the more permanent water at the northern part of the site. About 8 cm of air was left at the top of the trap so animals would not drown.

Animals were trapped on 8 nights (3/7, 3/8, 3/21, 3/22, 4/7, 4/8, 4/9 and 4/30) during 2005. Traps were opened and distributed in the early afternoon on trap days, left out overnight and checked the next morning. This was done in order to sample both diurnal and nocturnal species. Captured *P. feriarum* were sexed and several morphological measurements were taken (TW, TL, ED, TMD, SW, HW, TibL, LLT, SVL and mass). After measurements were taken, animals were released at respective trap site. SVL and mass were determined with Vernier ™ calipers and Pesola™ spring scales (5 grams). Soil and water temperatures were measured with Reotemp™ thermometers and water pH values were determined with Oakton™ pH Testr2 meters. Relative

humidity and air temperature data were collected at ground level with a WWR™ Humidity/Temperature Pen.

Results

2004 and 2005 Weather Comparisons

A Mann-Whitney test found no significant difference (p=0.765) between precipitation from November 2003 through January 2004 and November 2004 through January 2005 (months leading up to the breeding season). A t-test showed no significant difference (p=0.226) between lowest temperatures for the same time periods.

The average for all lowest temperatures in February 2004 was ¯5.0˚C and for February 2005 was ¯2.5˚C; a student's t-test determined a significant difference between these temperatures (p=0.049—2005 was warmer). Average relative humidity for February 2004 was 60.4% and for February 2005 was 62.3%; a student's t-test revealed a significant difference between these percentages (p=0.025—2005 was more humid). Average precipitation for February 2004 was 0.3 cm and for February 2005 was 0.08 cm; a student's t-test demonstrated no significant difference (p=0.0675). Throughout both study seasons, pH values averaged 7.4, which is not considered to be detrimental for amphibians (Freda and Dunson, 1986).

The average for all lowest temperatures in March 2004 was 1.1˚C and for March 2005 was ¯0.8˚C. A Mann-Whitney test showed no significant difference between these temperatures (p=0.181). Average relative humidity for March 2004 was 63.1% and for March 2005 was 62.5%. A student's t-test determined no significant difference between these percentages (p=0.877). Average precipitation for March 2004 was 0.2 cm and for March 2005 was 0.3 cm; again, a student's t-test deduced there was not a significant difference (p=0.100).

The average for all minimum temperatures in April 2004 was 6.1˚C and for April 2005 was 5.5˚C. A student's t-test determined no significant difference between these

temperatures (p=0.620). Average relative humidity for April 2004 was 64.4% and for April 2005 was 56.5%. A Mann-Whitney test determined there was not a significant difference between these percentages (p=0.207). Average precipitation for April 2004 was 0.5 cm and for April 2005 was 0.2 cm; again, a Mann-Whitney test showed no significant difference (p=0.073).

Field versus Laboratory Morphological Measurements for Pseudacris feriarum

Significant differences were found between TW, TL, TMD, SW, HW, TibL and SVL measurements. LLT and ED were the only 2 measurements not significantly different (p=0.265 and p=0.297, respectively). Apart from these 2, field means were significantly greater in all other morphological measurements (Figure 7).

Emergence (2004)

The first trip to the study site was not made until 25 March. By this date, *P. feriarum* were already calling from my site in large numbers. *Ambystoma maculatum, P. c. crucifer* (calling), *Notophthalmus v. viridescens, Rana sylvatica* (calling) and *Bufo a. americanus* (calling) were also noted.

Egg Deposition and Egg Length (2004)

On 26 March 2004, *P. feriarum* eggs were brought into Marshall University's Herpetology Laboratory to stage. Eggs were placed in a 10-Gallon aquarium with approximately 8 cm of water (air and water temperature were approximately 17ºC and 18ºC, respectively). Stages of all eggs were determined as described by Gosner (1960) (Table 2). Upon arrival, most eggs were in the "B" stage (16 cell, 32 cell, mid-cleavage, late cleavage and dorsal lip), on 1 April most eggs were in the "C" stage (mid-gastrula, late gastrula, neural plate, neural folds and rotation), on 7 April most eggs were in the "D" stage (neural tube, tail bud, muscular response and heart beat) and on 12 April most eggs had hatched with most tadpoles in the "F" stages (operculum). Egg period lasted at least 17 days.

Larvae Development and Froglet Stage (2004)

Each clutch was placed in a separate Tupperware container and given a combination of *Elodea* and fish food flakes to eat. On 22 April most larvae were in the "G" stage (limb buds) and from 26 April through 1 May, most were in the "H" and "I" stages (toes and subarticular tubercles). On 7 May most were in the "J" stage (cloacal tail piece lost, forelimbs emerged and larval mouthparts were gone), on 17 May most were in the "K" stage (mouth development and tail resorption). Larvae development took 36 days. Froglets were released back at the study site on 23 June.

Emergence (2005)

The weekend of March 4th through 6th 2005 is probably when *P. feriarum* emerged and started calling. There were 7 days when the temperature reached the 50s (2/5, 2/6, 2/7, 2/12, 2/16 and 2/21) and 3 days when the temperature reached the 60s (2/8, 2/9 and 2/15) in February. On 14 February, 0.6 cm of precipitation fell in Berkeley Springs and the following 2 days temperatures were in the 50s and 60s. However, the land owner of the thesis site had not heard the frogs as of the beginning of March.

Sunday (3/6) and Monday (3/7) were the first days the weather was warm (upper 50s to upper 60s high and 30s low) in March. Around noon on 6 March, *P. feriarum* were heard calling at my site in Berkeley Springs, West Virginia; the property owner said this was the first she had heard them calling that year (I.L.D., personal communication). The night of 8 March, precipitation amounted to 0.2 cm.

March 7 through 8, several amphibians were caught and measured; among these were *A. jeffersonianum* (4 males and 1 female), *A. maculatum* (30 males and 7 females) and *N. v. viridescens* (20 males and 1 female). *P. c. crucifer* (19 males and 4 females), *P. feriarum* (30 males and 6 females) and *R. sylvatica* (28 males and 1 female) were calling. Three juvenile *Rana catesbeiana* were also captured and measured. *A. maculatum* and *R. sylvatica* were seen entering the main water trench of

the study site from an open field and represent a new population for *A. jeffersonianum* in West Virginia. There is a horse field adjacent to my site which had more calling frogs; therefore, the amphibians were probably in the process of making their way (northwest bound) into the study site where it is much wetter. I concluded this because in 2004, the main study site had more calling frogs and there were no frogs heard calling in the adjacent horse field site.

Egg Deposition (2005)

On 8 March 2005, 2 gravid and 7 male *P. feriarum* were brought back to Marshall University's Herpetology Laboratory (MUHL) to measure and see if amplexus would occur (air and water temperature were approximately 17ºC and 18ºC, respectively). Frogs were placed in a 10-Gallon aquarium with approximately 8 cm of water and rocks to rest on. Less than 24 hours after combining the males and females, 26 egg masses were observed. Both gravid females were noted to be egg-less so each female had deposited approximately 13 egg masses each the night before. Average egg mass length was 23.3 mm, average width was 14.6 mm and average height was 16.8 mm. Eight days later, almost half of the eggs hatched with an average tadpole length of 7.5 mm. All tadpoles hatched out by 22 March (total of 13 days).

Discussion

No significant differences were found during March and April for lowest temperatures, relative humidity and precipitation during 2004 and 2005. This is important to note because only larvae development is known for 2004 while emergence and egg deposition are known for 2005. Although average temperatures can indicate when egg-laying can take place, minimum temperatures are probably more indicative because most egg deposition occurs when temperatures are at a minimum (Livezey, 1952).

Emergence and Breeding Period

Temperature and precipitation are both correlated with migration to breeding pools (Smith, 1983). The beginning of March (4th through 6th) 2005 is probably when *P. feriarum* emerged from hibernation. Livezey (1952) showed egg deposition generally followed a pattern of (1) a drop in temperature, (2) a subsequent rise in temperature with precipitation and (3) egg laying during/after this rise in temperature. This pattern was seen at my site in 2005. In February, there were 10 days when temperatures reached the 50s and 60s (2/5 through 2/21) with 0.6 cm of precipitation on 2/14. Temperatures had cooled off until 3/6 and 3/7 when it warmed up to the upper 50s to upper 60s. The night of 6 March, precipitation amounted to 0.4 cm in Berkeley Springs. Landreth and Ferguson (1966) explained how chorus frogs may use both auditory (other sympatric males calling) and visual cues (reference points, celestial events) to orient themselves to their breeding site which explains why *P. feriarum* were seen/heard calling en route to the site.

It has been shown that *P. feriarum* emerge in early March in West Virginia (Green and Pauley, 1987). During typical weather, Striped Chorus Frogs emerge later in the year in cooler, higher elevations (Blair, 1951a; Jacobs, 1950; Smith, 1983) and earlier in the year at lower elevations (Pollio and Kilpatrick, 2002). Breeding seasons also last longer in lower elevations.

P. feriarum were found from 7 March through 9 April, 2005 (34 days) at my study site; however, most were caught before 21 March. Typically, Striped Chorus Frogs breed for 6 to 8 weeks (Green and Pauley, 1987; Pollio and Kilpatrick, 2002; Whitaker, 1971). In Pennsylvania, the breeding activity usually peaks in April and drops off by the end of May (Hulse *et al*., 2001). In this study, the peak was found to coincide with breeding commencement (8 March). Hence, *P. feriarum* appear to be an even more

explosive breeder and female emergence is more concentrated than previously believed.

Throughout the breeding season, Upland Chorus Frogs had a sex ratio around 6.3:1 (50 males and 8 females). It is common to have ratios in favor of males because females are only present a few nights while males are present at the breeding site for more extended periods of time. Ratios as high as 10:1 have been found in *P. triseriata* (Whitaker, 1971). Sexual size dimorphism is also common in this species (Hulse *et al*., 2001) with mean SVL for males being 25 mm and 29 mm for females at my site. SVL ranges ranged from 17 to 30 mm for males and from 26 to 31 mm for females at my site. Adult *P. feriarum* normally range in size from 19 to 39 mm SVL (Conant and Collins, 1998; Green and Pauley, 1987; Pollio and Kilpatrick, 2002).

Field morphological means were found to be significantly greater in most comparisons (except LLT and TMD) (Figure 7). Laboratory specimens were taken from Hardy and Mineral Counties while field measurements were taken in Morgan County. Geographically, all 3 counties are in the same physiographic province. The most probable reasons for discrepancies are (1) human error (it is much easier to measure an animal that is not squirming in an attempt to get away) and (2) because specimens may shrink during preservation.

Males typically call from hidden, grassy areas (alongside the water) at my site (Crenshaw and Blair, 1959; Landreth and Ferguson, 1966; Lord and Davis, 1956) which make them especially hard to capture by hand. During peak breeding times, males call both day and night (Landreth and Ferguson, 1966).

During my study period, *A. jeffersonianum, A. maculatum, A. opacum, B. a. americanus, E. b. bislineata, H. versicolor, N. v. viridescens, P. c. crucifer, R. catesbeiana, R. c. melanota, R. palustris* and *R. sylvatica* (at various life stages) were observed alongside *P. feriarum. Ambystoma*, *Bufo*, *Hyla*, *Notophthalmus*, *Pseudacris*

and *Rana* have all been documented to be found in the vicinity of *P. triseriata* (Blair, 1951a; Jacobs, 1950; Mitchell, 1990; Roble, 1985; Smith, 1983; Skelly, 1996; Whitaker, 1971).

Egg Deposition and Egg Length

On 9 March 2005, 26 new egg masses were observed in the laboratory; 2 females had deposited approximately 13 egg masses each the night before. Average egg mass length was 23.3 mm and average width was 14.6 mm. Lengths ranged from 16 to 34.3 mm while widths varied from 14 to 16.3 mm (n=5). Whitaker (1971) also found egg mass sizes varying in Indiana (n=13); length varied from 32 to 140 mm while width varied from 10 to 26 mm.

Eight days later, almost half of the eggs hatched (water temperature was approximately 18ºC). All tadpoles hatched out by 22 March (total of 13 days). In the laboratory, Whitaker (1971) found *P. triseriata* eggs hatching between 4 and 46 days, depending on water temperature (at 6.7˚C, eggs hatched between 25 and 46 days and at 22.8˚C, eggs hatched between 4 and 5 days). In the field, Whitaker (1971) found eggs hatching between 8 and 13 days and between 15 and 17 days (the latter was during a colder period). Green and Pauley (1987) documented 3 to 4 days as the egg period for *P. feriarum*.

However, air temperature averaged 2.2˚C at the study site during this same period. March 7 was a warm day with many *P. feriarum* calling; however, March 8 turned cold (difference of 22˚C) so if eggs were deposited on either the 7th or 8th of March, egg development would probably have taken longer in the field than in the laboratory due to temperature differences (Harkey and Semlitsch, 1988; Whitaker, 1971). In general, Striped Chorus Frogs egg periods range from 3 to 17 days (Green and Pauley, 1987; Heinrich, 1985; Johnson, 2000; Livezey, 1952; Pollio and Kilpatrick, 2002; Smith, 1983; Whitaker, 1971).

Average newly hatched tadpole SVL was 7.5 mm (range was 6.3 to 9.2 mm). Wright and Wright (1949) tadpoles were about 8 mm (New York). Tadpole SVL in this study was greater than in Indiana (4.8 to 6.1 mm), Kansas (4.5 to 5 mm) and Texas (5 to 6 mm) (Livezey, 1952; Whitaker, 1971; Youngstrom and Smith, 1936). This could be due to several reasons including different temperatures and nutrient levels (Doughty and Roberts, 2003; Whitaker, 1971). Because there is geographic variation in total egg complements of *P. triseriata* (Gosner and Rossman, 1959; Wright and Wright, 1949), fewer eggs could mean more resources for developing embryos, hence bigger tadpoles.

Larval Development and Froglet Stage

On 12 April, 2004, *P. feriarum* eggs hatched in Marshall University's Herpetology Laboratory (eggs had been brought in from the field). By 17 May (36 days, 5.1 weeks), most were in the "K" stage (final Gosner, 1960 stage). Larval period has been noted to last from 6 to 13 weeks (Jacobs, 1950; Livezey, 1952; Johnson, 2000; Smith, 1983; Whitaker, 1971) in Minnesota, Texas, Missouri, Michigan and Indiana. In Virginia and West Virginia, it is usually 6 weeks (Green and Pauley, 1987; Pollio and Kilpatrick, 2001) with most metamorphosing by mid-July and hibernating by early September (Green and Pauley, 1987).

Summary

In my study, *P. feriarum* emerge in early March. Males emerge first and may use intraspecific calls to aid in finding their breeding site. Amplexus and egg deposition coincide together. During the breeding season, sexual ratios are in favor of males and sexual size dimorphism is observed with females being larger. Males tend to call near water, hidden in vegetation, calling both day and night during the breeding season. Egg masses average 23 X 15 mm with egg periods ranging from 8 to 13 days. Larvae

development takes about 36 days and newly hatched larvae range in size from 6.3 to 9.2 mm SVL (Table 3). *P. feriarum* breed in association with several other amphibian species.

Pseudacris feriarum versus other Pseudacris species

When comparing breeding seasons of other *Pseudacris* spp to my results (Table 4), *Pseudacris* spp., including *P. feriarum*, egg lengths exhibit little variation because they usually last a few days to 2 weeks. In my study, *P. feriarum* egg period was 8 to 13 days. Differences in egg periods can be due to geographical variation (*i.e*. colder temperatures) (Whitaker, 1971). *Pseudacris* spp., including *P. feriarum*, larval periods range from 1 to 4 months and size at metamorphosis range from 6 to 17 mm SVL. In my study, *P. feriarum*'s larval period was 5.1 weeks and size at metamorphosis ranged from 6.3 to 9.2 cm. Again, longer larval periods can be due to lower temperatures, higher altitudes, tadpole crowding and low nutrient levels.

Hypotheses for declines of *Pseudacris* spp. include introduced species and habitat alteration. However, most causes are probably unknown. Currently, there is little literature pertaining to *P. feriarum*. Knowing the natural history of a species is a huge component in understanding possible causes of their decline. Hence, more detailed species accounts need to be studied and published in hopes of discovering which species are declining and why others appear secure.

Table 2. Descriptions of Gosner (1960) Stages

Gosner (1960) Stages	Lettered Stages	Developmental Stage
1-5	“A”	Fertilization, Gray crescent, 2-cell, 4-cell and 8-cell
6-10	“B”	16 cell, 32 cell, mid-cleavage, late cleavage and dorsal lip
11-15	“C”	Mid-gastrula, late gastrula, neural plate, neural folds and rotation
16-19	“D”	Neural tube, tail bud, muscular response and heart beat
20-22	“E”	Gill Circulation, transparent cornea and tail fin circulation
23-25	“F”	Operculum
26-30	“G”	Limb buds
31-35	“H”	Toes
36-39	“I”	Toes and subarticular tubercles
40-42	“J”	Cloacal tail piece lost, forelimbs emerged and larval mouthparts gone
43-46	“K”	Mouth development and tail resorption

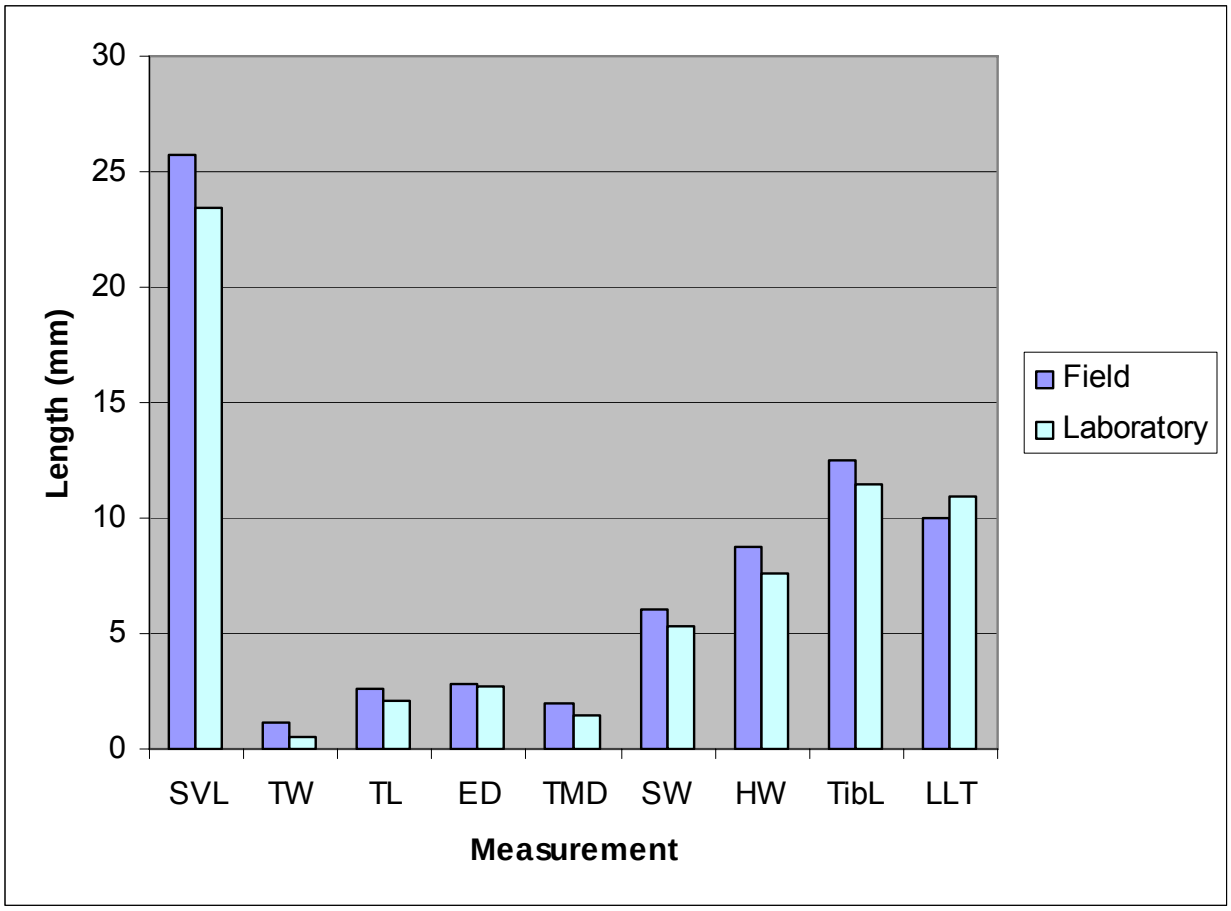
Table 3. *Pseudacris feriarum* Natural History Characteristics

Pseudacris feriarum Natural History	2004	2005
Emergence?	Before 25 March	4-6 March
First sex to emerge?	Probably males	Males
Calling before reaching site?	Probably	Yes
First egg deposition/amplexus?	Before 25 March (Field)	8 March (Lab)
Egg period?	≥26 March-12 April (Lab) ≥17 days	8-22 March (Lab) 8-13 days
Larvae development?	12 April – 17 May (Lab) 36 days	
Froglet stage?	17 May (Lab)	

Table 4. *Pseudacris* species Natural Histories

Species	Breeding Season	Egg Length	Larval Length	Size at Metamorphosis	Declines?	Literature Cited
P. brachyphona	Late Feb-early June	7-10 d	30-64 d	11-13 mm SVL	Yes	4, 47-50, 86
P. brimleyi	Feb-Apr		30-60 d	9-11 mm SVL		44
P. cadaverina	Early Feb-early Oct		40-75 d		Maybe	39, 121, 123, 127
P. clarkii	Jan-early June	2.5-3 d	30-45 d	8-17 mm SUL		10, 14, 79, 115, 116, 144, 150
P. crucifer	Nov-May	6-15 d	90-100 d	12-14 mm TL	Maybe	1, 3, 5, 26, 81, 88, 131, 137, 150
P. nigrita	Most of year	3 d	40-120 d	9-15 mm SVL	Yes	12, 25, 33, 38, 42, 83, 93, 150
P. ocularis	Jan-Sept	1-2 d	45-70 d	7-9 mm SVL	No	3, 46, 52, 149, 150
P. ornata	Nov-Apr	7 d	90-120 d	14-16 mm SVL	Maybe	3, 7, 25, 36, 87, 94, 150
P. regilla	Nov-July	7-35 d	60-75 d	10-17 mm SVL	No	59, 74, 95, 138, 150
P. streckeri	Jan-mid-May		30-60 d	12-13.5 mm SVL	Yes	13, 17, 22, 23, 65, 130, 150
P. triseriata Complex	Jan-June	4-46 d	42-91 d	7-12 mm SVL	Yes	9, 16, 63, 78, 113, 134, 142
P. feriarum, WV	Early Mar-early Apr	8-13 d	36 d	6-9 mm SVL	Yes	

Figure 7. Field versus Laboratory Morphological Means in *Pseudacris feriarum*



- SVL=Snout-vent length
- TW=Thumb width
- TL=Thumb length
- ED=Eye diameter
- TMD=Tympanic membrane diameter
- SW=Snout width
- HW=Head width
- TibL=Tibia length
- LLT=Length of longest toe

Chapter 3. Phenology of a Wetland in Eastern West Virginia

Abstract

Phenology is the study of the times of recurring natural phenomena, especially in relation to climate. Fifteen amphibian species were predicted to be found at my study site. Visual surveys (2004 and 2005) and drift fences with pitfall traps (2005) were used to determine amphibians present. Between 2004 and 2005 research seasons, 13 of 15 expected species were observed and all typically followed documented natural history parameters such as time of breeding and breeding habitat preference. *Acris c. crepitans* and *Rana pipiens* were 2 anticipated species not found. Reasons for their absences include insufficient cover objects, lower substrate temperatures, my study site being too far away from over-wintering sites and shallow water.

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Introduction

Phenology

Phenology is the study of the times of recurring natural phenomena, especially in relation to climate. Because many of these phenomena (*i.e*. amphibian breeding) are sensitive to small variations in climate, phenology is useful in the study of how amphibians react during different times of the year in relation to climatic changes.

Sampling Amphibians

Refer to Chapter 2.

Predicted Species

Predicted species were based on ranges of species, habitat types and breeding seasonality in West Virginia (according to Conant and Collins, 1998; Green and Pauley, 1987). Fifteen amphibian species were predicted to be found at my study site. *Acris c. crepitans* (Northern Cricket Frog—S2, G5T5) are late spring breeders that typically start calling in April or May in ponds, swamps and sluggish streams. They are found in the eastern panhandle and are considered an uncommon species in West Virginia. *Ambystoma jeffersonianum* (Jefferson Salamander—S3, G4) are early spring breeders that usually begin breeding in February or March. They usually breed in woodland pools or in pools near wooded areas. Northern Cricket Frogs are considered a common species and are found statewide in West Virginia. *A. maculatum* (Spotted Salamander)

are early spring breeders that frequently begin breeding in February or March. Spotted Salamanders typically breed in woodland ponds or in pools near wooded areas. They are found statewide and are considered a common species in West Virginia.

Ambystoma opacum (Marbled Salamander) are fall breeders that often breed on land near a variety of aquatic habitats such as ponds and small terrestrial depressions which will usually fill up with water causing the eggs to hatch. The larvae then overwinter and can be observed in the spring when they become active due to increased temperatures. Marbled Salamanders are found statewide below 3,000 feet and are considered a common species in West Virginia. *Bufo a. americanus* (Eastern American Toad) are spring breeders that regularly start calling in March or April from a wide variety of aquatic habitats including permanent ponds, temporary shallow pools, swamps, puddles and ditches. Eastern American Toads are found statewide and are considered a common species in West Virginia. *Eurycea b. bislineata* (Northern Two-lined Salamander) are fall breeders that typically oviposit in March or April in small streams, seepages and flood plains; however, Brophy and Pauley (2001) found *E. b. cirrigera* (sibling species to *E. b. bislineata*) breeding in lentic habitats in West Virginia. Northern Two-lined Salamanders are found in the northern half of the state and are considered a common species in West Virginia.

Hyla versicolor (Gray Treefrog) are late spring breeders that breed in temporary and permanent water (*i.e*. flooded meadows, cattail swamps and artificial impoundments) beginning in May. Gray Treefrogs are found east of the Allegheny Mountains and are considered a common species in the state. *Notophthalmus v. viridescens* (Red-spotted Newt) are spring breeders that characteristically begin breeding in late March or early April. Red-spotted Newts breed in a wide variety of aquatic habitats including pools, lakes, marshes, ditches, ponds, swamps and streams. They are found statewide and are considered a common species in the state. *Pseudacris c. crucifer* (Northern Spring

Peeper) are early spring breeders that start calling in February from temporary and permanent pools, puddles, ditches and swamps. Northern Spring Peepers are found statewide and are considered a common species in West Virginia.

Pseudacris feriarum (Upland Chorus Frog—S2, G5T5) are early spring breeders that frequently start calling in March and can be seen breeding in less permanent water such as swampy areas of broad valleys, grassy swales, moist areas of woodlands, borders of heavily vegetated ponds/bogs/marshes and river-bottom swamps. Upland Chorus Frogs are only found in the eastern counties and are considered an uncommon species in West Virginia. *Rana catesbeiana* (American Bullfrog) are late spring/early summer breeders that begin calling between April and June from larger, more permanent bodies of water such as rivers, lakes, ponds, swamps, bogs, streams and marshes. American Bullfrogs are found throughout West Virginia at lower elevations and are considered a common species in the state. *R. clamitans melanota* (Northern Green Frog) are spring breeders that normally start calling in April or May from permanent bodies of water such as ponds, lakes, slow-moving rivers, springs, marshes, creeks, ditches and brooks. Northern Green Frogs are found statewide and are considered a common species in West Virginia.

Rana palustris (Pickerel Frog) often breed in permanent pools, sloughs, ponds, marshes and creeks starting in March or April. Pickerel Frogs are probably found statewide and are considered a common species in West Virginia. *R. pipiens* (Northern Leopard Frog—S2, G5) are early spring breeders that regularly start calling in March from a wide variety of aquatic habitats including temporary and permanent ponds, swamps and streams. Northern Leopard Frogs are typically found in western West Virginia counties and sporadically in eastern counties and are considered an uncommon species in the state. *R. sylvatica* (Wood Frog) are early, explosive spring breeders who characteristically start calling in February or March, usually from temporary but

sometimes permanent pools. Wood Frogs are found statewide and are considered a common species in West Virginia.

Materials and Methods

Refer to Chapter 2.

Results

Over an 8-day trapping period in spring 2005 (March through April), 749 amphibians representing 11 species were captured. Species and life stages included: (1) *A. jeffersonianum* adults, (2) *A. maculatum* adults and eggs, (3) *A. opacum* larvae, *(4*) *B. a. americanus* adults and eggs, (5) *E. b. bislineata* adult, (6) *N. v. viridescens* adults (larvae in 2004), (7) *P. c. crucifer* adults, (8) *P. feriarum* adults and eggs (9) *R. catesbeiana* adults and juveniles, (10) *R. palustris* adults and juveniles and (11) *R. sylvatica* adults. In June 2004, (12) *H. versicolor* and (13) *R. clamitans melanota larvae* were observed (Figure 9 and Table 5). *A. c. crepitans* and *R. pipiens* were two anticipated species not found at my site.

A. jeffersonianum normally begin breeding in late February to early March (Green and Pauley, 1987). Five adults were captured on two trap nights (03/07/05 and 03/08/05) with a sex ratio of 4:1 (4 males and 1 female). Mean SVL for males was 69 mm while for females it was 55 mm (Figure 8). Males are typically smaller in SVL than females (Hulse *et al*., 2001) but this is not seen here probably due to the small sample size (n=5). Jefferson Salamanders were found from 03/07 through 03/08/05 (2 days) at my study site (Figure 9).

Ambystoma maculatum typically start breeding at the same time as *A. jeffersonianum,* or a few days later (Green and Pauley, 1987). Sixty-five adult Spotted Salamanders (48 males and 17 females) were caught on 4 trap nights (03/07/05, 03/08/05, 03/21/05 and 03/22/05) with a sex ratio around 2.8:1. Most adults were captured on 8 March (28 males and 7 females) with a sex ratio around 4:1 (Table 5).

This sex ratio is similar to published literature (Whitford and Vinegar, 1966) and could be due to higher mortality rates in females or females breeding every other year (Woodward, 1982). Mean SVL for males was 71 mm while for females it was 81 mm; sexual size dimorphism is common in this species with females being larger (Figure 8) (Blackwell *et al*., 2003). Spotted Salamanders were found at my study site from 03/07 through 04/09/05 (34 days) (Figure 9).

Ambystoma opacum are fall breeders (around September or October) whose eggs typically hatch into larvae that overwinter (Green and Pauley, 1987). Once temperatures start increasing in the spring, larvae become more active and can be seen preying upon other amphibian larvae (Stenhouse, 1983). Three larvae were captured in minnow traps and brought back to Marshall University's Herpetology Laboratory for identification. One Marbled Salamander larva was captured on 03/21/05 and 2 more on 04/09/05 at my study site (Table 5).

Bufo a. americanus normally begin breeding in March or April (Green and Pauley, 1987). One-hundred and twenty American Toads (102 males and 18 females) were caught in minnow traps on 3 trap nights (04/07 through 04/09/05) with a sex ratio around 5.7:1. Most were caught (51 males and 7 females) on 7 April with a sex ratio of 7.3:1 (Table 5). Mean SVL was 63 mm for males and 74 mm for females (Figure 8). This sexual size dimorphism is very typical of this species (Hulse *et al*., 2001). American Toads were present from 04/07 through 04/09/05 (3 days) at my study site (Figure 9). Three days is the shortest breeding period known for American Toads in West Virginia (T.K.P., personal communication).

Eurycea b. bislineata are fall breeders while oviposition takes place in the spring, even as early as March (Green and Pauley, 1987). One adult Northern Two-lined Salamander (unidentified sex) was found on 04/08/05 at my study site (Figure 9 and Table 5).

Hyla versicolor usually begin breeding in May (Green and Pauley, 1987). Only larvae were observed at my study site on 06/23/04 (Table 5).

Notophthalmus v. viridescens begin breeding in late March or early April (Green and Pauley, 1987). One-hundred and twenty adult Red-spotted Newts with a sex ratio around 4.7:1 (99 males and 21 females) were captured on 03/08, 03/21, 03/22, 04/08, and 04/09/05. Most were caught (32 males and 11 females) on 9 April (Table 5) with a sex ratio around 2.9:1. Mean SVL for both males and females was 41 mm (Figure 8). Both sexes tend to be similar in body size (Hulse *et al*., 2001). Red-spotted Newts were found from 03/08 through 04/09/05 (33 days) at my study site (Figure 9).

Pseudacris c. crucifer normally begin breeding in February or March (Green and Pauley, 1987). Two-hundred and fifteen Northern Spring Peepers were caught on 6 trap nights (03/08, 03/21, 03/22, 04/07, 04/08, and 04/09/05). It has been shown that breeding populations have a sex ratio in favor of males (Oplinger, 1966); the sex ratio throughout their breeding period was around 4.1:1 (173 males and 42 females). Most were caught on 21 March (74 males and 14 females) with a sex ratio around 5.3:1 (Table 5). As with most amphibian species, female SVL was found to be larger than male SVL (Hulse *et al*., 2001); mean SVL for males was 26 mm and 29 mm for females (Figure 8). Northern Spring Peepers were found from 03/08 through 04/09/05 (33 days) at my study site (Figure 9).

Pseudacris feriarum characteristically begin breeding in March (Green and Pauley, 1987). Fifty-eight Upland Chorus Frogs with a sex ratio around 6.3:1 (50 males and 8 females) were caught on 6 trap nights (03/07, 03/08, 03/21, 04/07, 04/08 and 04/09/05). Most were caught on 8 March (28 males and 6 females) with a sex ratio around 4.7:1 (Table 5). Sexual size dimorphism is also common in this species (Hulse *et al*., 2001)

with mean SVL for males being 25 mm and 27 mm for females (Figure 8). Upland Chorus frogs were found from 03/07 through 04/09/05 (34 days) at my study site (Figure 9).

Rana catesbeiana typically commence breeding in April or May (Green and Pauley, 1987). Nine juveniles were found on 4 trap nights (03/08, 04/08, 04/09 and 04/30/05) (Table 5). Average SVL for juveniles was 54 mm. One male and one female were found on 8 April (SVLs can be seen in Figure 8) and 1 tadpole was observed on 9 April at my study site (Table 5).

Rana c. melanota, on average, start breeding in April or May (Green and Pauley, 1987). Only larvae were observed on 06/23/04 (Table 5).

Rana palustris frequently start breeding in March or April (Green and Pauley, 1987). Three adult males and 1 juvenile were trapped on 2 nights (04/07 and 04/08/05). Larvae were seen on 06/23/04 (Table 5).

Rana sylvatica start breeding in February or March (Green and Pauley, 1987). One-hundred Wood Frogs with a sex ratio around 19:1 (95 males and 5 females) were caught on 5 trap nights (03/07, 03/08, 03/21, 03/22 and 04/08/05). Most were caught on 21 March (60 males and 4 females) with a sex ratio around 15:1 (Table 5). The highly skewed ratio is probably due to observer error. There is sexual size dimorphism in this species (Hulse *et al*., 2001) with mean SVL for males being 48 mm and 55 mm for females (Figure 8). Wood frogs were found from 03/07 through 04/08/05 (33 days) at the study site (Figure 9). Thirty-three days is the longest Wood Frogs have been found at a breeding site in West Virginia (T.K.P., personal communication).

Discussion

Between the 2004 and 2005 spring research seasons, 13 of 15 expected species were observed: (1) *A. jeffersonianum* adults, (2) *A. maculatum* adults and eggs, (3) *A. opacum* larvae, (4) *B. a. americanus* adults and eggs, (5) *E. b. bislineata* adult, (6) *H.*

versicolor larvae, (7) *N. v. viridescens* adults and larvae, (8) *P. c. crucifer* adults, (9) *P. feriarum* adults and eggs (10) *R. catesbeiana* juveniles, (11) *R. c. melanota* larvae, (12) *R. palustris* adults, juvenile and larvae and (13) *R. sylvatica* adults. *A. c. crepitans* and *R. pipiens* were two anticipated species not found at the site (Table 5).

Of 13 observed species, all typically followed documented natural history parameters such as time of breeding and breeding habitat preference (Conant and Collins, 1998; Green and Pauley, 1987; Hulse *et al*., 2001).

Only *H. versicolor* larvae were observed on June 2004. The main reason only larvae were observed is probably because this is one of the last species to emerge from hibernation, with breeding peaking in June. Trips made to the study site during the above period may have missed the adults. Larvae typically metamorphose 45 to 65 days after oviposition (Hulse *et al*., 2001).

A couple of possibilities exist for why only one *E. b. bislineata* was found. One potential reason is they are rarely found in water outside of their breeding season. Another is that rocks are their preferred cover for eggs (Hulse *et al*., 2001). These may explain why a greater population size of *E. b. bislineata* was not found at the site (the trapping period was outside of their breeding season and there were little rocks for cover at the site).

Nine *R. catesbeiana* juveniles, 1 male and 1 female were observed in 2005. Reasons for small adult and juvenile numbers are probably due to the facts that American Bullfrogs tend to use more permanent, deeper bodies of water for breeding and the trapping period was earlier than when their breeding starts (Green and Pauley, 1987). Captured juveniles are larvae that overwintered and just metamorphosed (Hulse *et al*., 2001).

Only *R. c. melanota* larvae were observed during June 2004. Eggs laid earlier typically hatch the first year but eggs laid later typically overwinter and hatch the

following spring; larvae caught probably represent eggs laid later in the season the prior year (Martof, 1956). Northern Green Frogs are late spring breeders (end of April/beginning of May) with a lengthy breeding season (Green and Pauley, 1987). Due to their lengthy breeding season and presence of larvae, *R. c. melanota* adults should have been observed. The reason they were not observed could be due to fact that *R. c. melanota* adults prefer deeper water (Green and Pauley, 1987).

Three adults and 1 juvenile *R. palustris* were observed in April 2005. Pickerel Frogs have a long activity period with breeding peaking in mid-April through the beginning of May (Green and Pauley, 1987) but for whatever reason, higher adult numbers were not seen or heard at the site. Again, this could be due to adult preferences for deeper water (Green and Pauley, 1987).

Acris c. crepitans is 1 of 2 anticipated species that was not found at my study site. *A. c. crepitans* (S2, G5) is a late spring breeder that typically start calling in April or May from the edges of ponds and streams with submerged or emergent vegetation (Green and Pauley, 1987; Stebbins, 1966). *A. c. crepitans* are found in the eastern panhandle of West Virginia (Green and Pauley, 1987). *A. c. crepitans* has declined in the north and northwestern part of its range for various reasons revolving around habitat change (Stebbins, 2003). With decreasing population numbers and an average life span of only 4 months, one can see how this species would have trouble recovering from anthropogenic forces (Harding, 1997). Surveys for *A. c. crepitans* in West Virginia have yielded few sites in Jefferson, Mineral, Hampshire, Morgan and Berkeley counties (Green and Pauley, 1987). Because my study site is in the known range for *A. c. crepitans* (only 16 to 18 km away from a historic site) and suitable habitat was present, *A. c. crepitans* should have been present, but for unknown reasons were not found.

In a field and laboratory study conducted in Missouri, *A. c. crepitans* were found to prefer microhabitats with moist substrates close to shelter items (*i.e*. rocks). Mean substrate temperature was 27.4 ± 0.2˚C (range: 20.9 through 35.5˚C) and mean air temperature was 27.6 ± 0.2˚C (range: 21.9 through 32.4˚C) in Missouri (Smith *et al*., 2003). Mean substrate temperature at my study site in May 2004 was 21˚C and mean air temperature was 30˚C. Lack of presence of this species at my study site could be due to several factors including absence of rocks for shelter and lower substrate temperatures. Whitaker (1971) claims *A. crepitans* is similar in habits and competes directly with *P. triseriata*. However, *A. c. crepitans* is a later breeder than *P. triseriata*.

Rana pipiens (S2, G5) is the other anticipated species not found at my study site. They are typically found in western West Virginian counties and sporadically in eastern counties (Green and Pauley, 1987). They are early spring breeders that typically start calling in March while utilizing a wide variety of aquatic habitats for breeding including temporary and permanent ponds, swamps and streams. Reproduction often occurs in less permanent water (Hulse *et al*., 2001) but they also use calm water of lakes, ponds, canals and streams for egg deposition (Stebbins, 2003).

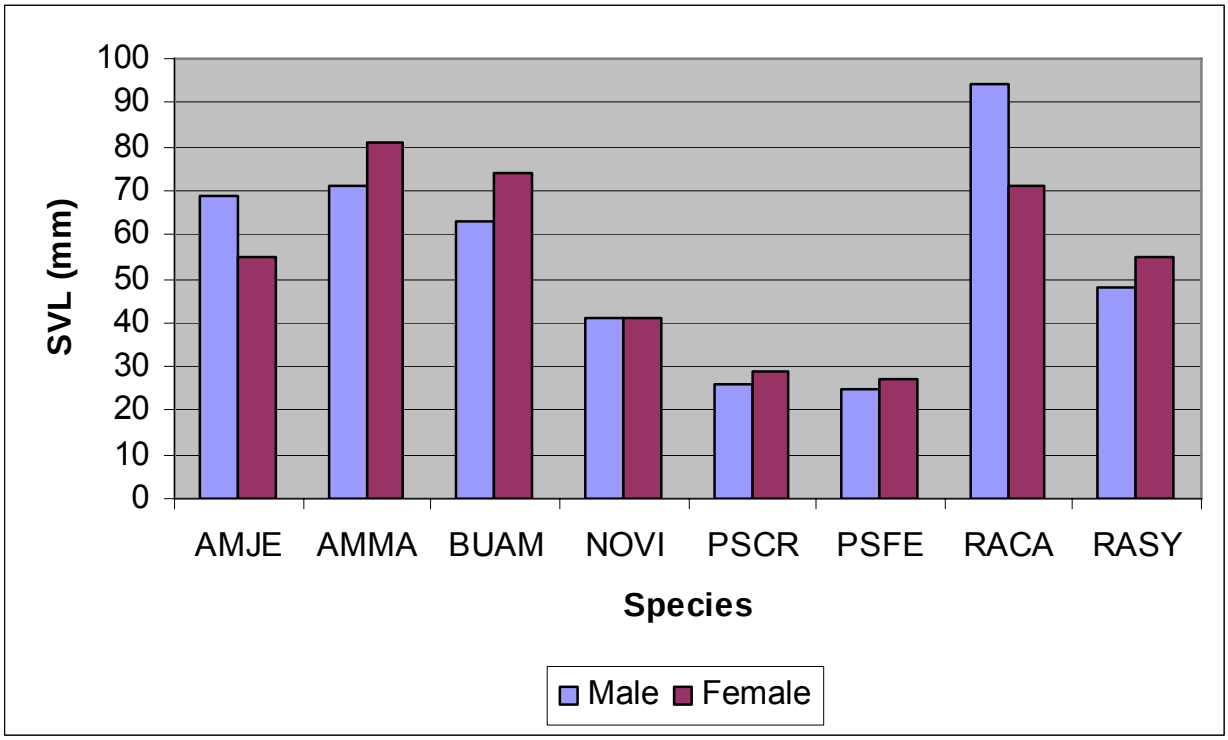
Leopard frogs were once common and widespread throughout much of North America; however, some populations have experienced serious declines (Hulse *et al*., 2001). Leopard frog populations, along with many other frog species, are at risk of declining or are declining due to issues such as the use of Atrazine (Hayes *et al*., 2002), nitrates (Hecnar, 1995), organochlorines (Glennemeier and Denver, 2001), acidification (Brodkin *et al*., 2003), UV radiation (Peterson *et al*., 2002), trematodes (Schothoeffer, 2003), fungal infections (Fellers *et al*., 2001), introduced species (Lannoo *et al*., 1994) and habitat loss (Linck, 2000). Leopard frogs are also extensively collected in some

areas for use in classrooms, laboratories and are used as bait. These activities can wipe out local populations (Harding, 1997).

Ideal *R. pipiens* breeding habitat possess the following characteristics: (1) some degree of permanence (so metamorphosis can occur before it dries up), (2) abundant aquatic and emergent vegetation (for cover and places to attach eggs), (3) shallow open water (direct sunlight), (4) non-acidic water (pH range of 6.5 through 8.5), (5) shallow water (ranging between 10 and 65 cm), (6) gradual sloping shoreline (support vegetation) and (7) within 1.6 km from over-wintering habitat (Krendell, 2002). Depth ranged from 5 to 30 cm at my study site. Aside from not knowing if the Berkeley Springs study was within the appropriate distance of *R. pipiens* over-wintering sites, the site possessed the other above characteristics. Even though *R. pipiens* is listed as a species of concern in West Virginia and its declines have been well reported, it seems *R. pipiens* should have been found at the study site. Some of the reasons for its absence at my study site include (a) my site being too far away from their over-wintering sites or (b) the water was not deep enough.

In summary, 13 of 15 predicted species were observed at my study site. All exhibited documented natural history parameters such as time of breeding and breeding habitat preference (Conant and Collins, 1998; Green and Pauley, 1987; Hulse *et al*., 2001). Two species not observed were *A. c. crepitans* and *R. pipiens.* Their absences may be attributed to the absence of rocks for shelter, lower substrate temperatures, my study site being too far away from over-wintering sites or shallow water.

Figure 8. Mean SVLs for Adults Caught in Traps (Spring 2005)



- AMJE= *A. jeffersonianum*
- AMMA= *A. maculatum*
- BUAM= *B. a. americanus*
- NOVI= *N. v. viridescens*
- PSCR= *P. c. crucifer*
- PSFE= *P. feriarum*
- RACA= *R. catesbeiana*
- RASY= *R. sylvatica*

Figure 9. Species and Number of Adult Amphibians Caught at Study Site (Spring 2005)

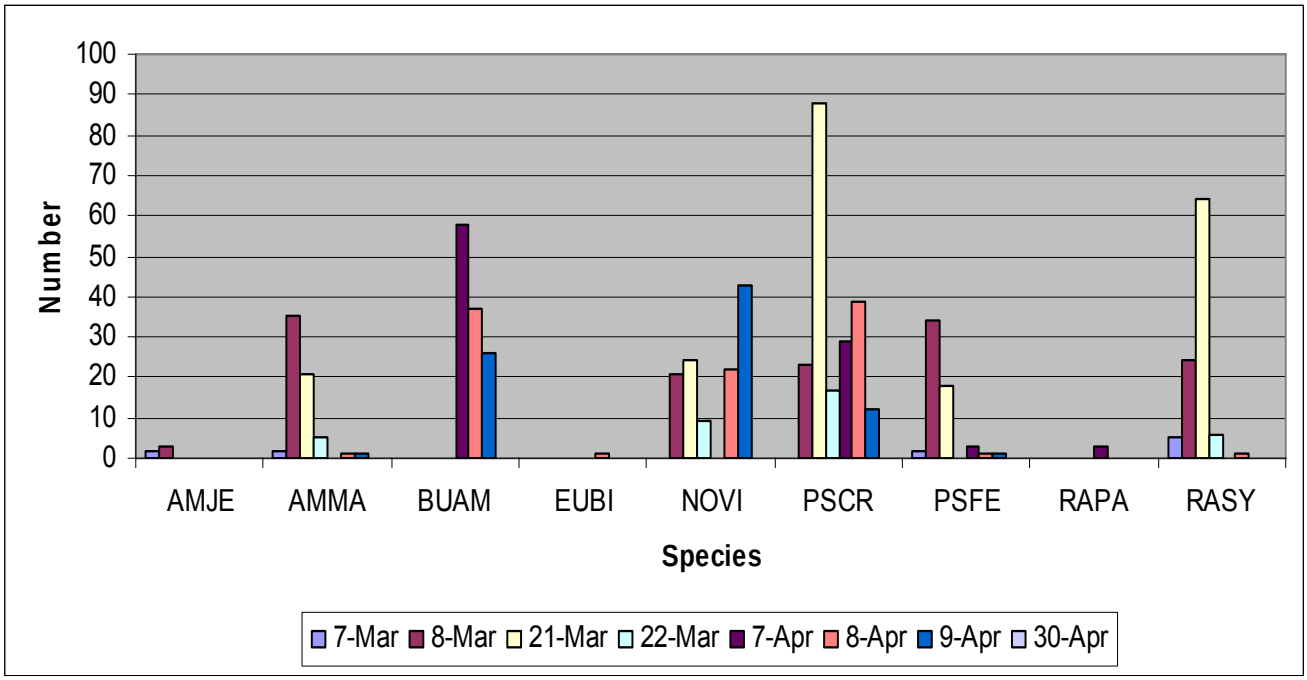


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Table 5. Amphibians Caught/Observed During 2004 and 2005

Species	When Breeding Season Begins	Adult Capture Peak in 2005 and Other Observations in 2004
A. c. crepitans	April/May	Not present
A. jeffersonianum	February/March	Adults on 3/8/5
A. maculatum	February/March	Adults on 3/8/5
A. opacum	September/October	Larvae on 3/21/5 & 4/9/5
B. a. americanus	March/April	Adults on 4/7/5
E. b. bislineata	September/October	1 adult on 4/8/5
H. versicolor	May	Larvae on 6/23/4
N. v. viridescens	March/April	Adults on 4/9/5 & larvae on 6/23/4
P. c. crucifer	February/March	Adults on 3/21/5
P. feriarum	March	Adults on 3/8/5
R. catesbeiana	April	Juveniles on 3/8/5, 4/9/5, 4/30/5, 6/23/4
R. c. melanota	April/May	Larvae on 6/23/4
R. palustris	March/April	Adults on 4/7/5, juveniles on 4/8/5 & larvae on 6/23/4
R. pipiens	March	Not present
R. sylvatica	February/March	Adults on 3/21/5

Chapter 4. Distribution of *Pseudacris feriarum* in West Virginia

Abstract

Amphibian declines have prompted global attention towards this issue along with long-term studies using standardized methods for comparison across regions. It is difficult to discern if amphibians are declining due to natural climatic events or anthropogenic forces because little is known about natural fluctuations in amphibian populations. Declines are also disconcerting because amphibians are often referred to as "bioindicators" of their environment. *Pseudacris feriarum* is listed as S2, G5 in West Virginia. Several breeding populations of *P. feriarum* were known to occur in Greenbrier, Monroe and Summers counties during the 1970s and 1980s. As of 2000, Upland Chorus Frogs were no longer found there. When this study commenced, *P. feriarum* were only known to occur from Pocahontas County north into Morgan and Berkeley counties. Surveys were conducted during ideal weather in spring of 2004 and 2005 to help delineate their distribution within the state. Historical sites in Greenbrier, Monroe and Summers County yielded no *P. feriarum* populations. However, *P. feriarum* are still found in Berkeley, Hampshire, Hardy, Mineral, Morgan and Pocahontas counties. They were also found in Grant and Pendleton counties which represent 2 new records. From 1970 through 2000, historical precipitation data were obtained and analyzed. One-way ANOVA tests showed, although not significantly different, total precipitation was greater in areas where *P. feriarum* still reside versus extirpated sites. Streams were identified in the range of *P. feriarum* and several were found to be polluted due to industrial and agricultural processes. Pollutants included fecal coliforms and polychlorinated biphenyls; effects of these on amphibian health are not well known. It is hypothesized that when precipitation decreases occurred in the state during extensively high temperatures, *P. feriarum* were not able to relocate to more hospitable areas, such as northeastern areas. This could be because *P. feriarum* are small, fairly immobile frogs. As a result, they were not able to cross the Allegheny Mountains into areas where habitat requirements could be met.

Introduction

Amphibian Declines, Possible Causes and Impacts

At the first World Congress of Herpetology in 1989, a central topic kept recurring; many instances of amphibian declines appeared to be occurring throughout the world, especially in anurans. This suggested something more than just natural fluctuations and prompted global attention towards this issue along with long-term studies using standardized methods (Heyer *et al*., 1994). The central question for scientists and conservationists, as a result of the discussions, was whether amphibians are experiencing declines due to natural climatic events or are being affected by anthropogenic forces. It is difficult to answer this question because little is known about

natural fluctuations in amphibian populations—how often, how long, when and why (Blaustein *et al*., 1994; Pechmann and Wilbur, 1994). One thing that can be said with confidence is that with the "absence of long-term, precise information on population changes, it is impossible to say that a seemingly abundant species has not undergone a decline" (Stebbins and Cohen, 1997).

There are many probable causes of amphibian declines, both local and global. Examples of local impacts are the use of pesticides, heavy metals, radioactivity, over grazing, silviculture, landfills, land development, road kills via vehicles, deforestation, draining wetlands, introducing competitors and/or predators, classroom scientific use, pet trade and medicinal use. These practices only increase with human population growth (Stebbins and Cohen, 1997).

Global impacts are mostly due to increasing pollution. Examples include ozone thinning which is caused by chlorofluorocarbons and allows increased ultraviolet exposure; acid precipitation and global warming are both caused by an increased atmospheric CO_2 and are responsible for altering suitable habitats. Again, these practices only increase with human population growth (Stebbins and Cohen, 1997).

One effect of amphibian decline would be a change in predation patterns because amphibians constitute a large portion of the biomass in ecosystems. An example is an increase of mosquitoes in the Orient due to the heavy consumption of frogs by people (Regier and Baskerville, 1986). Another example involves *Thamnophis elegans* which prey on *R. muscosa* and *B. canorus* which are currently undergoing declines in the Sierra Nevada. Declines in the Garter Snake could affect birds and other species that feed on this snake (Jennings *et al*., 1992). Herbivorous tadpoles probably consume the largest amount of algae and detritus in smaller aquatic systems.

If algae growth is left unaltered, eutrophication could occur which reduces the dissolved oxygen content and can cause extinction of other organisms (Stebbins and Cohen, 1997).

Amphibians as "Bioindicators"

Are amphibians experiencing declines any greater or faster than other animal groups? To answer this, one must take into account several features that amphibians possess. One is their life cycle. Most amphibians require both land (for migration and "home" areas) and water habitats (for breeding) to complete their complex life cycles; alterations to either habitat may have negative effects. Amphibians also depend on skin respiration and dermal absorption of water. Because their surfaces are permeable to gases and liquids, this allows entry for other things such as harmful pathogens and chemical contaminants through their integument and into their circulatory systems (Stebbins and Cohen, 1997).

A third reason is their exposure to ultraviolet light. Because amphibians are poikilothermic, exposure to direct sunlight can elevate their body temperatures. Increased ground level UV-B radiation can cause higher rates of embryo deformities and death (Starnes *et al*., 2000). Neural tube defects have been observed in amphibian larvae (Jablonski, 1998). Fourth involves their diet. Most tadpoles forage widely on plant and animal matter in the water, both on the surface and in the bottom which increases the possibility of ingesting contaminants (*e.g*. chlorinated chemicals). These fat soluble compounds then accumulate in the fat deposits of the animal and can remain there for life. After metamorphosing, amphibians mostly feed on animal matter which allows for biomagnification in the food web (Stebbins and Cohen, 1997).

Fifth is their susceptibility to temperature and precipitation extremes. Because amphibians are ectotherms (meaning they are dependent on ambient temperatures to

dictate their internal temperature), they are vulnerable to temperature extremes and dryness. Sometimes excessive cold and drought can prevent reproduction for an extensive period of time, even years. Sixth is their fragmented distribution. Species with fragmented distributions (especially those with restricted ranges) are particularly susceptible to population losses. Amphibians are precluded from moving to new sites once they have been extirpated from an area because they have such low dispersal rates, high site fidelity and physiological constraints (Stebbins and Cohen, 1997).

Seventh involves metamorphosis and its implications. After metamorphosing, there is a radical reorganization of structural and physiological components. As a result, feeding and locomotion are impaired causing amphibians to be more vulnerable to things such as pesticides and other toxins. After metamorphosis, growth, estivation and/or hibernation depend upon fat reserves; thus, they may be extra susceptible to the impact of internally released chemical contaminants. Eighth is their breeding cycle. In general, amphibians undergo changes that require both low (hibernation) and high (reproduction) amounts of energy. During times of high energy requirements, when fatty tissues are metabolized, any fat-soluble chemical can be released. Release could be rapid during times such as post-emergence when metabolism increases and breeding starts. Effects could be especially harmful if animals' immune systems are compromised (*i.e*. due to low temperatures and desiccation) which could postpone breeding. Females also rely upon fat reserves for producing yolk which supplies nutrition for developing embryos (Stebbins and Cohen, 1997).

Considering the above characteristics, it is easy to see why amphibians are susceptible to things such as changing climatic conditions and the altering of land which are due to the ever-increasing human population. However, because amphibians play a vital role in the food web, declines are not limited to amphibians.

Amphibians are characterized as having limited dispersal abilities, strong site fidelity and spatially disjunct breeding habitat. Because of these, pond-breeding species may form metapopulations. Amphibian species worldwide appear to be suffering population-level declines caused, at least in part, by the degradation and fragmentation of habitat and the intervening areas between habitat patches (Smith and Green, 2005). In the past, these animals have had access (via unaltered and more pristine environments) to other metapopulations that could help repopulate declining or extinct populations. That is no longer the case today as more land is developed and more pollution is introduced into the environment.

Status of Pseudacris feriarum in West Virginia

Currently, *P. feriarum* is listed as a species of concern by the WVDNR (state rank: S2, global rank: G5). State Ranks are assigned and tracked by the Wildlife Diversity Program (WDP) of the WVDNR and are based on documented occurrences and distribution of the species within the state. S2 signifies there are 6 to 20 documented occurrences, or few remaining individuals within the state which makes the species very rare and imperiled and vulnerable to extirpation (WV DNR, 2005).

Global Ranks are determined by the Natural Heritage Network botanists and The Nature Conservancy. Global ranks are based on the range-wide status of a species and these ranks are used by various agencies as a way to assess a species rarity. The number of documented occurrences, number of individuals and factors threatening the species are taken into consideration when assigning a global rank. G5 signifies the species is very common and demonstrably secure although it may be rare in parts of its range, especially at the periphery (WV DNR, 2005).

Species of concern is an informal term for a plant or animal with declining populations and believed to be in need of concentrated conservation actions such as research, monitoring or removal of threats and given legal classification as threatened

or endangered. A species' status is tracked in West Virginia by the Department of Natural Resources Natural Heritage Program; however, offers no legal protection for any listed species. Species of concern that are tracked are those species considered to have been either once more common or widespread in the state but now are thought to be declining, species that have probably always been uncommon in West Virginia because the state is on the periphery of its range or species believed to be common in the state but supportive data are lacking (Levell, 1997).

In West Virginia (not unlike most places), herpetological conservation often stems from factors such as habitat destruction, habitat fragmentation and habitat degradation. Perhaps the greatest concern is mountain top mining where the tops of mountains are removed and dumped into valleys impacting both aquatic and terrestrial habitats. Water (which is vital for amphibian life cycles) is impacted by many things, including residential, agricultural and industrial discharges as well as acid mine drainage. Also at issue are timbering, ski slopes, rights-of way and roads and trails that fragment many areas (Levell, 1997).

State regulations restrict the pet trade of aquatic turtles only; however, box turtles, lizards, snakes and amphibians (except *Plethodon nettingi* which is a federally protected species) are not included under these regulations. There are bag limits on most species but the limits are too excessive to be an effective conservation measure (*i.e*. 100 aquatic turtles/bag) (Levell, 1997).

Declining: Pseudacris feriarum in West Virginia

Several locations of breeding populations of *P. feriarum* in Greenbrier, Monroe and Summers counties (the southern edge of their range in WV) are known from the 1970s and 1980s. In 2000, Jessica Wooten (then a graduate student of T.K. Pauley's) searched these historical sites but did not find any Upland Chorus Frogs. T.K. Pauley

visited these historical sites in 2001 and determined these frogs were no longer there. He then searched for populations and found several scattered at different sites from Pocahontas County north into Morgan County. As it stands now, *P. feriarum* no longer occurs in Greenbrier, Monroe and Summers counties. Before this study, only a handful, disjunct populations were known to have *P. feriarum* and were in/near the eastern panhandle (T.K.P. and J. Wooten, personal communications).

Materials and Methods

Surveys

During March through May, 2004 and 2005, day and night auditory and visual surveys for *P. feriarum* populations were performed during ideal weather conditions (*e.g*. warm, wet periods). Potential habitat was identified in the known range and then an auditory survey was performed for approximately five minutes at each site. Pierce and Gutzwiller (2004) did not find a significant difference in detection efficiency between 5 and 10-minute surveys in detecting frog species. However, 15-minute surveys were found to be the best at detecting 94% of frog species (versus 71% with 5-minute surveys). Shorter survey periods were employed allowing for more sites to be visited which increases sample size and statistical power (Pierce and Gutzwiller, 2004). During my study, historical locations in Berkeley, Greenbrier, Hampshire, Hardy, Mineral, Monroe, Morgan, Pocahontas and Summers counties were searched along with other locations in Berkeley, Grant, Greenbrier, Hampshire, Hardy, Jefferson, Mineral, Monroe, Morgan, Pendleton, Pocahontas and Summers counties.

A GIS map was created (Figure 10) showing counties searched (including historical sites, sites searched by myself and sites searched by T.K.P. during the study period) and results (*P. feriarum present*, *P. feriarum* absent). This map was overlaid

with a West Virginia topography shapefile and major river shapefile to illustrate where *P. feriarum* are found or not found in West Virginia.

DNR Article

Responses from my published West Virginia Wildlife magazine article (Sias, 2005) about the status of *P. feriarum* in West Virginia suggested I search at Shanghai in Morgan County, Fort Seybert in Pendleton County, Sleepy Creek Mountain in Morgan County, Capon Bridge in Hampshire County, Green Spring in Hampshire County and Arthur in Grant County.

Historical Weather

From 1970 through 2000, historical precipitation data were obtained (Weather Underground, 2006) and analyzed using Sigma Stat 2.03. One-way ANOVA tests were used to compare precipitation means for the breeding season of *P. feriarum* (February, March, April and May), foraging season (June, July, August and September) and hibernating season (October, November, December and January) during these 3 decades. The period form 1994 through 1996 was not analyzed due to lack of data. Areas compared were Monroe and Greenbrier counties to Morgan, Berkeley and Jefferson counties. Areas between include Pocahontas, Pendleton, Grant and Hardy counties; however, no weather data was available for this central portion of *P. feriarum'*s range. Monroe and Greenbrier counties represent areas where *P. feriarum* used to be found while Morgan, Berkeley and Jefferson counties represent areas where *P. feriarum* is still found (Morgan and Berkeley) and never been found (Jefferson).

Water Quality Parameters

The Clean Water Act of 1972, in section 303(d), requires each state to develop a list of impaired streams, rivers and lakes. A body of water is considered impaired if it does not meet the water quality standards that the state has set for it, even after point sources of pollution have been controlled and pollution control technologies have been

installed under the National Pollutant Discharge Elimination System (NPDES). Therefore, these waters must have further reduction in pollution loads in order to meet standards. The next step in this pollution reduction plan is to develop a Total Maximum Daily Load (TMDL). A TMDL determines the maximum amount of pollutant which is allowed in an impaired steam; simply a TMDL acts in conjunction with the NPDES to further reduce pollution (Skousen, 2002).

Streams were identified in all counties known to be in the range of *P. feriarum* (both historically and presently). These counties include: Monroe, Summers, Greenbrier, Pocahontas, Pendleton, Hardy, Grant, Mineral, Hampshire, Morgan, Berkeley and Jefferson. The Division of Environmental Protection's (DEP) Office of Water Resources lists streams which have failed to meet state water quality standards every two years in their 303(d) list. These water quality limited bodies of water were then compared to determine if they are found in any of the above 12 counties.

Results

Surveys

Nine historical *P. feriarum* sites in Greenbrier, 1 in Monroe and 2 in Summers County were searched but Upland Chorus Frogs were neither seen nor heard. *P. feriarum* are still found in Berkeley County (in 5 of 11 sites searched), Hampshire County (in 11 of 26 sites searched), Hardy County (in 4 of 38 sites searched), Mineral County (in 1 of 3 sites searched), Morgan County (in 11 of 13 sites searched) and Pocahontas County (in 1 of 10 sites searched). Thirteen sites were searched in Jefferson County but *P. feriarum* were neither seen nor heard. Two new county records were found during my study: Grant County (in 1 of 7 sites searched) and Pendleton County (in 2 of 20 sites searched) (Figure 10 and Table 6).

DNR Article

Results from my West Virginia Wildlife magazine article yielded 2 new sites. *P. feriarum* records existed for Shanghai in Morgan County, Sleepy Creek Mountain in Morgan County and Capon Bridge in Hampshire County; however, 2 new sites included Arthur in Grant County (Grant County represents a county record for *P. feriarum*) and Green Springs in Hampshire County. Fort Seybert in Pendleton County was checked but *P. feriarum* was neither seen nor heard.

Historical Weather

ANOVA one-way tests showed precipitation for all but 1 breeding season (1998), 1 foraging season (1996) and 1 hibernating season (1997) were not significantly different. While there were several months that precipitation was at or above average, there were also a number of months that precipitation was below average. Although not significantly different, total precipitation was greater in areas where *P. feriarum* still reside ($p=0.207$).

Water Quality Parameters

Both the South Fork and North Fork of the South Branch Potomac River are found in the DEP's 1998 303(d) List. Fecal coliforms due to agriculture are found the entire length from Pendleton through Grant and Hardy counties. As of 1998, Total Maximum Daily Loads (TMDL) had been completed for both rivers. There are several streams that drain from the South Branch Potomac River and have biological impairment due to unknown pollutants. These include: Black Thorn Creek, South Fork, Mill Run, Reeds Creek (Pendleton County), Dumpling Run, Mud Lick Run (Hardy County) and Lunice Creek (Grant County). Total miles affected are unknown and all streams are lowest TMDL. Simply, these are lowest priority streams in terms of "cleaning up" their pollution. Abram Creek (Mineral County) stems off the North Branch

of Potomac and is a medium TMDL priority. Abram Creek has low pH and metals from mine drainage; 18.5 miles are affected (WVDEP, 1998) (Figures 11 and 12).

A section of Lost River (from its headwaters to Rt. 55 bridge crossing above Wardensville—26.03 miles) in Hardy County has fecal coliforms due to agriculture. As of 1998, TMDL had been completed (WVDEP, 1998) (Figures 11 and 12).

From the mouth of Stony River through Mill Run, Grant County, 16.5 miles are affected by mine drainage (low pH, unionized ammonia and metals). As of 1998, TMDL was highest priority (WVDEP, 1998) (Figure 11).

The entire length of the Shenandoah River is affected by polychlorinated biphenyls (PCBs) and as of 1998, was a medium TMDL priority. Bullskin Run in Jefferson County drains off the Shenandoah and has biological impairment due to unknown pollutants; however, it is lowest TMDL priority (WVDEP, 1998) (Figure 11).

Discussion

Amphibian declines can be attributed to habitat modifications. Habitat fragmentation (roads), habitat alteration (draining wetlands, introducing new species) and habitat degradation (chemical contaminants) are some examples. Climatic changes, over-collecting and disease are other possible causes. Pollio and Kilpatrick (2002) report that the most likely reasons *P. feriarum* are disappearing from northern Virginia are habitat loss or erratic weather patterns.

Climatic Changes

West Virginia, among other states, experienced abnormally high temperatures during the 1980s (Livermore, 1992) and it believed that during this time, a decline occurred in *P. feriarum* populations (T.K.P., personal communication). As mentioned before, *P. feriarum* are largely found in the Ridge and Valley Province of West Virginia (Figure 13). Because this area is east of the Allegheny Front, it receives less yearly

precipitation (average 93.0 cm) than the Allegheny Plateau (110.2 cm) and Allegheny Mountain (136.6 cm) provinces (Lee *et al*. 1977). When precipitation comparisons (1970 through 2000) were made for *P. feriarum*'s breeding season, foraging season and hibernating season, there were mostly no significant differences between areas where they reside (Morgan and Berkeley) to areas where it is believed they have been extirpated (Monroe and Greenbrier). This is surprising and suggests other cause(s) for their decline or that perhaps subtle changes in temperature and moisture are critical to small amphibians.

Habitat Modifications

Habitat modifications are largely due to the increasing human population. In West Virginia, the Eastern Panhandle is the fastest growing region in terms of population and housing growth (Figure 13). In July 2005, the United States Census Bureau released a list of the top 100 counties according to housing growth. Berkeley County was 86th in the nation among the 3,000+ United States counties surveyed. Jefferson County was not far behind at 88th (Wikipedia, 2006).

As of 2000, 10 of 51 West Virginia counties had population sizes greater than 50,000. Besides extensive growth in Berkeley (+41,000) and Jefferson counties (+41,000), Mercer County has had an increase in population size as well (+40,000) (Real Estate, 2002). Perhaps, *P. feriarum* was historically present in Mercer and Jefferson counties but has been extirpated due to increasing human pressures. As a whole, Mercer County has been thoroughly searched prior to this study without any sightings. Repeated attempts before and during this study yielded no *P. feriarum* populations in Jefferson County despite that fact that Jefferson County falls within the current known range.

Surveys

Of 12 counties searched, Morgan County had the highest number of *P. feriarum* sites found per total sites searched (11 of 13). Perhaps this is because my study site was located within this county which allowed more time to monitor optimal areas (*i.e*. during down times between sampling periods). Hardy County was searched most; however, only 4 of 38 sites had Upland Chorus Frogs. Hampshire County was searched second most with 11 of 26 sites positive for Upland Chorus Frogs. Pocahontas County had 1 site with *P. feriarum*; however, only 1 male was heard which may indicate that this population is declining. Simply hearing choruses does not indicate successful reproduction at that site because it does not guarantee female presence. Presence of eggs is also not a sign of successful reproduction because they may fail to complete development. Observations of newly transformed froglets leaving the natal pond are a much better indicator of successful reproduction (Tucker, 1997c). All counties need to be searched more in order to locate new populations. Except for Morgan County, most sites searched yielded no *P. feriarum*. Mineral County was only searched at 3 sites and Jefferson is still a good candidate for finding Upland Chorus Frogs.

Water Quality Parameters

Streams located within the range of *P. feriarum* in West Virginia were found to be contaminated with fecal coliforms, mine drainages, PCBs and unknown pollutants. Fecal coliforms may indicate a higher risk of pathogens present in the water. It is interesting to note both the South Fork of the South Branch Potomac River and the Lost River both had high levels of fecal coliforms and that areas around both rivers have been searched numerous times for *P. feriarum* without success (Figures 11 and 12).

Although increasing evidence links PCBs to decreases in survival and reproduction of fish, mammals and birds, relatively little is known of their bioaccumulation or their possible effects in amphibians (Karasov *et al*. 1999). In a study comparing effects of exposure of 2 Ranids to PCB 126, Karasov *et al*. (1999) found no significant differences in mortality of embryos before hatching; however, survival of larvae was significantly reduced at the highest concentration for both species. Some deformities were observed and the incidence of edema was significantly higher in tadpoles exposed to the highest concentration. Swimming speed and tadpole growth were also significantly reduced in this treatment. Percent of tadpoles that reached metamorphosis was significantly lower in *R. clamitans* at the highest concentration, and no *R. pipiens* survived past day 47 of the experiment in this treatment. Cooke (1973) notes how smaller sized breeding pools can magnify the effects of pollutants because the chance for dilution is reduced.

Declining Anurans in West Virginia

Other West Virginian anuran species that appear to be in decline include: A*cris c. blanchardi, A. c. crepitans, P. brachyphona* and *Rana pipiens*. Hypotheses include habitat degradation, habitat destruction, disease, predators, over collection, short life spans and physiological constraints (*i.e*. low freezing and hypoxia tolerances) (Bayne, 2004; Dickson; 2002; Mitchell and Pauley, 2005; Sutton, 2004). Causes of amphibian declines are convoluted and likely due to synergistic interactions of multiple factors; in fact, with time, it may be clearer whether declines are natural or if anthropogenically induced.

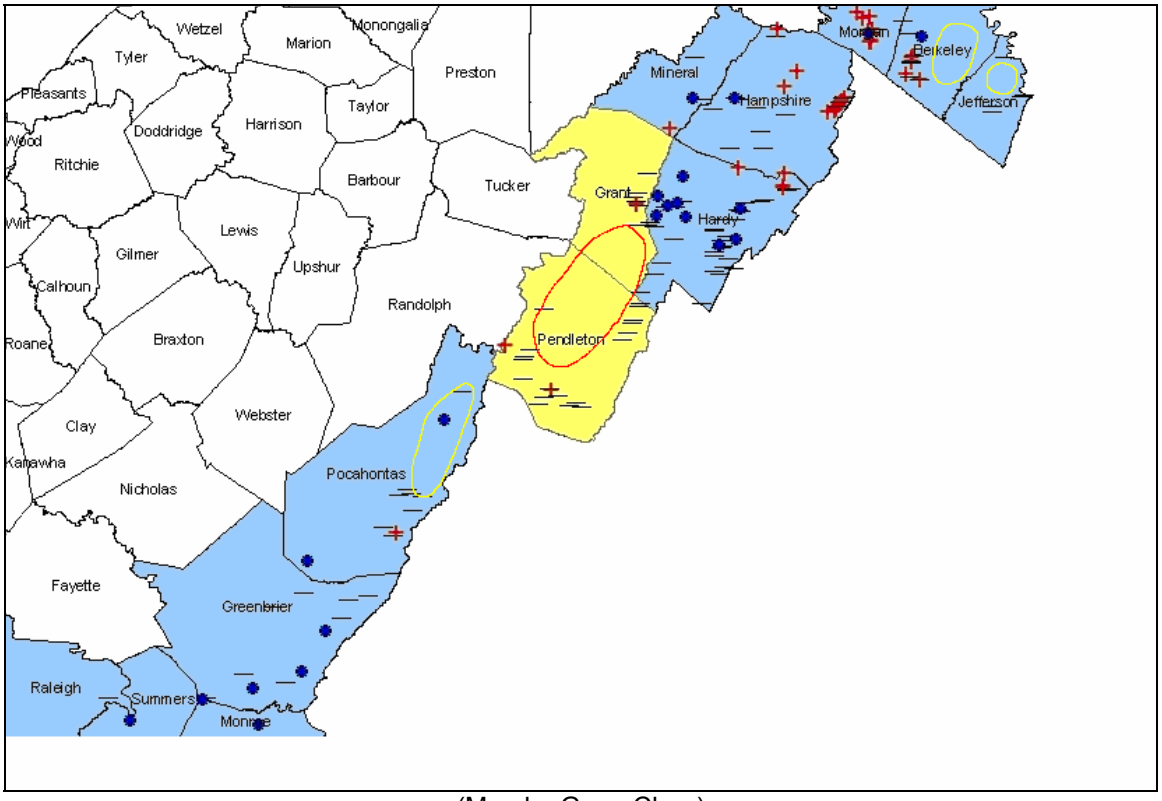
Why have Upland Chorus Frogs declined in West Virginia? It appears excessively high temperatures alone were not enough to cause extinction of *P. feriarum* in the southern counties. Periodic draughts (*i.e*. 1980, 1988, 1999 and 2002) and/or

floods (*i.e*. 1977 and 1985) have also occurred in the state (West Virginia Division of Culture and History, 2006). Perhaps there is/was something acting in tandem with these climatic changes to decrease *P. feriarum* populations.

Although not significantly different, during the past 3 decades there has been more precipitation in the northeastern part of their range than in the southern portions. This is opposite of expectations due to effects of the rain shadow (Lee *et al*., 1977). With lower precipitation and higher temperatures in the southern counties, *P. feriarum* may not able to relocate to more hospitable areas, such as the northeastern areas. A few reasons exist for this. *P. feriarum* are small, short-lived and not very mobile animals which make it difficult for them to recolonize areas where populations have been extirpated. Amphibians are especially vulnerable to desiccation because they have a higher proportion of wet surface exposed to the air than any other vertebrate. Also, smaller amphibians have an increased risk of dehydration because they are not able to hold as much water as larger frogs (Spight, 1958). This probably made *P. feriarum* more susceptible to the drier/warmer conditions that occurred in the 1980s in West Virginia. As a result of all of these factors, they were not able to cross the Allegheny Mountains and colonize areas of suitable habitat. However, as with all species declines, more time and research are needed to determine which factors have caused observed population decreases.

The inability of *P. feriarum* to colonize new areas and to recolonize areas from which they have been extirpated indicate the need for conservation efforts to be enacted for known healthy populations. Further surveys are needed to locate new populations, monitor known populations and to confirm suspected extirpations. In addition, new laws need to be enacted to protect Species of Concern in West Virginia.

Figure 10. West Virginia Distribution of *Pseudacris feriarum* before and after Study



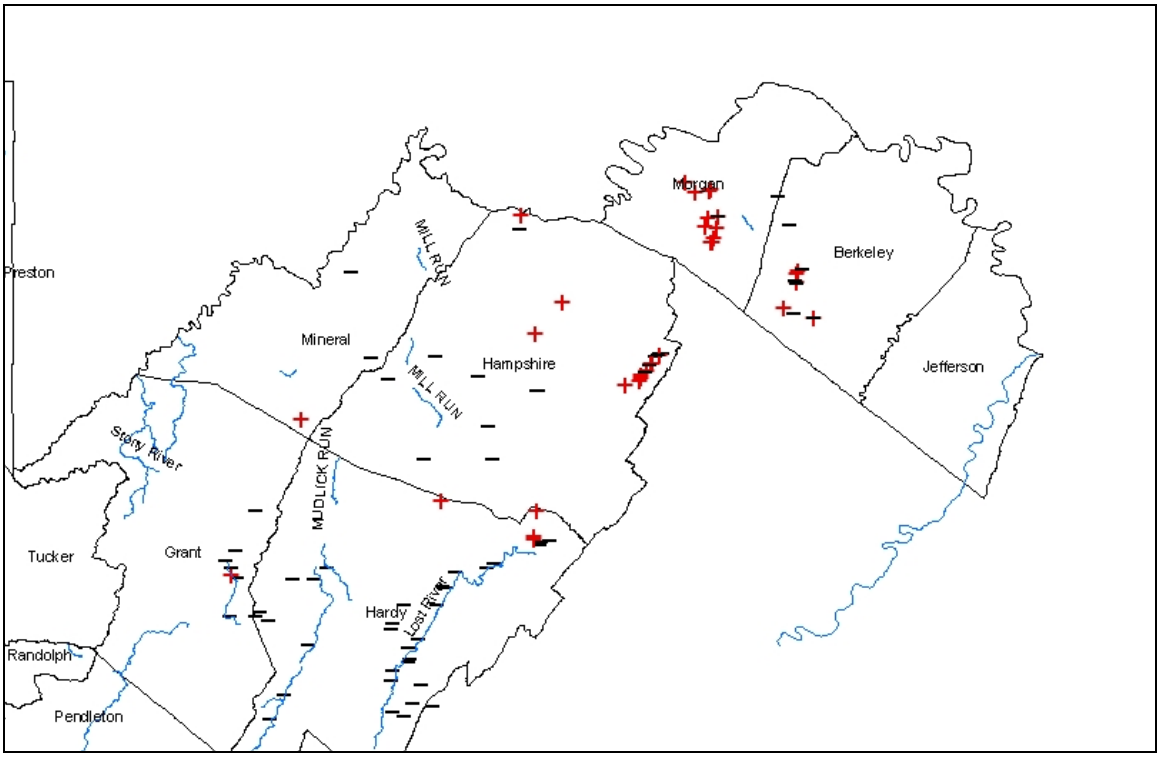
(Map by Gene Chou)

- Blue counties denote counties searched during study
- Yellow Counties denote new *Pseudacris feriarum* county records during study
- Blue circles denote historical *Pseudacris feriarum* locations
- Red positives denote new *Pseudacris feriarum* locations during study
- Black negatives denote places searched but did not locate *Pseudacris feriarum during* study
- Yellow and red circles denote areas searched prior to study where *P. feriarum* were not found

Table 6. Counties Searched and Presence/Absence of *Pseudacris feriarum*

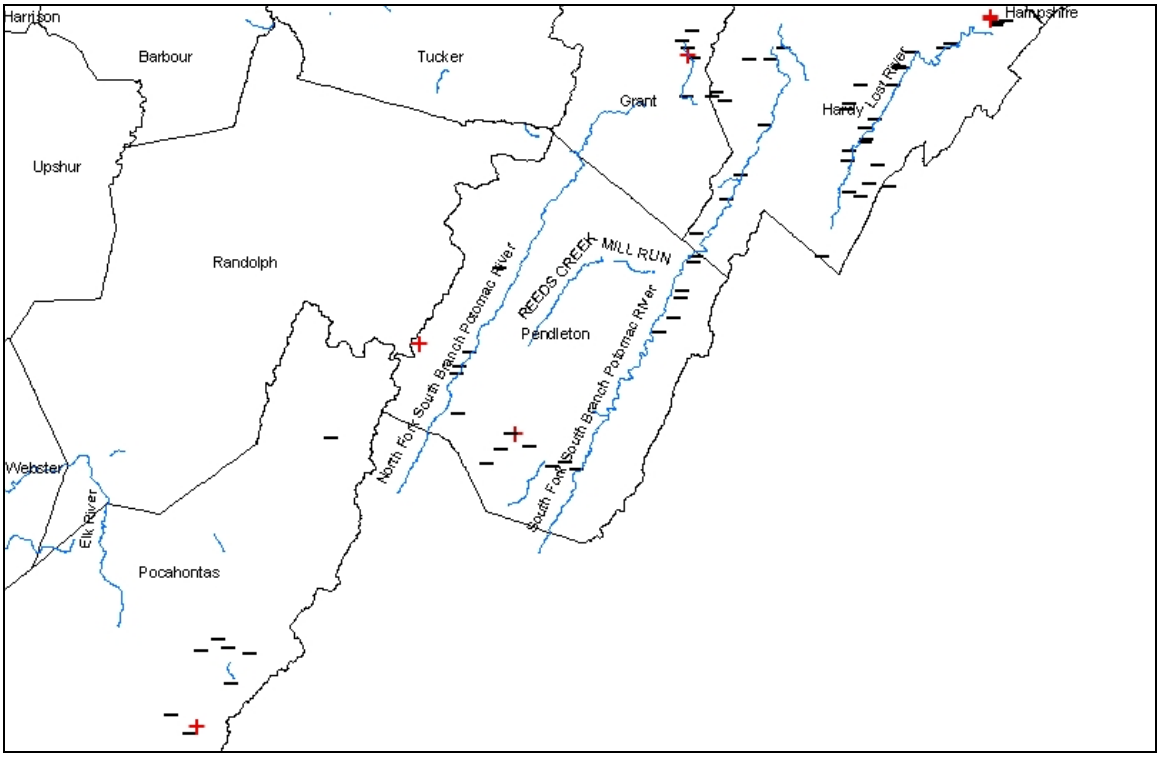
County	Historically Found	Presently Found	New County Record
Berkeley	Yes, at 1 site	Yes, at 5 of 11 sites checked	No
Grant	No	Yes, at 1 of 7 sites checked	Yes
Greenbrier	Yes, at 3 sites	No, at 9 sites checked	No
Hampshire	Yes, at 1 site	Yes, at 11 of 26 sites checked	No
Hardy	Yes, at 9 sites	Yes, at 4 of 38 sites checked	No
Jefferson	No	No, at 13 sites checked	No
Mineral	Yes, at 1 site	Yes, at 1 of 3 sites checked	No
Monroe	Yes, at 1 site	No, at 1 site checked	No
Morgan	Yes, at 1site	Yes, at 11 of 13 sites checked	No
Pendleton	No	Yes, at 2 of 20 sites checked	Yes
Pocahontas	Yes, at 2 sites	Yes, at 1 of 10 sites checked	No
Summers	Yes, at 1 site	No, at 2 sites checked	No

Figure 11. Water Quality Limited Streams in the Northern Range of *Pseudacris feriarum* in West Virginia



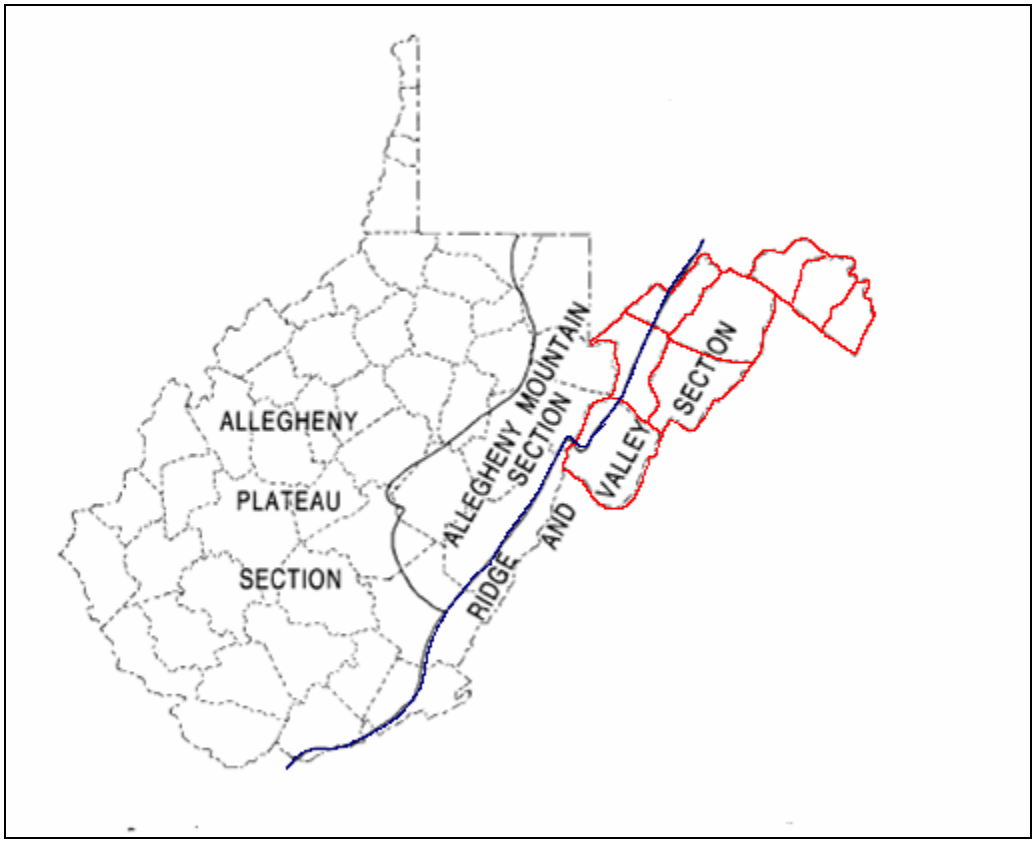
(Map by Gene Chou)

Figure 12: Water Quality Limited Streams in the Southern Range of *Pseudacris feriarum* in West Virginia



(Map by Gene Chou)

Figure 13. West Virginia Physiographic Provinces



(Modified from Green and Pauley, 1987)

- Eastern panhandle counties are outlined in red
- Blue line denotes the Allegheny Front

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Jaime Sias

Curriculum Vitae

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EDUCATION

Masters of Science: Biological Science
Marshall University, West Virginia
Graduation date: May 2006
GPA: 3.88/4.0
Advisor: Dr. Thomas K. Pauley, 304.696.2376
Thesis: Natural History and Distribution of the Upland Chorus Frog, *Pseudacris feriarum*, in West Virginia

Bachelor of Science: Biological Science
Marshall University, West Virginia
Graduation date: May 2000
GPA: 3.26/4.0
Gamma Beta Phi Honor Society and Dean's List

INTERNSHIPS/VOLUNTEER

(1) Epcot's "The Living Seas" Orlando, FL, 01/2001 – 05/2001

- Performed research and recorded data on Bottlenose dolphins
- Set up research apparatus underwater
- Met with research director to interpret and discuss results

(2) International Center for Gibbon Studies Santa Clarita, CA, 09/2000 – 11/2000

- Participated in Animal Husbandry with 30 plus gibbons
- Researched and observed animal behavior on site
- Arranged and guided local school tours

(3) Olson Animal Hospital Barboursville, WV, 02/1998 – 05/2000

- Had hands on experience with domestic animals
- Observed surgeries and other procedures
- Helped with day-to-day operations of clinic

(4) Missouri Land Use Effects on Amphibian Populations (MOLEAP) Project

Hermann, MO, 05/2005 – 10/2005

- Facilitated large scale amphibian mark/recapture study
- Maintained approximately 1 mile of drift fence
- Assisted additional graduate research projects

ORAL PRESENTATIONS

- Biology 662, Marshall University: "Herpetological Marking Techniques with an Emphasis on Fluorescence"
- Annual Meeting of the Association of Southeastern Biologist (ASB) 2005: "pH Tolerance of *H. scutatum* and *R. sylvatica*

RESEARCH GRANTS

- 2004 West Virginia Division of Natural Resources Wildlife Diversity Program Grant ($6,400)
- 2004 Marshall University Research Foundation Summer Research Grant ($500.00)
- NASA/SIGMA XI 2003 Higher Education Grant ($1000.00)
- NASA/SIGMA XI 2004 Higher Education Grant ($500.00)

TEACHING EXPERIENCE

(1) 2003 Teaching Assistant, Marshall University

- Prepped introductory biology laboratories
- Taught introductory biology laboratories
- Graded papers and quizzes

(2) 2004 Fall Herpetology Laboratory Instructor, Marshall University

- Instructed a weekly laboratory on the identification of West Virginia reptiles and amphibians
- Reviewed basic taxonomic principles that apply to reptiles and amphibians
- Constructed and graded materials pertaining to the laboratory

GRADUATE RESEARCH EXPERIENCE

Graduate Research Assistant: January 2004 – May 2005, Marshall University, Graduate stipend through WV Department of Natural Resources and US Fish and Wildlife Service

(1) Amphibian and Reptile Inventory of the Gauley River National Recreation Area, Harper's Ferry National Park, Catoctin National Park and Chesapeake and Ohio Canal National Park

Funded by: National Park Service

Position: Research assistant

- Surveyed for salamanders, anurans, lizards and snakes with visual encounter searches and evening call surveys
- Measured captured amphibians and reptiles and recorded locations with a GPS
- Performed data entry and editing of final report

(2) Small-mouthed Salamander (*Ambystoma texanum*) surveys along the Ohio River Floodplain

Funded by: WV Department of Natural Resources

Position: Research assistant

- Located potential sites along the Ohio River Floodplain in West Virginia
- Implemented tray arrays within the located sites
- Discovered the largest known population of *A. texanum* within West Virginia

(3) Effect of disturbance and habitat fragmentation on amphibians in a continuously forested landscape

Funded by: MEAD WESTVACO Corporation

Position: Research assistant

- Constructed drift fence arrays around anthropogenic vernal pools
- Checked drift fence arrays for ingress/egress of amphibians
- Elastomer-tagged egressing metamorphs form pools
- Performed data collection

(4) Cheat Mountain Salamander (*Plethodon nettingi) repatriation project*

Funded by: Snowshoe Mountain Resort/ WV Department of Natural Resources and US Fish and Wildlife Service

Position: Principal investigator

- Took soil and leaf litter samples from control sites and compared them to possible repatriation sites using moisture content, pH and air/soil temperature
- Transfered imperiled salamanders to repatriated sites
- Will take data on salamander ability to adapt to new site locations
- Compiled literature list based on past repatriation efforts

(5) West Virginia Biological Survey Museum (WVBS) of Reptiles and Amphibians

Funded by: WV Department of Natural Resources

Position: Assistant curator

- Added new specimens to the WV Biological Survey Museum
- Maintained specimens and laboratory field equipment
- Loaned specimens to other institutions
- Maintained computer database of laboratory specimens

(6) Marshall University Herpetological Laboratory animal care
Position: Principal coordinator

- Cared for, fed and cleaned for all live animals within the laboratory
- Transported animals to and from laboratory for outreach programs

(7) Marshall University Outreach Program
Position: Principal coordinator

- Organized school presentations around West Virginia pertaining to amphibian and reptile conservation
- Presented PowerPoint presentations to children and teachers
- Described live animals to children

(8) WV North American Amphibian Monitoring Program (WVNAAMP)
Funded by: US Geological Survey
Position: Assistant coordinator

- Placed newspaper ads in WV newspapers to solicit route volunteers
- Assigned 40+ routes to volunteers
- Mailed out information packets to volunteers
- Assisted volunteers with anuran natural history information
- Entered call survey data

(9) Habitat Conservation Plan (HCP) for Blackwater Canyon
Funded by: Allegheny Wood Product
Position: Research assistant

- Collected and entered biological and environmental data
- Developed literature list of timbering effects on amphibians

(10) The effects of ski slopes on *Plethodon nettingi* at Timberline Ski Resort
Funded by: Timberline, WV
Position: Technician

- Collected and analyzed biological and environmental data
- Compared impact versus non-impact sites using biological and environmental parameters

(11) Assisted with additional Marshall University Thesis Projects (all funded via WV Department of Natural Resources:

- Northern Leopard Frog (*Rana pipiens*) ecology at Green Bottom Swamp, West Virginia
- Systematics of the Black-bellied Salamander (*Desmognathus quadramaculatus*) within the southern Appalachians
- Herpetofaunal assemblages on a Reclaimed Strip Mine
- The Distribution and Natural History of the Shenandoah Mountain Salamander, *Plethodon virginia*, in West Virginia
- Distribution of *Ambystoma texanum* and *A. barbouri* in West Virginia

MASTER'S THESIS RESEARCH

Thesis title: Natural History and Distribution of the Upland Chorus Frog, *Pseudacris feriarum*, in West Virginia

Advisor: Dr. Thomas K. Pauley
Research start date: March 2004
Research end date: April 2005
Defense date: 12 April, 2006

Thesis abstract: Chapter 1 is a literature review of *Pseudacris feriarum*, largely based on published *P. triseriata* Complex species accounts. Chapter 2 presents the natural history of *P. feriarum* in West Virginia and compares some parameters with other *Pseudacris* species. Chapter 3 looks at the phenology of a wetland in eastern West Virginia. Chapter 4 examines the current range of *P. feriarum* and compares it with the historical range in the state. Finally, hypotheses are given as to why Upland Chorus Frogs have declined in West Virginia. All information obtained from this study should be used to create a management plan for the conservation of all present and future *P. feriarum* populations.

RELEVENT COURSEWORK
Ornithology, Herpetology, Plant Taxonomy, Conservation Biology, Mammalogy, Ecology, Biostatistics and Geographic Information Systems

FIELDWORK SKILLS
Drift fences, cover boards, funnel traps, call surveys, quadrat survey, transect survey, dip netting, road search, acrylic elastomer marking, eye shine location, snorkeling (also SCUBA certified), toe clipping, pit-tagging, field photography, visual and auditory identification of West Virginian anurans and birds, West Virginian plant identification, plant pressing and preparing herbarium specimens

COMPUTER SKILLS
MS word, MS Excel, MS Access, MS PowerPoint and Basic GIS

REFERENCES

Dr. Elaine Baker
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