The Natural History and Morphology of the Eastern Cricket Frog, Acris crepitans crepitans, in West Virginia

Kimberly Ann Bayne

Follow this and additional works at: http://mds.marshall.edu/etd

Part of the Aquaculture and Fisheries Commons, and the Behavior and Ethology Commons

Recommended Citation

This Thesis is brought to you for free and open access by Marshall Digital Scholar. It has been accepted for inclusion in Theses, Dissertations and Capstones by an authorized administrator of Marshall Digital Scholar. For more information, please contact zhangj@marshall.edu.
The Natural History and Morphology of the Eastern Cricket Frog, 
_Acris crepitans crepitans_, in West Virginia.

Thesis submitted to 
The Graduate School of 
Marshall University

In partial fulfillment of the 
Requirements for the Degree of 
Master of Science 
Biological Sciences

By

Kimberly Ann Bayne 

Marshall University 
Huntington, West Virginia 

April 2, 2004
Table of Contents

Acknowledgements ......................................................................................................................... ii
List of Tables ........................................................................................................................................ iii
List of Figures ....................................................................................................................................... iv
Abstract ............................................................................................................................................... vi
Introduction ......................................................................................................................................... 1
  Taxonomy ....................................................................................................................................... 1
  Distribution .................................................................................................................................... 2
  Description .................................................................................................................................... 2
    Adult and immature frogs ............................................................................................................... 2
    Larvae ......................................................................................................................................... 3
Natural History ................................................................................................................................. 9
  Adult and immature frogs ............................................................................................................... 9
  Larvae ......................................................................................................................................... 11
Purpose of Study .............................................................................................................................. 11
Materials and Methods .................................................................................................................. 13
  Description of Study Sites ........................................................................................................... 13
    Site 1: Lake Louise ...................................................................................................................... 13
    Site 2: Leetown Fish Hatchery .................................................................................................. 16
    Site 3: Altona Marsh .................................................................................................................. 16
    Site 4: Harewood Marsh ........................................................................................................... 21
    Site 5: Edwards Run .................................................................................................................. 21
    Site 6: Ganotown Marsh ............................................................................................................ 26
    Site 7: Pine Valley Pond ............................................................................................................. 26
Biological Data Collection ........................................................................................................... 31
Environmental Data Collection ..................................................................................................... 36
Statistical Analysis .......................................................................................................................... 36
  Biological Data .......................................................................................................................... 37
  Environmental Data .................................................................................................................... 37
Results .......................................................................................................................................... 38
  Phenology and Environmental Data .......................................................................................... 38
    Adult Data ............................................................................................................................... 62
    Subadult Data .......................................................................................................................... 74
    Froglet Data ............................................................................................................................ 74
Discussion ....................................................................................................................................... 91
  Biological Data .......................................................................................................................... 91
  Environmental Data .................................................................................................................... 96
Summary ....................................................................................................................................... 98
Literature Cited .............................................................................................................................. 100
Acknowledgements

I would first like to thank my advisor, Dr. Thomas K. Pauley, for allowing me the opportunity to work with him and learn from him. He has been a great instructor and advisor. Special thanks to my committee members Drs. Mary Etta Hight and Charles Somerville for their support and reviews of the manuscript.

Thanks to Dr. Mark Watson for helpful suggestions in the field and for the wonderful photographs he provided for my thesis. Thanks to Nancy J. Dickson for all her help and for the photograph she gave to me. Thanks also to Keith A. Johnson for the great pictures that he contributed.

Thanks to Stauffer Miller, Mr. & Mrs. S. Morgan, and Pine Valley School for allowing me the opportunity to perform my graduate work on their property. Acknowledgements to Mr. & Mrs. L. Rephann for providing food, water, and shelter to two homeless girls for the summer. I would also like to thank Mr. & Mrs. R. Collins for the help and the Korean food they provided for me all summer long. I would like to thank Mr. & Mrs. John Casto, NASA, Department of Biological Sciences at Marshall University, and the Marshall University Graduate Student Council Research Committee for partial funding for my research.

Thank you to Dr. Jim Hansen for all the wonderful help and suggestions in the statistical part of this thesis.

Thank you to the Natural Resources Conservation Service for location on all GPS points for all my sites.

Thanks to my hobbit friend, Ariana Breisch, for everything. She has been a great help in the field, and in the laboratory. She deserves special thanks for listening to me chatter all summer and living through it. She has been encouraging, funny, and a good friend when times really became tough during my research.

Thanks to everyone in Room 310 for being so supportive and for making me laugh all year round.

I wish to acknowledge and thank Richard Duane Wolford Jr. for helping me with my research. He has been especially helpful, patient, and supportive with my work. I give him thanks for helping me with anything computer related. I would still be stuck figuring out my database right now if it weren’t for him. Thank You.

I especially wish to thank my parents, Kum Hwa Bayne and Michael B. Casto, for encouraging me to pursue my degree. They have helped me through some very tough times and I appreciate it immensely. I could not have made it without their support and love. Thanks to my brother, Michael Bayne, for being my brother and for keeping my spirits high.

All specimens were collected under a scientific collecting permit that I attained from the West Virginia Department of Natural Resources.
List of Tables

Table 1: Description of morphological measurements .....................................................35
Table 2: Table of soil, air and water temperatures taken at sites containing A. c. crepitans ..................................................................................................................................40
Table 3: Identified plant Genus/Species collected at all sites...........................................53
Table 4: Significant difference of mean values by grouped similar sites.......................57
List of Figures

Figure 1: Distribution map of *Acris c. crepitans* in U.S. ...................................................4
Figure 2: Distribution map of *A. c. crepitans* in W.V. ....................................................5
Figure 3: Photograph of dorsal colors of *A. c. crepitans* ..................................................6
Figure 4: Photographs of *A. c. crepitans* life stages .......................................................7
Figure 5: Photographs of *A. c. crepitans* male and female ............................................8
Figure 6: Map showing study site 1 location .......................................................................14
Figure 7: Photographs of study site 1 ................................................................................15
Figure 8: Map showing study site 2 location .......................................................................17
Figure 9: Photograph of study site 2 ................................................................................18
Figure 10: Map showing study site 3 location .....................................................................19
Figure 11: Photographs of study site 3 ...............................................................................20
Figure 12: Map showing study site 4 location .....................................................................22
Figure 13: Photographs of study site 4 ...............................................................................23
Figure 14: Map showing study site 5 location .....................................................................24
Figure 15: Photographs of study site 5 ...............................................................................25
Figure 16: Map showing study site 6 location .....................................................................27
Figure 17: Photographs of study site 6 ...............................................................................28
Figure 18: Map showing study site 7 location .....................................................................29
Figure 19: Photographs of study site 7 ...............................................................................30
Figure 20: Photograph of measurement methods ................................................................32
Figure 21: Toe Clipping Illustration ....................................................................................34
Figure 22: Number of Calling Males ..................................................................................41
Figure 23: May temperatures (mean) for soil, water, and air for sites with *A.c.crepitans* and sites without *A.c.crepitans* .................................................................42
Figure 24: June temperatures (mean) for soil, water, and air for sites with *A.c.crepitans* and sites without *A.c.crepitans* .................................................................43
Figure 25: July temperatures (mean) for soil, water, and air for sites with *A.c.crepitans* and sites without *A.c.crepitans* .................................................................44
Figure 26: August temperatures (mean) for soil, water, and air for sites with *A.c.crepitans* and sites without *A.c.crepitans* .................................................................45
Figure 27: September temperatures (mean) for soil, water, and air for sites with *A.c.crepitans* and sites without *A.c.crepitans* .................................................................46
Figure 28: Mean Soil Temperatures for sites with *A.c.crepitans* and sites without *A.c.crepitans* ...........................................................................................................47
Figure 29: Mean Air Temperatures for sites with *A.c.crepitans* and sites without *A.c.crepitans* ...........................................................................................................48
Figure 30: Mean Water Temperatures for sites with *A.c.crepitans* and sites without *A.c.crepitans* ...........................................................................................................49
Figure 31: Photograph of *A. c. crepitans* collected egg mass in a Petri Dish ..................50
Figure 32: Incubation period of *A. c. crepitans* eggs .......................................................51
Figure 33: The mean pH for sites with *A.c.crepitans* and sites without *A.c.crepitans* ....58
Figure 34: The mean Dissolved Oxygen for sites with *A.c.crepitans* and sites without *A.c.crepitans* ...........................................................................................................59
Figure 35: The mean Carbon Dioxide for sites with *A.c.crepitans* and sites without
*A.c.crepitans* ...................................................................................................60

Figure 36: The mean Hardness for sites with *A.c.crepitans* and sites without
*A.c.crepitans* ...................................................................................................61

Figure 37: Mean head width, longest toe length, and webbing length of adults ..........63

Figure 38: Mean tibia, snout, and head lengths of adults .............................................64

Figure 39: Significantly different mean snout-to-vent lengths for adults.......................65

Figure 40: Significantly different mean tympanic membrane lengths for adults ..........66

Figure 41: Mean eye diameter measurements for adults ..............................................67

Figure 42: Mean weight of adults at Ganotown and Pine Valley ..................................68

Figure 43: Body measurements of adult males and females at Ganotown ....................69

Figure 44: Adult male vs. female mean weights (g) at Ganotown .................................70

Figure 45: Significantly different body measurements of adult males and females at
Pine Valley.......................................................................................................71

Figure 46: Body measurements of adult males and females at Pine Valley ....................72

Figure 47: Adult male vs. female mean weights (g) at Pine Valley ..............................73

Figure 48: Significantly different mean head width, longest toe length, and
webbing length of subadults ...........................................................................76

Figure 49: Significantly different mean SUL, snout, and tympanic
membrane lengths of subadults.......................................................................77

Figure 50: Mean tibia, eye diameter and head length measurements for
Subadults..........................................................................................................78

Figure 51: Mean weight of subadults at Ganotown and Pine Valley .............................79

Figure 52: Significantly different body measurements of subadult males and females at
Ganotown.........................................................................................................80

Figure 53: Body measurements of subadult males and females at Ganotown ...............81

Figure 54: Subadult male vs. female mean weights (g) at Ganotown ............................82

Figure 55: Significantly different body measurements of subadult males and females at
Pine Valley.......................................................................................................83

Figure 56: Subadult male vs. female mean weights (g) at Pine Valley .........................84

Figure 57: Significantly different mean body measurements of froglets .......................85

Figure 58: Significantly different weight (g) of froglets ...............................................86

Figure 59: Mean body measurements of froglets ......................................................87

Figure 60: Significantly different head lengths of larvae .............................................88

Figure 61: Mean body measurements of larvae ..........................................................89

Figure 62: Mean weight (g) of larvae .........................................................................90
Abstract

Two subspecies of cricket frogs, *Acris crepitans blanchardi* and *Acris crepitans crepitans*, historically have occurred in West Virginia. The range of *Acris c. blanchardi*, Blanchard’s Cricket Frog, begins along the Ohio River extending into West Virginia. The Eastern Cricket Frog, *Acris c. crepitans*, is found in counties located in the eastern panhandle. The Eastern Cricket Frog is a species of great concern. Two sites where *Acris c. crepitans* historically occurred, two sites that never contained *A. c. crepitans*, one historical site that currently has *A. c. crepitans*, and two new sites that have *A. c. crepitans* were studied by auditory and visual observation. Calls were first recorded during the period of May 2001 through August 2001. Breeding activity occurred from May-August, reaching its peak in June. Egg deposition occurred during amplexus. A range of 50-400 eggs were laid per female and incubation lasted approximately 8-9 days. Morphological measurements of larval, froglet, subadult, and adult stages were recorded. Significant relationships of morphological measurements between frogs at the seven sites, and between males and females were examined. Water chemistry, soil temperature, air temperature, and water were analyzed for differences in habitat. Water pH was generally the same for sites containing *A. c. crepitans*. Water, soil, and air temperatures were essentially higher at sites with *Acris c. crepitans*. Significant differences in water temperature between the months of May-September show that the breeding activity of *A. c. crepitans* is affected by water temperature.
Introduction

“The true man of science will know nature better by his finer organization; he will smell, taste, see, hear, feel, better than other men. His will be a deeper and finer experience. We do not learn by inference and deduction and the application of mathematics to philosophy, but by direct intercourse and sympathy” (Thoreau 1999).

This study focuses on the natural history and morphology of the Eastern Cricket Frog, *Acris crepitans crepitans*. *Acris c. crepitans* is a member of family Hylidae and subfamily Hylinae (Duellman and Trueb 1986). All frog species are in Superorder Salientia, and extant frog species are in Order Anura (Duellman and Trueb 1986). The genus *Acris* is comprised of two species, *Acris crepitans* and *Acris gryllus* (Duellman and Trueb 1986). Most hylids are arboreal, but some (*Acris*) are aquatic. According to fossil history, hylids are known from the Oligocene through the Pleistocene periods in North America (Duellman and Trueb 1986).

Taxonomy

Duméril and Bibron first recognized the genus *Acris* in 1841 (Duellman and Trueb 1986). Baird recognized *A. crepitans* in 1854 (Website 1). In 1953, Schmidt stated that its type locality was in Harper’s Ferry, West Virginia (Frost 1985). *Acris* is derived from the Greek word “Akris”, meaning “a locust”. *Creptans* is derived from the Latin word “crepito”, meaning, “to rattle” (Green and Pauley 1987). *Acris crepitans* is found throughout most of the U.S. east of the Rockies while *A. gryllus* is found only in the Southeastern states (Taylor and Guttman 1977). The species-specific mating call of the male and the selective response of the female provide a reproductive isolating mechanism between these two species in their zone of sympatry (Capranica, et al. 1973).
Distribution

_Acris c.crepitans_, is found from southeastern New York to the Florida panhandle and eastern Texas (Figure 1) (Conant and Collins 1998). The genus ranges from southeastern New York, the southern peninsula of Michigan, and southeastern South Dakota south to the tip of Florida and northeastern Mexico (Conant and Collins 1998).

Green and Pauley (1987) reported the local distribution of _A. c. crepitans_ as only in the eastern panhandle of West Virginia. It has been collected in Jefferson, Berkeley, Morgan, Hampshire, and Mineral counties. One other subspecies of _Acris crepitans_, _Acris c. blanchardi_, known as Blanchard’s Cricket Frog, has also been collected in West Virginia. _Acris c. blanchardi_ has been documented in Wayne, Putnam, Clay, and Mason counties. There are unverified records from Pocahontas and Fayette counties (Green and Pauley 1987). _Acris c. crepitans_ is found on aquatic vegetation around ponds, sluggish streams, and swamps where they rest on algal mats or leaves of spatterdock (Green and Pauley 1987).

Description

Adult and immature frogs

The dorsal color of adult and immature _A. c. crepitans_ is green, red, brown, yellow, and orange (Figure 3). The green color phase absorbs more of solar radiation than nongreen phases (brown, gray, etc.), which may place them at a disadvantage (through heating effects) when faced with drying periods (Stebbins and Cohen 1995). _Acris c. crepitans_ can be distinguished from _A. c. blanchardi_ and some chorus frogs by the slightly bulkier and rougher skin of _A. c. blanchardi_. Chorus frogs (_Pseudacris_) are
less warty than *A. c. crepitans* and have an extremely elongated fourth digit on the hind foot (Green and Pauley 1987).

The Eastern Cricket Frogs are one of the smallest species of frogs, reaching a snout-to-urostyle length of 1.6-3.5 cm, in West Virginia. They weigh 1.5 to 2.0 grams (Capranica, et al. 1973). Distinguishing characteristics include a dark triangle or V-shaped spot located between the eyes, and a longitudinal dark stripe that runs along the rear surface of the thigh (Green and Pauley 1987). *Acris c. crepitans* has extensive webbing between the hind toes (reaching the tip of the first toe and the next-to-last joint of the longest toe), and one or two pairs of white tubercles below the cloacal vent (Green and Pauley 1987). The belly is a cream color. Males include a yellow vocal sac flecked with dark pigment (Figure 5). Female frogs are slightly larger than the males.

**Larvae**

Egg and larvae stages are critical stages in the life histories of amphibians (Mitchell and Anderson 1995). The overall size of larval *A. c. crepitans* is variable (Figure 4). Tadpoles have a distinctive black-tipped tail and attain a much larger size in proportion to metamorphosed frogs than do other tadpoles (Green and Pauley 1987). Tadpoles can attain total body lengths of 2.54 cm, or more when hatched (website 1). The dorsal color is green with various spots, the ventral color is creamy white, and the sides are slightly iridescent pink to purple. There is a dark band that runs across the chest area. The eyes are dorsal, and the labial tooth-row formula is 2/2. The narrow midventral gap is absent in the marginal papillae (Website 2).
Figure 1: Map showing the range of *A. crepitans* in United States (Modified from Conant and Collins 1998)
Figure 2: Map showing range of *A. c. crepitans* in West Virginia (Modified from Green and Pauley 1987)
Figure 3: Photographs of various dorsal colors of

*A. c. crepitans*

(Photo by: Nancy J. Dickson)
Figure 4: Photographs of the life stages of *A. c. crepitans*

a) larvae; b) froglet; c) subadult; d) adult

(Photos by Keith A. Johnson)
Figure 5: *Acris c. crepitans*
  a) male; b) female

a) (Photo by: [http://www.comm.cnd.edu/herp/keys/frogpix.htm](http://www.comm.cnd.edu/herp/keys/frogpix.htm))

b) (Photo by: Mark Watson)
**Natural History**

**Adult and immature frogs**

In mid-March, males emerge from hibernation although their chorus is not heard until April or May (Green and Pauley 1987). Cricket frogs remain in the breeding areas until the onset of unfavorable weather and unlike other frogs they do not vacate the breeding area after reproduction (Green and Pauley 1987). The call of the male is a metallic gick,gick,gick – resembling the sound made by striking two stones together. There is about one call per second, the rate gradually increasing (Stebbins 1985). Male cricket frogs’ choruses serve to attract females and to maintain an individual’s calling space (Burmeister, et al. 1999). Call rates of *Acris crepitans* increases significantly at higher temperatures (Jackson 1952). They are the last of the local species to breed, and pairs in amplexus have been recorded as late as the middle of July (Green and Pauley 1987). Males aggregate around pools and call in early spring and summer (Forester and Daniel 1986). Calling males sit in areas of dense vegetation around the edges of breeding pools. Male frogs are active both day and night and males call from land (Wright and Wright 1949). They are within one meter of the shoreline (Forester and Daniel 1986). Cricket frogs will venture from the shoreline only when mats of algae are present on the surface (Burkett 1984). Males are sexually reproductive at a little less than one year of age (Collins 1975).

Most *A. c. crepitans* tend to aggregate on relatively level, bare areas at the water’s edge while avoiding steep, vegetation-covered slopes (Burkett 1984). Following rains and in mild, humid weather, they dispersed in all directions; movements of more than 100
meters are not uncommon. Rainfall cannot account for long movements alone; relative humidity, temperature conditions and breeding activity are also important (Burkett 1984).

Breeding activities vary according to geography and weather (Nevo 1973). Females, stimulated by rain events (Martof, 1956), arrive at the breeding pools later than males throughout the spring and summer. Peak oviposition occurs in late April through June (Mecham 1964). Females are sexually reproductive at a little less than one year of age (Collins 1975). Females are immediately clasped by the male as soon as they respond to the male chorus. Amplexus will occur in any quantity of water present and egg deposition occurs immediately during amplexus (Pauley pers. comm.). Eggs are deposited on aquatic vegetation either singly or in clumps (Green and Pauley 1987), between 50 and 400 eggs.

Average life expectancy is about four months, only 5% survive the winter, and complete population turnover occurs in about sixteen months (Nevo 1973). The snout-to-urostyle length of *Acris* increases primarily in response to increasingly arid environments (Nevo 1973).

The diet of *A. crepitans* may vary based on geographic location, season, and habitat. Jameson (1947) reported that stomach contents of *A. crepitans* consisted mainly of aquatic insects many of which were bottom dwellers. Major food items include dipterons, formicids, collembolons, and coleopterons (Labanick 1976). *Acris* also feed on carnivorous and phytophagous arthropods, which means that the economic impact of their feeding habits vary widely with changing ecological conditions (Johnson and Christiansen 1976). Froglets and tadpoles are preyed upon by the Eastern Garter Snakes, Northern Water Snakes, fishes, spiders, birds, and small mammals (Burkett 1984).
Larvae

Most spawning occurs from late May to early July. Newly metamorphosed frogs are found between mid-July and late September (Burkett 1984). Eggs are deposited and attached to aquatic vegetation. Tadpoles are typically found around mats of algae or along shorelines. Larval development generally requires from 5 to 10 weeks (Burkett 1969). Larval growth and metamorphosis is in part affected by temperature and other environmental factors (Breven and Smith-Gill 1979). Transformation into frogs takes about 2 days (Wright and Wright 1949). Two periods of rapid growth are observed: from July until late September and from March though July (Burkett 1984). Diets of larvae *A. crepitans* mainly consist of algae and diatoms. Larvae are preyed upon by the Eastern Garter Snake, Northern Water Snake, fish, spiders, birds, and small mammals (Burkett 1984).

Eggs and larvae are the most critical stages of the life history of amphibians (Mitchell and Anderson 1995). This is due to their sensitivity to weather and water conditions for proper development, and the vulnerability to predators. Eggs and larvae of *A. crepitans* are unable to tolerate limited exposure to low salinity water or seasonally dry conditions (Mitchell and Anderson 1995).

Purpose of Study

The natural history and morphology of *A. c. crepitans* in West Virginia has not been studied previously. It is ranked on the Species of Concern list in WV by the WVDNR (Pauley pers.comm.). Amphibians are ectothermic; hence, breeding periods, growth, activity patterns, and development of a single species can vary depending upon latitude, longitude, elevation, and climatic variation (Stebbins and Cohen 1995).
Objectives of my study are 1) to determine distribution of the *A. c. crepitans* in West Virginia 2) determine reasons for the restricted range of the *A. c. crepitans* 3) document the breeding season of *A. c. crepitans* 4) determine the larval period and transformation time 5) determine size, dispersal, and basic dietary habits and 6) determine habitat differences in water chemistry, water temperature, and vegetation between the study sites.

Objectives 3, 4, and 5 address potential differences in *A. c. crepitans* larval period, breeding season, size, dispersal and dietary habits. Diet may vary based on geographic location, season, and habitat. Breeding season is also dependent on geographic location, habitat, and season.

The last objective is to assess variances in various aquatic and vegetative habitat types. Variation in vegetation may provide insight on reasons for occupation of specific ponds and marshes. Water quality may be used to determine if degradation has occurred in a specific area. Biological and chemical analysis is a systematic procedure that can evaluate the quality of an aquatic ecosystem. Water chemistry is a subsequent lab analysis that portrays the condition of a stream. Hardness and pH are all indicators of the health and life of a stream.
Materials and Methods

Description of Study Sites

Seven study sites were established in ponds, streams, and marshes in the eastern panhandle in West Virginia to address the study objectives. Two historical sites were chosen to observe if *A. c. crepitans* still inhabited the sites. Two non-historical sites with favorable cricket frog habitats were chosen to determine if *A. c. crepitans* inhabited the area. The last two sites were chosen because they were in the range of cricket frogs but frogs had never been recorded in the sites before. These sites were sampled from May until August of 2001. Four sites were established in Jefferson County at Lake Louise, Leetown Fish Hatchery, Altona Marsh, and Harewood Marsh. One site was located at Edward’s Run, Hampshire County, one site located in Ganotown, Berkeley County, and another site was located at a pond at Pine Valley School, Morgan County. All coordinates were provided by the Natural Resources Conservation Service.

Site 1: Lake Louise

- **Elevation:** 568 ft. (173 m)
- **Water Temperature Range:** 26º C
- **Habitat Type:** Cow pond
- **Mean Water pH:** 7.9
- **Coordinates:** N 39° 18′ 04″
  W 77° 58′ 18″
- **County:** Jefferson

Lake Louise: This site is the only historical site that had cricket frogs present in 2001. It is a cattle-drinking pond approximately 304.8 cm. wide and 536.4 cm. long located at the bottom of a hill of the Morgan residence. Refer to figures 6 and 7. In the winter, the water level ranges from 0-25.4 cm. In early spring and throughout the summer, the water level fluctuates from 0-88.9 cm. Few plant species were found in and around this pond.
Figure 6: Map showing location of Site 1 at Lake Louise, Jefferson Co., WV (modified from DeLorme 1997).
Figure 7: Photographs of Study Site 1 at Lake Louise, Jefferson Co., WV (Photos by: Kimberly Bayne)
Site 2:  Leetown Fish Hatchery

Elevation:  521 ft. (159 m)          Water Temperature Range:  19.5 °C
Habitat Type:  Ditch                    Mean Water pH:  6.4
Coordinates:  N 39°21′00″          County:  Jefferson
            W 77°55′50″

Leetown Fish Hatchery:  This site is a historical site that no longer contains favorable conditions for *A. c. crepitans*.  It is a small ditch, about 144.8 cm. long and 78.7 cm wide located near the Leetown Fish Hatchery.  Refer to figures 8 and 9.  Water depth ranges from 0-52.1 cm. The ditch dried up by June and remained dry for most of the summer.  Figure 9 shows the marshy area located behind the hatchery and behind the ditch.  Several amphibians and plant species were recorded here.

Site 3:  Altona Marsh

Elevation:  532 ft. (162 m)          Water Temperature Range:  14-21° C
Habitat Type:  Marsh                    Mean Water pH:  8
Coordinates:  N 39°17′28″          County:  Jefferson
            W 77°52′50″

Altona Marsh:  This is a historical site that is a marsh approximately 0.85 ha in size.  Refer to figures 10 and 11.  *Acris c. crepitans* no longer inhabits any areas of Altona Marsh.  Water depth fluctuates from 0-15.85 meters.  Several species of plants and amphibians/reptiles were observed and collected at this site.
Figure 8: Map showing location of Study Site 2 located at Leetown Fish Hatchery, Jefferson Co., WV (modified from DeLorme 1997).
Figure 9: Photograph of Site 2 at Leetown Fish Hatchery, Jefferson Co., WV
(Photos by: Kimberly Bayne)
Figure 10: Map showing location of Site 3 located at Altona Marsh, Jefferson Co., WV (modified from DeLorme 1997).
Figure 11: Photographs showing Study Site 3 located at Altona Marsh, Jefferson Co., WV
(Photos by: Kimberly Bayne)
Site 4:  **Harewood Marsh**

- Elevation: 567 ft. (173 m)  
  Water Temperature: 19.5-28º C
- Habitat Type: Marsh  
  Mean Water pH: 7.7
- Coordinates: N 39º18'00"  
  W 77º54'41"
  County: Jefferson

**Harewood Marsh:** This privately owned marsh has favorable conditions to support *A. c. crepitans*, but they have not been found, currently or historically. Refer to figures 12 and 13. It ranges from 5.08-54.6 cm. in depth at the time of measurement. Several amphibian and plant species inhabit the marsh.

Site 5:  **Edwards Run**

- Elevation: 835 ft. (254.6 m)  
  Water Temperature: 0-29º C
- Habitat Type: Marsh  
  Water pH: 6
- Coordinates: N 39º19'22"  
  W 78º26'05"
  County: Hampshire

**Edwards Run:** Edwards Run is a non-historical site that neither contains nor has contained *A. c. crepitans*. It is about .13 ha in size. Refer to figures 14 and 15. Water depth ranges from about 0-82.6 cm. Several species of amphibians and reptiles and plant species have been collected and observed at this marsh.
Figure 12: Map showing location of Site 4 located at Harewood Marsh, Jefferson Co., WV (modified from DeLorme 1997).
Figure 13: Photographs showing Site 4 located at Harewood Marsh, Jefferson Co., WV  
(Photos by: Kimberly Bayne)
Figure 14: Map showing location of Study Site 5 located at Edwards Run, Hampshire Co., WV (modified from DeLorme 1997).
Figure 15: Photographs showing location of Site 5 located at Edwards Run, Hampshire Co., WV
(Photos by: Kimberly Bayne)
Site 6:  Ganotown Marsh

Elevation:  483 ft. (147 m)        Water Temperature Range:  19-26º C
Habitat Type:  Marsh                Mean Water pH:  7.5
Coordinates:  N 39º25′19″        County:  Berkeley
            W 78º08′14″

Ganotown Marsh:  This marsh is approximately 45 acres in size.  Refer to
figures 16 and 17.  Water depth ranges from about 17.8 cm. in shallower areas of the
marsh to 113 cm. at the more deep ends of the marsh.  Ganotown Marsh currently has A.
c. crepitans but there are no historical records for this site.  It has favorable conditions to
support the cricket frogs.  Several plant species were collected at this site for analysis,
and several amphibian and reptile species were observed.

Site 7:  Pine Valley Pond

Elevation:  830 ft. (253 m)        Water Temperature Range:  19-26º C
Habitat Type:  Pond                 Mean Water pH:  7.4
Coordinates:  N 39º27′52″        County:  Morgan
            W 78º13′49″

Pine Valley Pond:  Pine Valley Pond is approximately 803 ft. in long and 350 ft.
wide.  Refer to figures 18 and 19.  The depth recorded at the pond ranges from 0-10 ft.
There are no previous records of A. c. crepitans inhabiting the area.  This pond is a non-
historical site with favorable conditions to support the habitat of A. c. crepitans.  Few
plant and amphibian species were collected and observed at this site.
Figure 16: Map showing location of Study Site 6 location at Ganotown, Berkeley Co., WV (modified from DeLorme 1997).
Figure 17: Photographs showing location of Site 6 at Ganotown, Berkeley Co., WV
Figure 18: Map showing location of Study Site 7 location at Pine Valley, Morgan Co., WV (modified from DeLorme 1997).
Figure 19: Photographs showing location of Site 7 at Pine Valley, Morgan Co., WV
(Photos by: Kimberly Bayne)
Biological Data Collection

To capture *A. c. crepitans*, I walked through the entire marsh/pond and listened for males calling. Males were spotlighted with flashlights and caught by hand. Females were also captured by hand. Capturing *A. c. crepitans* by hand seemed to be the most reliable method. Frogs were placed in a ziplock bag ½ full of the marsh water, taken to a more lighted area and flat surface to be measured and marked.

Measurements of adults were taken and the observations of two white tubercules located below the cloacal vent were observed. Length of the tibia, longest toe, snout length, snout-to-urostyle length, diameter of eye, diameter of tympanic membrane, width and length of cranium, length of webbing between toes, and weight of adults were taken. Measurements were taken with veriner dial calipers. Weight was acquired by weighing a small plastic bag and calibrating a spring scale to the weight of the bag. Adult frogs were then placed in the bag and weighed. All measurements were recorded to the nearest 0.1mm and 0.01g.

Froglets and larvae measurements were acquired with the same instruments. Measurements taken for froglets and larvae were the same as measurements taken for adult frogs. All reptiles and amphibians captured at each site were weighed with spring scales, and morphological measures were taken with veriner dial calipers. Reptiles and amphibians were identified to species and recorded.
Figure 20: Photograph illustrating methods of measurement
   a) spring scale  b) calipers

(Photo by Keith Johnson)
Length of tail was a measurement taken for froglets and larvae. Adult male and female frogs were placed in a container to allow amplexus and deposition of eggs. Eggs were collected with a spoon and placed in water acquired from respective sites. Egg diameter was measured daily and recorded with vernier dial calipers to the nearest 0.1mm.

To determine population sizes, adult frogs that were captured and released were marked by toe clipping with cuticle scissors (Pauley pers.comm.). Each adult was assigned a specific identification number based on the toe clipping sequence (Figure 21). Recaptures were recorded as recaptures, measured, weighed, and released. Male calling census was conducted each night upon visiting the sites. Calls were estimated in frequency of number and recorded.

Ten *A. c. crepitans* adults per site were anesthetized and dissected to remove contents in the stomach. Each stomach was emptied and contents removed and then identified. Due to prolongation of the sacrificing of the adults, limited to no stomach contents were extracted. Studies have suggested that handling the frogs and placing them in an abnormal environment slows and may even stop digestion (Johnson and Christiansen 1976).

All adult, froglet, and larvae sacrificed were anesthetized with “Baby Orajel” and fixed in 10 percent formalin. Frog eggs were preserved in a small vial filled with water and 10 percent formalin. Sacrificed specimens were deposited in the N.B. Green Museum located at Marshall University.
Figure 21: Toe Clipping Illustration
Table 1: Description of morphological measurements made on eggs, embryos, larvae, froglets, and frogs (modified from Rogers 1999).

<table>
<thead>
<tr>
<th>Character</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egg Total Length</td>
<td>Diameter of egg; including the vitellus</td>
</tr>
<tr>
<td>Embryo Total Length</td>
<td>Tip of posterior end of embryo to tip of anterior end; including vitellus</td>
</tr>
<tr>
<td>Larval Total Length</td>
<td>Straightened larva laid on its side; tip of nose to tip of tail fin</td>
</tr>
<tr>
<td>Snout-to-Urostyle Length</td>
<td>Frog laid on dorsal side; straightened back; tip of snout to posterior projection of the urostyle</td>
</tr>
<tr>
<td>Tibia Length</td>
<td>Posterior end of tibia (knee) to anterior end of tibia (heel)</td>
</tr>
<tr>
<td>Cranial Width/Length</td>
<td>Behind eyes on either side of head at widest point/ tip of snout to back of head</td>
</tr>
<tr>
<td>Longest Toe Length</td>
<td>Longest toe on hind feet</td>
</tr>
<tr>
<td>Diameter of Eye and Tympanic Membrane</td>
<td>Diameter of eye and tympanic membrane</td>
</tr>
<tr>
<td>Webbing of Toes</td>
<td>Length of webbing between hind toes</td>
</tr>
<tr>
<td>Snout Length</td>
<td>Tip of snout to below the eyes</td>
</tr>
</tbody>
</table>
**Environmental Data Collection**

Water chemistry is a subsequent lab analysis that portrays the condition of water in ponds or marshes. Hardness and pH are indicators of the health and life of a pond or marsh. A sample of water was taken each time, between 8 p.m. and 2 a.m., a site was visited. The sample of water was analyzed two times with a Hach Kit to ensure accuracy. Evaluations included: pH, carbon dioxide (mg/L), oxygen (mg/L), hardness (mg/L CacO3), iron (mg/L), sulfate (mg/L), and manganese (mg/L). Water temperature was measured with an armored thermometer to the nearest 0.5 C. Temperature was taken twice at each site to ensure accuracy. When observing environmental conditions, cloud coverage and canopy coverage measurements were taken as a percentage of clouds to clear skies and tree coverage to open space, respectively. Vegetation was collected at each site and identified to species using the *Flora of West Virginia* (Strausbaugh and Core 1978).

**Statistical Analysis**

All biological and environmental data collected were divided by site designations as follows: Harewood Marsh (Site 4), Ganotown Marsh (Site 6), Lake Louise (Site 1), Altona Marsh (Site 3), Edwards Run (Site 5), Pine Valley School (Site 7), and Leetown Fish Hatchery (Site 2). Each data set was analyzed for significant differences using various tests at the 95 percent (P<0.05) confidence level with Sigma Stat 2.0 (1997) statistical software package. Dr. Jim Hansen, a statistician, ensured the accuracy of the results of the data analyzed and provided further analysis of the data collected.
**Biological Data**

ANOVA was used to determine differences in sizes of froglets, subadults, and adult specimens. ANOVA was used to analyze snout-to-urostyle, tibia length, cranium width and length, and weight measurements. More than two life stages were compared within each data set which entails the use of ANOVA (Sokal and Rohlf 1981). Froglets, subadults, and adult specimen morphologies were compared between sites. Graphs and tables were used to illustrate the differences in morphology of different life stages and morphology of frogs within each site.

**Environmental Data**

Environmental data were grouped by sites and subjected to ANOVA to determine significant differences in habitat. ANOVA was used because more than two habitats were compared (Sokal and Rohlf 1981). A table was made to compare vegetation collected from each site to illustrate differences in habitat. ANOVA was used to compare data analyzed from water chemistry to determine significant differences from site to site.
**Results**

**Phenology and Environmental Data**

Results of the approximate number of calling males conducted from May to August of 2001 are shown in Figure 22. All collections were made from 20:00 to 02:00 hours. Table 2 display the air, water, and soil temperatures of Ganotown and Pine Valley Pond. Figures 23, 24, 25, 26, and 27 illustrate the mean soil, air, and water temperatures for sites containing *A. c. crepitans* and for sites that did not contain *A. c. crepitans*. Figures 28, 29, and 30 portrayed the mean recorded temperatures for soil, air, and water for all months. The first recorded date of calling males for Ganotown Marsh was May 20th, 2001 (n=100), and May 23rd, at the Pine Valley Pond (n=100). No calling males were observed at Lake Louise because the site was not found until August. June was the peak calling time for all sites containing *A. c. crepitans* (n=200). Calling male numbers dropped in July at both sites (n= 50-75). Approximately 25 or fewer calling males were observed in August. Few to no calling males were heard in September.

Each site was thoroughly observed after each calling census between May and September. Males were observed perching on areas along the bank and in dense vegetation. Females were observed floating in water near the calling male. No amplexing adult frogs were observed at any sites. No eggs were found attached to vegetation around calling male frogs. Amplexing adult frogs were observed however in captivity and egg deposition occurred during amplexus. Male and female frogs were placed in containers for marking, and amplexus was observed while the frogs were in captivity. Eggs were carefully placed in tupperware containers where they were measured and observed daily. It was observed that eggs were deposited in any depth of
water as long as water was present. Eggs were laid in masses of 50-200 eggs as shown in Figure 31. Incubation of eggs was approximately 8-9 days as seen in Figure 32.
Table 2: Table of soil, air and water temperatures taken at sites containing *A. c. crepitans*.

<table>
<thead>
<tr>
<th>Date</th>
<th>Ganotown Marsh</th>
<th></th>
<th>Pine Valley Pond</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Soil °C</td>
<td>Air °C</td>
<td>Water °C</td>
<td>Soil °C</td>
</tr>
<tr>
<td>5/20/2001</td>
<td>18</td>
<td>12.5</td>
<td>19</td>
<td>*</td>
</tr>
<tr>
<td>5/23/2001</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>19</td>
</tr>
<tr>
<td>5/25/2001</td>
<td>18</td>
<td>13.5</td>
<td>19</td>
<td>*</td>
</tr>
<tr>
<td>5/29/2001</td>
<td>27</td>
<td>22</td>
<td>28</td>
<td>*</td>
</tr>
<tr>
<td>5/30/2001</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>19</td>
</tr>
<tr>
<td>5/31/2001</td>
<td>20</td>
<td>12</td>
<td>21</td>
<td>*</td>
</tr>
<tr>
<td>6/12/2001</td>
<td>24</td>
<td>20</td>
<td>25</td>
<td>*</td>
</tr>
<tr>
<td>6/16/2001</td>
<td>23</td>
<td>21</td>
<td>26</td>
<td>*</td>
</tr>
<tr>
<td>6/17/2001</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>21</td>
</tr>
<tr>
<td>6/29/2001</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>24</td>
</tr>
<tr>
<td>7/6/2001</td>
<td>21</td>
<td>17</td>
<td>23</td>
<td>*</td>
</tr>
<tr>
<td>7/14/2001</td>
<td>23</td>
<td>23</td>
<td>25</td>
<td>*</td>
</tr>
<tr>
<td>7/19/2001</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>23</td>
</tr>
<tr>
<td>7/27/2001</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>22</td>
</tr>
<tr>
<td>8/8/2001</td>
<td>19</td>
<td>17</td>
<td>19</td>
<td>*</td>
</tr>
<tr>
<td>8/9/2001</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>21</td>
</tr>
<tr>
<td>8/20/2001</td>
<td>18</td>
<td>16</td>
<td>18</td>
<td>20</td>
</tr>
<tr>
<td>9/13/2001</td>
<td>17</td>
<td>12</td>
<td>18</td>
<td>19</td>
</tr>
</tbody>
</table>

* Indicates no temperature taken; measurements were taken on different dates due to distance between sites.
Figure 22: Approximate Number of Calling Males from May to August 2001
Figure 23: May temperatures (mean) for soil, water, and air for sites with *A.c.crepitans* and sites without *A.c.crepitans*.
Figure 24: June temperatures (mean) for soil, water, and air for sites with *A.c.crepitans* and sites without *A.c.crepitans*
Figure 25: July temperatures (mean) for soil, water, and air for sites with *A.c.crepitans* and sites without *A.c.crepitans*
Figure 26: August temperatures (mean) for soil, water, and air for sites with *A.c.crepitans* and sites without *A.c.crepitans*
Figure 27: September temperatures (mean) for soil, water, and air for sites with \textit{A.c.crepitans} and sites without \textit{A.c.crepitans}
Figure 28: Mean Soil Temperatures for sites with *A.c.crepitans* and sites without *A.c.crepitans*
Figure 29: Mean Air Temperatures for sites with *A.c.crepitans* and sites without *A.c.crepitans*
Figure 30: Mean Water Temperatures for sites with \textit{A.c.crepitans} and sites without \textit{A.c.crepitans}
Figure 31: Photograph of *A. c. crepitans* collected egg mass in a Petri Dish

(Photo by Keith Johnson)
Figure 32: Incubation period of *A. c. crepitans* eggs
Vegetation was collected near and around all sites observed. These sites included two historical sites that no longer contained *A. c. crepitans*, two sites that had favorable conditions to support frogs but did not contain them, two new sites that had frogs, and one historical site that had frogs. Table 3 shows the several plant species identified from each site.

Table 4 illustrates all parameters of water chemistry tested: hardness (mg/L), pH (H⁺ conc.), dissolved oxygen (mg/L), acidity (mg/L), and carbon dioxide (mg/L) for all study sites. There was a significant difference in all water chemistry data except for dissolved oxygen as shown in Table 4. Table 4 displays all sites and all water chemistry by grouping each similarity with specific letters. As seen in Table 4, there was no significant difference in acidity and dissolved oxygen mean values. Table 4 illustrates each sites’ categories labeled by letters A,B,C. The same letters have statistically equivalent average levels of the constituent. The mean water pH for each site is illustrated in Figure 33. Figure 34 exhibits the mean dissolved oxygen for sites with *A.c. crepitans* and for sites without *A.c. crepitans*. Figure 35 and 36 display the mean values for carbon dioxide and hardness. No acidity graph was illustrated because all values were the same for each site.
Table 3: Identified plant Genus/Species collected at sample sites

<table>
<thead>
<tr>
<th>Family Name</th>
<th>Genus/Species</th>
<th>Harewood Marsh</th>
<th>Leetown Fish Hatchery</th>
<th>Ganotown Marsh</th>
<th>Pine Valley Pond</th>
<th>Lake Louise</th>
<th>Edward's Run</th>
<th>Altona Marsh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aceraceae</td>
<td><em>Acer rubrum</em></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graminae</td>
<td><em>Agrostis alba</em></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carylaceae</td>
<td><em>Alnus serrulata</em></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amaranthaceae</td>
<td><em>Amaranthus spinosus</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><em>X</em></td>
</tr>
<tr>
<td>Rosaceae</td>
<td><em>Amelanchier arborea</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primulaceae</td>
<td><em>Anagallis arvensis</em></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graminae</td>
<td><em>Andropogon scoparius</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Asclepiadaceae</td>
<td><em>Asclepia syriaca</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asclepiadaceae</td>
<td><em>Asclepias incarnata</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><em>X</em></td>
</tr>
<tr>
<td>Compositae</td>
<td><em>Bidens frondosa</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Urticaceae</td>
<td><em>Boehmeria cylindrica</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Graminae</td>
<td><em>Bromus commutatus</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Cruciferae</td>
<td><em>Cardamine sp.</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Cyperaceae</td>
<td><em>Carex comosa</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Cyperaceae</td>
<td><em>Carex frankii</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Cyperaceae</td>
<td><em>Carex scoparia</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Cyperaceae</td>
<td><em>Carex sp.</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Cyperaceae</td>
<td><em>Carex squarrosa</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Cyperaceae</td>
<td><em>Carex stipata</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Cyperaceae</td>
<td><em>Carex tribuloides</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Leguminosae</td>
<td><em>Cassia hebecarpia</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rubiaceae</td>
<td><em>Cephalanthus occidentalis</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Caryophyllaceae</td>
<td><em>Cerastium nutans</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><em>X</em></td>
</tr>
<tr>
<td>Leguminosae</td>
<td><em>Cercis canadensis</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Compositae</td>
<td><em>Cichorium intybus</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Santalaceae</td>
<td><em>Comandra umbellata</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cornaceae</td>
<td><em>Comus amomum</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Cyperaceae</td>
<td><em>Cyperus strigosus</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><em>X</em></td>
</tr>
</tbody>
</table>
Table 3 (cont.)

<table>
<thead>
<tr>
<th>Family Name</th>
<th>Genus/Species</th>
<th>Harewood Marsh</th>
<th>Leetown Fish Hatchery</th>
<th>Ganotown Marsh</th>
<th>Pine Valley Pond</th>
<th>Lake Louise</th>
<th>Edward's Run</th>
<th>Altona Marsh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Umbelliferae</td>
<td>Daucus carota</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dipsacaceae</td>
<td>Dipsacus sylvestris</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gramineae</td>
<td>Echinochloa crusgalli</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Thymelaeaceae</td>
<td>Elaeagnus umbellata</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cyperaceae</td>
<td>Eleocharis obtusa</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Equisetaceae</td>
<td>Equisetum arvense</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Compositae</td>
<td>Erigeron strigosus</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compositae</td>
<td>Eupatorium fistulosum</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Compositae</td>
<td>Eupatorium perfoliatum</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Compositae</td>
<td>Eupatorium pubescens</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compositae</td>
<td>Eupatorium purpureum</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Rubiaceae</td>
<td>Galium tinctorium</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Malvaceae</td>
<td>Hibiscus moscheutos</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Rubiaceae</td>
<td>Houstonia caerulea</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Rubiaceae</td>
<td>Houstonia longifolia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Balsaminaceae</td>
<td>Impatiens capensis</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Juglandaceae</td>
<td>Juglans nigra</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Juncaceae</td>
<td>Juncus acuminatus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Juncaceae</td>
<td>Juncus effusus</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Juncaceae</td>
<td>Juncus tenuis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Cupressaceae</td>
<td>Juniperus virginiana</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Acanthaceae</td>
<td>Justicia americana</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Compositae</td>
<td>Latuca sp.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Scrophulariaceae</td>
<td>Linaria vulgaris</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Lauraceae</td>
<td>Lindera benzoin</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Scrophulariaceae</td>
<td>Lindernia dubia</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Labiatae</td>
<td>Mentha piperita</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>
Table 3 (cont.)

<table>
<thead>
<tr>
<th>Family Name</th>
<th>Genus/Species</th>
<th>Harewood Marsh</th>
<th>Leetown Fish Hatchery</th>
<th>Ganotown Marsh</th>
<th>Pine Valley Pond</th>
<th>Lake Louise</th>
<th>Edward's Run</th>
<th>Altona Marsh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caprifoliaceae</td>
<td>Lonicera tatarica</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Onagraceae</td>
<td>Ludwigia palustris</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ericaceae</td>
<td>Lyonia ligustrina</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scrophulariaceae</td>
<td>Mimulus alatus</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scrophulariaceae</td>
<td>Mimulus ringens</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Scrophulariaceae</td>
<td>Mimulus ringens x alatus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Labiatae</td>
<td>Monarda clinopodia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Boraginaceae</td>
<td>Myosotis laxa</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Polypodiaceae</td>
<td>Onoclea sensibilis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Graminae</td>
<td>Panicum capillare</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Graminae</td>
<td>Panicum clandestinum</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Graminae</td>
<td>Panicum lanuginosum</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Graminae</td>
<td>Paspalum laeve</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Scrophulariaceae</td>
<td>Penstemon digitalis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Hydrophyllaceae</td>
<td>Phacelia dubia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Polemoniaceae</td>
<td>Phlox maculata</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Pinaceae</td>
<td>Pinus rigida</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Platanaceae</td>
<td>Platanus occidentalis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Polygonaceae</td>
<td>Polygonum hydropiperoides</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Polygonaceae</td>
<td>Polygonum pensylvanicum</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Polygonaceae</td>
<td>Polygonum punctatum</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Labiatae</td>
<td>Pycnanthemum flexuosum</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Anacardiaceae</td>
<td>Rhus radicans</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rosaceae</td>
<td>Rosa multiflora</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Rosaceae</td>
<td>Rosa palustris</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Rosaceae</td>
<td>Rubus sp.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Alismalaceae</td>
<td>Sagittaria latifolia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

55
Table 3 (cont.)

<table>
<thead>
<tr>
<th>Family Name</th>
<th>Genus/Species</th>
<th>Harewood Marsh</th>
<th>Leetown Fish Hatchery</th>
<th>Ganotown Marsh</th>
<th>Pine Valley Pond</th>
<th>Lake Louise</th>
<th>Edward's Run</th>
<th>Altona Marsh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salicaceae</td>
<td>Salix babylonica</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salicaceae</td>
<td>Salix nigra</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cyperaceae</td>
<td>Scirpus atrovirens</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cyperaceae</td>
<td>Scirpus cyperinus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Graminae</td>
<td>Setaria glauca</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solanaceae</td>
<td>Solanum carolinense</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solanaceae</td>
<td>Solanum dulcamara</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Compositae</td>
<td>Solidago canadensis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Compositae</td>
<td>Solidago flexicaulis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compositae</td>
<td>Solidago juncea</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Sparganiaceae</td>
<td>Sparganium americanum</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Graminae</td>
<td>Sphenopholis obtusata</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Orchidaceae</td>
<td>Spiranthes cernua</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Rosaceae</td>
<td>Spirea latifolia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graminae</td>
<td>Triodea flava</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Typhaceae</td>
<td>Typha latifolia</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Urticaceae</td>
<td>Uniola dioica</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Valerianaceae</td>
<td>Valerianella locusta</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Verbenaceae</td>
<td>Verbena hastata</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Verbenaceae</td>
<td>Verbena urticifolia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Compositae</td>
<td>Verbesina alternifolia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Compositae</td>
<td>Verbesina occidentalis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Scrophulariaceae</td>
<td>Veronica serpyllifolia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Caprifoliae</td>
<td>Vibumum recognitum</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Vitaceae</td>
<td>Vitis sp.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>
Table 4: Significant difference of mean values by grouped similar sites

<table>
<thead>
<tr>
<th></th>
<th>ALTONA</th>
<th>EDWARDS</th>
<th>GANO</th>
<th>HAREWOOD</th>
<th>LEE</th>
<th>LOUISE</th>
<th>PINE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acidity</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>pH</td>
<td>A</td>
<td>B</td>
<td>A</td>
<td>A</td>
<td>B</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Dissolved Oxygen</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Carbon Dioxide</td>
<td>A</td>
<td>C</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>Hardness</td>
<td>B</td>
<td>C</td>
<td>C</td>
<td>A</td>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
</tbody>
</table>

* Counties with the same letter have statistically equivalent average levels of the constituent (Jim Hansen 2002)
Figure 33: The mean pH for sites with *A. c. crepitans* and for sites without *A. c. crepitans*

<table>
<thead>
<tr>
<th>pH (H+ conc.)</th>
<th>Sites w/ Frogs</th>
<th>Sites w/out Frogs</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**F-Test**

*p-value* = 0.00

*pH*

* p-value is the Type I error for an ANOVA F-test of equality of means
Figure 34: The mean Dissolved Oxygen for sites with *A. c. crepitans* and for sites without *A. c. crepitans*

<table>
<thead>
<tr>
<th>Sites w/ Frogs</th>
<th>Sites w/ out Frogs</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.5</td>
<td>13.2</td>
</tr>
<tr>
<td>14</td>
<td>13</td>
</tr>
<tr>
<td>13.5</td>
<td>13</td>
</tr>
<tr>
<td>13</td>
<td>12.5</td>
</tr>
<tr>
<td>12.5</td>
<td>12</td>
</tr>
</tbody>
</table>

**Mean Dissolved Oxygen**

F-Test

\[
p\text{-value} = 0.00
\]

Dissolved Oxygen

* p-value is the Type I error for an ANOVA F-test of equality of means
Figure 35: The mean Carbon Dioxide for sites with *A. c. crepitans* and for sites without *A. c. crepitans*

<table>
<thead>
<tr>
<th>Sites</th>
<th>Concentration (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sites w/ Frogs</td>
<td>10</td>
</tr>
<tr>
<td>Sites w/ out Frogs</td>
<td>25</td>
</tr>
</tbody>
</table>

**F-Test**

<table>
<thead>
<tr>
<th>p-value*</th>
<th>Carbon Dioxide</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td></td>
</tr>
</tbody>
</table>

* p-value is the Type I error for an ANOVA F-test of equality of means
Figure 36: The mean Hardness for sites with *A. c. crepitans* and for sites without *
*A. c. crepitans* 

<table>
<thead>
<tr>
<th>Concentration (mg/L)</th>
<th>Sites w/ Frogs</th>
<th>Sites w/out Frogs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sites w/ Frogs</td>
<td>Sites w/out Frogs</td>
</tr>
<tr>
<td></td>
<td>Sites w/ Frogs</td>
<td>Sites w/out Frogs</td>
</tr>
</tbody>
</table>

F-Test

p-value*

0.00 Hardness

*p-value is the Type I error for an ANOVA F-test of equality of means*
Adult Data

Adult males were first heard and seen in May. Adults were collected at only 2 sites, Ganotown Marsh (n=56) and Pine Valley Pond (n= 16). Lake Louise was found in the later part of the summer so the collection of adults and subadults was not made. Figures 37, 38, 39, 40, 41 and 42 show the mean measurements of tibia, snout, head length and width, longest toe, eye diameter, webbing between toes, snout-to-urostyle, weight, and tympanic membrane diameter lengths. Figure 37 shows that there was a significant difference in head width, webbing between toes, and longest toe length between adult frogs from Ganotown and Pine Valley. Figure 38 shows that there was a significant difference in tibia lengths, head lengths and snout lengths between the two sites containing A. c. crepitans adults. Figure 39 shows that there was a significant difference in snout-to-urostyle length. Figure 40 shows that there was a significant difference in tympanic membranes of adults between the two sites. Figures 41 and 42 displays that there was no significant difference in weight or eye diameter between the adults at both sites.

Figure 43 and 44 indicate that there were no significant differences in body measurements of males (n=51) and females (n=2) at Ganotown. Figure 45 shows all the significantly different body measurements between the males (n= 15) and females (n= 1). Figures 45, 46 and 47 illustrate that there were no significant differences in weight (g), longest toe length, length of webbing between toes, and head length between males and females at Pine Valley Pond.
Figure 37: Significantly different mean head widths, longest toe lengths, and webbing lengths of adults

Mean Head Width, Longest Toe, and Webbing Length of Adults

- Head W = Head Width
- Longest Toe = Longest Toe Length
- Webbing = Webbing Between Toe Lengths

T-Test

<table>
<thead>
<tr>
<th>p-value*</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.000</td>
<td>Head W</td>
</tr>
<tr>
<td></td>
<td>Longest Toe</td>
</tr>
<tr>
<td>0.006</td>
<td>Toe</td>
</tr>
<tr>
<td>0.000</td>
<td>Webbing</td>
</tr>
</tbody>
</table>
Figure 38: Significantly different mean tibia, snout, and head lengths of adults

**Mean Tibia, Snout, and Head Length of Adults**

<table>
<thead>
<tr>
<th>Measurements Taken</th>
<th>GANO</th>
<th>PINE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tibia</td>
<td>6.50</td>
<td>5.50</td>
</tr>
<tr>
<td>Snout</td>
<td>3.20</td>
<td>2.80</td>
</tr>
<tr>
<td>Head L</td>
<td>8.00</td>
<td>7.00</td>
</tr>
</tbody>
</table>

*Tibia = Tibia Length
*Snout = Snout Length
*Head L = Head Length

**T-Test**

<table>
<thead>
<tr>
<th>p-value*</th>
<th>Measurements Taken</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.000</td>
<td>Tibia</td>
</tr>
<tr>
<td>0.000</td>
<td>Snout</td>
</tr>
<tr>
<td>0.003</td>
<td>Head L</td>
</tr>
</tbody>
</table>
Figure 39: Significantly different mean snout-to-vent lengths for adults

* SUL = Snout-to-Urostyle Length

<table>
<thead>
<tr>
<th>Sites</th>
<th>Lengths (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GANO</td>
<td>22.00</td>
</tr>
<tr>
<td>PINE</td>
<td>21.20</td>
</tr>
</tbody>
</table>

T-Test

<table>
<thead>
<tr>
<th>p-value*</th>
<th>SUL</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.000</td>
<td></td>
</tr>
</tbody>
</table>
Figure 40: Significantly different mean tympanic membrane lengths for adults

* Tympanic = Tympanic Membrane Diameter

T-Test

p-value* 0.002  Tympanic
Figure 41: Mean eye diameter measurements for adults
Figure 42: Mean weight of adults at Ganotown and Pine Valley

<table>
<thead>
<tr>
<th></th>
<th>Mean Weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GANO</td>
<td>1.17</td>
</tr>
<tr>
<td>PINE</td>
<td>1.24</td>
</tr>
</tbody>
</table>
Figure 43: Body measurements of adult males and females at Ganotown

<table>
<thead>
<tr>
<th>Measurements Taken</th>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUL</td>
<td>0.433</td>
<td>0.529</td>
</tr>
<tr>
<td>Eye</td>
<td>0.282</td>
<td>0.433</td>
</tr>
<tr>
<td>Snout</td>
<td>0.894</td>
<td>0.974</td>
</tr>
<tr>
<td>Head W</td>
<td>0.974</td>
<td>0.974</td>
</tr>
<tr>
<td>Webbing</td>
<td>0.974</td>
<td>0.974</td>
</tr>
</tbody>
</table>

T-Test

p-value

0.529  SUL
0.433  Eye
0.282  Snout
0.894  Head W
0.974  Webbing
Figure 44: Adult male vs. female mean weights (g) at Ganotown

<table>
<thead>
<tr>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Weight (g)</td>
<td>1.10</td>
</tr>
</tbody>
</table>
Figure 45: Significantly different body measurements adult males and females at Pine Valley

<table>
<thead>
<tr>
<th>Measurements Taken</th>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUL</td>
<td>0.000</td>
<td>SUL</td>
</tr>
<tr>
<td>Tympanic</td>
<td>0.010</td>
<td>Tympanic</td>
</tr>
<tr>
<td>Eye</td>
<td>0.000</td>
<td>Eye</td>
</tr>
<tr>
<td>Tibia</td>
<td>0.025</td>
<td>Tibia</td>
</tr>
<tr>
<td>Snout</td>
<td>0.040</td>
<td>Snout</td>
</tr>
<tr>
<td>Head W</td>
<td>0.020</td>
<td>Head W</td>
</tr>
</tbody>
</table>
Figure 46: Body measurements of adult males and females at Pine Valley

Adult Male vs. Female Mean Measurements at Pine Valley

<table>
<thead>
<tr>
<th>Measurements Taken</th>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Longest Toe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Webbing</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

T-Test

<table>
<thead>
<tr>
<th>p-value*</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.230</td>
<td>Head L</td>
</tr>
<tr>
<td>0.694</td>
<td>Longest Toe</td>
</tr>
<tr>
<td>0.847</td>
<td>Webbing</td>
</tr>
</tbody>
</table>
Figure 47: Adult male vs. female mean weights (g) at Pine Valley

<table>
<thead>
<tr>
<th></th>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Weight (g)</td>
<td>1.30</td>
<td>1.24</td>
</tr>
</tbody>
</table>
**Subadult Data**

Subadults were collected at two sites, Ganotown Marsh (n=12) and Pine Valley Pond (n=39). The first subadult collected at Ganotown was on May 29\(^{th}\), 2001 and on June 17\(^{th}\), 2001 at Pine Valley. Figures 48, 49, 50, and 51 show the mean measurements of tibia, snout, head length and width, longest toe, eye diameter, webbing between toes, snout-to-urostyle, weight, and tympanic membrane diameter lengths. Figure 48 shows that there was a significant difference in head width, webbing between toes, and longest toe length between subadult frogs from Ganotown and Pine Valley. Figure 49 show that there was a significant difference in SUL, snout, and tympanic membrane diameter lengths. Figure 50 shows that there was no significant difference in eye diameter, tibia length and head lengths. Figure 51 display that there was no significant difference in weight between the subadults at Ganotown Marsh and Pine Valley Pond.

Two females and 10 male subadults were collected at Ganotown. Figure 52 shows the difference in mean values for tympanic membrane diameter between sexes at Ganotown. Figures 53 and 54 show that there were no significant differences in weight or other body measurements between the sexes.

Three females and 36 male subadults were collected at Pine Valley Pond. Figures 55 and 56 illustrate that there were no significant differences in weight (g), longest toe length, length of webbing between toes, and head length.

**Froglet Data**

Froglets were collected at 3 sites, Ganotown Marsh (n=7) on July 6\(^{th}\), 2001, Lake Louise (n=8) on July 15\(^{th}\), 2001, and Pine Valley Pond (n=12) on July 19\(^{th}\), 2001. Figures 57 and 58 show the significantly different mean measurements of all froglets at
Ganotown, Pine Valley, and Lake Louise. Figure 59 shows that there was not a significant difference in tail length, eye diameter, and snout length in froglets from Ganotown, Lake Louise and Pine Valley.

Two larvae were collected at Ganotown and 2 at Pine Valley were all collected on July 15th, 2001. Two larvae were collected on August 6th, 2001 at Lake Louise. As seen in Figure 60, there were no significant differences represented in p-values between the larvae collected except for head length. Figures 61 and 62 shows that there were no significant differences in weight or other body measurements between the larvae collected.
Figure 48: Significantly different mean head width, longest toe length, and webbing length of subadults

Mean Head Width, Longest Toe, and Webbing of Subadults

* Head W = Head Width
* Longest Toe = Longest Toe Length
* Webbing = Webbing Between Toe Lengths

**T-Test**

<table>
<thead>
<tr>
<th>p-value*</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.011</td>
<td>Head W</td>
</tr>
<tr>
<td>0.010</td>
<td>Longest Toe</td>
</tr>
<tr>
<td>0.003</td>
<td>Webbing</td>
</tr>
</tbody>
</table>
Figure 49: Significantly different mean SUL, snout, and tympanic membrane lengths of subadults

Mean SUL, Tympanic, and Snout of Subadults

Measurements Taken

- **SUL** = Snout-to-Urostyle
- **Snout** = Snout Length
- **Tympanic** = Tympanic Membrane Diameter

**T-Test**

<table>
<thead>
<tr>
<th>p-value</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.002</td>
<td>SUL</td>
</tr>
<tr>
<td>0.002</td>
<td>Tympanic</td>
</tr>
<tr>
<td>0.004</td>
<td>Snout</td>
</tr>
</tbody>
</table>
Figure 50: Mean tibia, eye diameter and head length measurements for subadults

<table>
<thead>
<tr>
<th>Lengths (mm)</th>
<th>GANO</th>
<th>PINE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tibia</td>
<td>6.0</td>
<td>6.0</td>
</tr>
<tr>
<td>Eye</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Head L</td>
<td>8.0</td>
<td>8.0</td>
</tr>
</tbody>
</table>

T-Test

<table>
<thead>
<tr>
<th>p-value*</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.676</td>
<td>Tibia</td>
</tr>
<tr>
<td>0.751</td>
<td>Eye</td>
</tr>
<tr>
<td>0.141</td>
<td>Head L</td>
</tr>
</tbody>
</table>

* Tibia = Tibia Length
* Head L = Head Length
* Eye = Eye Diameter
Figure 51: Mean weight of subadults at Ganotown and Pine Valley

![Mean Weight (g) of Subadults at Ganotown and Pine Valley](image)

<table>
<thead>
<tr>
<th></th>
<th>GANO (1.13)</th>
<th>PINE (1.17)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Weight (g)</td>
<td>1.13</td>
<td>1.17</td>
</tr>
</tbody>
</table>
Figure 52: Significantly different body measurements of subadult males and females at Ganotown

Mean Tympanic Membrane Lengths

<table>
<thead>
<tr>
<th>Lengths (mm)</th>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.60</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

T-Test

p-value* 0.001 Tympanic
Figure 53: Body measurements of subadult males and females at Ganotown

Male vs. Female measurements at Ganotown

<table>
<thead>
<tr>
<th>Measurements Taken</th>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUL</td>
<td>25.00</td>
<td>20.00</td>
</tr>
<tr>
<td>Eye</td>
<td>5.00</td>
<td>4.00</td>
</tr>
<tr>
<td>Tibia</td>
<td>10.00</td>
<td>8.00</td>
</tr>
<tr>
<td>Snout</td>
<td>15.00</td>
<td>13.00</td>
</tr>
<tr>
<td>Head L</td>
<td>20.00</td>
<td>18.00</td>
</tr>
<tr>
<td>Head W</td>
<td>25.00</td>
<td>22.00</td>
</tr>
<tr>
<td>Longest Toe</td>
<td>30.00</td>
<td>28.00</td>
</tr>
<tr>
<td>Webbing</td>
<td>35.00</td>
<td>33.00</td>
</tr>
</tbody>
</table>

T-Test

<table>
<thead>
<tr>
<th>p-value*</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.628</td>
<td>SUL</td>
</tr>
<tr>
<td>0.436</td>
<td>Eye</td>
</tr>
<tr>
<td>0.294</td>
<td>Tibia</td>
</tr>
<tr>
<td>0.331</td>
<td>Snout</td>
</tr>
<tr>
<td>0.884</td>
<td>Head L</td>
</tr>
<tr>
<td>0.169</td>
<td>Head W</td>
</tr>
<tr>
<td></td>
<td>Longest Toe</td>
</tr>
<tr>
<td>0.223</td>
<td>Toe</td>
</tr>
<tr>
<td>0.830</td>
<td>Webbing</td>
</tr>
</tbody>
</table>
Figure 54: Subadult male vs. female mean weights (g) at Ganotown

Male vs. Female Mean Weight (g)

<table>
<thead>
<tr>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.11</td>
<td>1.13</td>
</tr>
<tr>
<td>1.12</td>
<td></td>
</tr>
<tr>
<td>1.13</td>
<td>1.15</td>
</tr>
<tr>
<td>1.14</td>
<td></td>
</tr>
<tr>
<td>1.15</td>
<td></td>
</tr>
<tr>
<td>1.16</td>
<td></td>
</tr>
</tbody>
</table>
Figure 55: Body measurements of subadult males and females at Pine Valley

T-Test

<table>
<thead>
<tr>
<th>p-value*</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.319</td>
<td>SUL</td>
</tr>
<tr>
<td>0.306</td>
<td>Tympanic</td>
</tr>
<tr>
<td>0.331</td>
<td>Eye</td>
</tr>
<tr>
<td>0.208</td>
<td>Tibia</td>
</tr>
<tr>
<td>0.267</td>
<td>Snout</td>
</tr>
<tr>
<td>0.193</td>
<td>Head L</td>
</tr>
<tr>
<td>0.745</td>
<td>Head W</td>
</tr>
<tr>
<td>0.247</td>
<td>Longest Toe</td>
</tr>
<tr>
<td>0.243</td>
<td>Webbing</td>
</tr>
</tbody>
</table>
Figure 56: Subadult male vs. female mean weights (g) at Pine Valley

Mean Weight (g) of males and females

<table>
<thead>
<tr>
<th></th>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.11</td>
<td>1.17</td>
<td>1.17</td>
</tr>
</tbody>
</table>

Weight (g)
Figure 57: Significantly different mean body measurements of froglets

<table>
<thead>
<tr>
<th>Measurements Taken</th>
<th>GANO</th>
<th>LOUISE</th>
<th>PINE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tympanic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tibia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Head L</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Head W</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Longest Toe</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Webbing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anal warts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SUL</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

F-Test

<table>
<thead>
<tr>
<th>p-value*</th>
<th>Measurements Taken</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.000</td>
<td>Tympanic</td>
</tr>
<tr>
<td>0.000</td>
<td>Tibia</td>
</tr>
<tr>
<td>0.000</td>
<td>Head L</td>
</tr>
<tr>
<td>0.000</td>
<td>Head W</td>
</tr>
<tr>
<td>0.000</td>
<td>Longest Toe</td>
</tr>
<tr>
<td>0.010</td>
<td>Webbing</td>
</tr>
<tr>
<td>0.025</td>
<td>Anal Warts</td>
</tr>
<tr>
<td>0.001</td>
<td>SUL</td>
</tr>
</tbody>
</table>
Figure 58: Significantly different weight (g) of froglets

<table>
<thead>
<tr>
<th>Site</th>
<th>Weight (g)</th>
<th>F-Test</th>
<th>p-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>GANO</td>
<td>0.35</td>
<td></td>
<td>0.038</td>
</tr>
<tr>
<td>LOUISE</td>
<td>0.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PINE</td>
<td>0.30</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 59: Mean body measurements of froglets

Mean Body Measurements of Froglets

<table>
<thead>
<tr>
<th>Sites</th>
<th>Eye</th>
<th>Snout</th>
<th>Tail</th>
</tr>
</thead>
<tbody>
<tr>
<td>GANO</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LOUISE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PINE</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

F-Test

<table>
<thead>
<tr>
<th>p-value*</th>
<th>Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.052</td>
<td>Eye</td>
</tr>
<tr>
<td>0.574</td>
<td>Snout</td>
</tr>
<tr>
<td>0.237</td>
<td>Tail</td>
</tr>
</tbody>
</table>
Figure 60: Significantly different head lengths of larvae

Significantly Different Head Lengths for Larvae by Site

F-Test

p-value*

0.049  Head L
Figure 61: Mean body measurements of larvae

Mean Body Measurements of Larvae

<table>
<thead>
<tr>
<th>Measurements Taken</th>
<th>GANO</th>
<th>LOUISE</th>
<th>PINE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUL</td>
<td>12.00</td>
<td>12.00</td>
<td>12.00</td>
</tr>
<tr>
<td>Tail</td>
<td>10.00</td>
<td>10.00</td>
<td>10.00</td>
</tr>
<tr>
<td>Tympanic</td>
<td>8.00</td>
<td>8.00</td>
<td>8.00</td>
</tr>
<tr>
<td>Eye</td>
<td>6.00</td>
<td>6.00</td>
<td>6.00</td>
</tr>
<tr>
<td>Tibia</td>
<td>4.00</td>
<td>4.00</td>
<td>4.00</td>
</tr>
<tr>
<td>Snout</td>
<td>2.00</td>
<td>2.00</td>
<td>2.00</td>
</tr>
<tr>
<td>Head Width</td>
<td>2.00</td>
<td>2.00</td>
<td>2.00</td>
</tr>
<tr>
<td>Longest Toe</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Webbing</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>

F-Test

<table>
<thead>
<tr>
<th>p-value*</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.705</td>
<td>SUL</td>
</tr>
<tr>
<td>0.942</td>
<td>Tail</td>
</tr>
<tr>
<td>0.075</td>
<td>Tympanic</td>
</tr>
<tr>
<td>0.609</td>
<td>Eye</td>
</tr>
<tr>
<td>0.830</td>
<td>Tibia</td>
</tr>
<tr>
<td>0.356</td>
<td>Snout</td>
</tr>
<tr>
<td>0.734</td>
<td>Head W</td>
</tr>
<tr>
<td>0.465</td>
<td>Longest</td>
</tr>
<tr>
<td></td>
<td>Toe</td>
</tr>
<tr>
<td></td>
<td>Webbing</td>
</tr>
</tbody>
</table>


Figure 62: Mean weight (g) of larvae

![Mean Weight(g) of Larvae](image)

<table>
<thead>
<tr>
<th>Sites</th>
<th>Weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GANO</td>
<td>0.15</td>
</tr>
<tr>
<td>LOUISE</td>
<td>0.30</td>
</tr>
<tr>
<td>PINE</td>
<td>0.25</td>
</tr>
</tbody>
</table>

F-Test

<table>
<thead>
<tr>
<th>p-value*</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.771</td>
<td></td>
</tr>
</tbody>
</table>
Discussion

Biological Data

The first objective of this study was to determine distribution of *Acris c. crepitans* in West Virginia. In West Virginia, Green and Pauley (1987) reported occurrences only in the Eastern Panhandle (Berkeley, Jefferson, Morgan, Mineral, and Hampshire counties). Of all historical sites where *A. c. crepitans* had previously been reported, only Lake Louise (Jefferson County) still had cricket frogs. Two new sites, Ganotown Marsh (Berkeley County) and Pine Valley Pond (Morgan County), were discovered and observed to have suitable habitats to support *A. c. crepitans*. *Acris c. crepitans* were found on mats of algae, along shorelines, and in aquatic vegetation at Ganotown Marsh and Pine Valley Pond.

The second objective of this study was to determine reasons for the restricted range of *A. c. crepitans*. Habitat degradation is undoubtedly the largest single factor contributing to amphibian declines (Lanoo 1998). The predator community might exert an influence on amphibian distributions along fragmentation gradients (Gibbs 1998). The ponds and marsh in this study had a small community of predators. The site at Lake Louise was a small cow pond in a pasture surrounded by various grasses in an open area. Lake Louise, a semi-pond/lake habitat, was approximately 100 feet from the small cow pond containing *A. c. crepitans*. Predators such as small rodents, turtles, other frogs, snakes, and fish were observed in the Lake Louise area. Ganotown Marsh, a 45-acre area, contained small rodents, snakes, fish, turtles, birds, and other frogs. *Acris c. crepitans* existed along the shoreline at Pine Valley Pond. Woody debris was restricted to the middle areas of the pond thus restricting turtle basking to be drawn away from the
edges of the pond. The pond is not stocked each year with fish, so limited numbers of fish inhabit the pond. *Acris c. crepitans* has a low freezing tolerance and a low tolerance of hypoxia (Irwin, et al. 1999). This information further supports that *A. c. crepitans* could not survive in the more mountainous regions of West Virginia. It is because of the lack of sufficient solar exposure that it could not survive the pass through the mountains. Cool temperatures in the more mountainous areas can not support *A. c. crepitans*. It is known that mountainous areas of West Virginia (north of Charleston and south of the Eastern Panhandle) are cooler in water, soil, and air temperatures. The range of *Acris c crepitans* lies within the Ridge and Valley section of West Virginia (Green and Pauley 1987). *Acris c. crepitans* would have to cross the Allegheny Mountains to inhabit all portions of the state. The lower temperature and presence of permanent water would inhibit further distribution of *A. c. crepitans*. The average temperature in the Allegheny Mountains is 49.4 °F (9.7°C) and is 52.8°F (11.5°C) in the Ridge and Valley province (U.S. Department of Commerce 1973). “The annual precipitation in the Allegheny Mountains is 53.8 inches (136.6 cm) and 36.6 inches (93.0 cm) in the Ridge and Valley Province (U.S. Department of Commerce 1973).” “The most common features of all *Acris* habitat observed is the presence of permanent water (at the site or nearby) and large amount of solar exposure” (Lipps 2000). Historical sites once containing cricket frogs were overgrown with tall vegetation and several trees. Observed sites that had suitable conditions, except for solar exposure, that could contain *A. c. crepitans* were shady and crowded with trees. Sites containing *A. c. crepitans* were clear open areas with solar exposure. Parts of West Virginia that are inhabitable by *A. c. crepitans* are bordered by mountains, making passage difficult for them. Although hibernating frogs were not
observed, it has been noted in literature that *A. c. crepitans* hibernate in terrestrial sites such as in cracks of soil of the pond bank (Walker 1946; Gray 1971) and logs (Neill 1948). The third objective was to document the breeding season of *A. c. crepitans*. Males emerge from hibernation in mid-March although their chorus is not heard until April or May (Green and Pauley 1987). Cricket frogs remain in the breeding area until the onset of unfavorable weather unlike other frogs which vacate the breeding area after reproduction (Green and Pauley 1987). May 20 was the first observed calling of males at Ganotown Marsh. May 23 was the first observed calling of males at Pine Valley Pond. As the temperature increased, the number of calling males increased as well as the tempo of the calls. Males and females were observed perched along shorelines and aquatic vegetation. There was no observed evidence of defensive territorialism. Frogs were heard calling within a few inches of one another on several occasions (Pyburn 1958). Peak calling was observed in June and decreased each month, ceasing in September.

The fourth objective was to determine the larval period and transformation time of *A. c. crepitans*. Deposition of eggs occurred during amplexus. No eggs were seen and found in the observed marsh and ponds. However, when in captivity, eggs were deposited by amplexing frogs in ziploc bags and plastic containers in any amount of water present. Masses of 50-100 eggs were laid. Depending on temperature, incubation of eggs was 8-9 days as seen in Figure 32. Larval development generally requires from 5 to 10 weeks (Burkett 1969). Larval growth and metamorphosis is in part affected by temperature and other environmental factors (Breven, Gill, and Smith-Gill 1979). Larval development was observed to last between 5-14 weeks depending on the air and water temperature of the captive frogs, in agreement with Burkett in 1969. Transformation into
frogs takes about 2 days (Wright and Wright 1942). The life span averages about four months.

The fifth objective was to determine size, dispersal, and basic dietary habits of adults, subadults, froglets, and larvae. It was concluded by Jameson (1947) that stomach contents of *A. crepitans* consisted mainly of aquatic insects many of which were bottom dwellers. Major food items include dipterons, formicids, collembolons, and coleopterons (Labanick 1976). *Acris* also feed on carnivorous and phytophagous arthropods, which means that the economic impact of their feeding habits would vary widely with changing ecological conditions (Johnson and Christiansen 1976). Due to prolongation of euthanize specimens, stomach contents were able to pass very quickly and therefore were impossible to collect once returned to the lab. There is an indication that handling the frogs and placing them in an abnormal environment slows and may even stop digestion (Johnson and Christiansen 1976).

Male *A. c. crepitans* typically stay within the same area all season, as shown by recapture of marked males. Following rains and in mild, humid weather, they dispersed in all directions; movements of more than 100 meters were not uncommon. Rainfall cannot account for long movements alone; relative humidity, temperature conditions and breeding activity are also important (Burkett 1984). During heavy rains and high humidity males that were recaptured were found within 20 feet from their original capture area.

Eggs were laid in clumps in masses of 50-75 eggs. Egg diameters ranged from 2 mm on day 1 to 4 mm on day 8. The incubation period lasts approximately 8-10 days. The rapid incubation period and large number of eggs produced allow for several new
populations of *A. c. crepitans* to emerge. Tadpoles emerged approximately on day 9-12. The only significantly different measurement between all three sites was the head length. Larvae collected from Pine Valley proved to have a longer head length than Ganotown and Lake Louise. “Size in *Acris* seems to increase primarily in response to increasingly arid environments” (Nevo 1973). Pine Valley is an open area with very few trees, shrubs, or vegetation used for coverage while Ganotown and Lake Louise contained more shrubs, grasses, and trees.

Ganotown froglets were larger in size than those from Pine Valley and Lake Louise. Weight, snout-to-urostyle length, tibia length, tympanic membrane diameter, head length and width, and longest toe length were significantly different between the three sites’ froglets. Ganotown froglets were larger in weight and length in comparison to Lake Louise and Pine Valley froglets. This may be due to availability of food, dietary habits, and temperature. Body size may be directly influenced by temperature and humidity (Nevo 1973). Mean air, soil, and water temperatures were warmer for Ganotown.

Ganotown subadults were significantly larger in all measurements compared to those measured at Pine Valley. Females were significantly smaller in size compared to subadult males, but weighed more than subadult males. This observation occurred at both sites. Lake Louise was discovered too late to yield subadults for collection and study.

The data exhibit a significant difference in length between the webbing of the toes, snout-to-urostyle length, tibia length, tympanic membrane diameter, head length and width, and longest toe length, between adults collected from Ganotown and Pine Valley.
No Lake Louise specimens were collected. Adults collected from Ganotown were larger in size than those from Pine Valley. At Ganotown adult females were smaller than the males while at Pine Valley the females were larger than the adult males. In general, females weighed more than adult males. This may be due to gravid conditions of the females. There is no sound explanation for the differences in size between the two sites. “Body size may be directly selected as an adaptive character by a complex of environmental factors involving, among others, temperature, humidity, habitat, food supply, competitors, and disease” (Nevo 1973).

**Environmental Data**

The final objective of this study was to determine the habitat differences in water chemistry, water temperature, and vegetation between the study sites. Table 3 lists all identified species of plants and trees collected at historical sites and new sites. The only significant difference between cricket frog sites and sites that no longer contained or never contained cricket frogs is that there are more species of trees. This supports the hypothesis that *A. c. crepitans* require sufficient solar exposure.

Hardness and pH are two indicators of the health and life of a pond or marsh. A pH of approximately 7 S.U., carbon dioxide content of 9-20 (mg/L), and a hardness level of 3-22 (mg/L) were the preferred range and set the common trend for the substantial quality of life for sites that contained *A. c. crepitans* in this study. Although water pH never fell below 6.0 standard units, some trends were observed. The pH values at Altona, Ganotown, Harewood, Lake Louise, and Pine Valley were significantly higher and were within the preferred range compared to those at Leetown and Edward’s Run. Altona Marsh’s carbon dioxide level was significantly higher than those of the other sites (p-
value = 0.00) and out of the preferred content range (9-20 mg/L). The hardness level at Edward’s Run, Ganotown, Lake Louise, and Pine Valley was within the preferred range.

May marked the beginning of the breeding season of *A. c. crepitans*. The latter part of June and early July were the warmest periods, and the peak of the breeding season. Several larval developments were observed within this time period. Late August and early September very few males were heard calling. Air and water temperatures began to drop in these two months. Fewer larvae were observed developing and transformation completely ceased by September.
Summary

All historical sites, sites that previously had documented to have *A. c. crepitans*, were observed. Lake Louise (Jefferson County) was the only historical site that still contains cricket frogs. Two new sites, Ganotown Marsh (Berkeley County) and Pine Valley Pond (Morgan County), were discovered and found to have suitable habitats to support *A. c. crepitans*.

*Acris c. crepitans* is generally found in warm areas with lots of solar exposure. The sites containing *A. c. crepitans* did not have much canopy cover. They were also low in predators and if several predators were inhabiting the area there was a balanced amount of prey (fish, other frogs, and insects) to help limit predation of *A. c. crepitans*. The range restriction may be due to low solar exposure and cooler climates of the more mountainous region of West Virginia.

Breeding activity is affected by soil, air, and water temperatures. Calling males were observed in the later part of May and heard throughout all sites until August. No calling males were heard in the month of September. Peak temperatures ranges were in the months of June and July corresponding to the peak of male calling. Amplexus takes place so long as some amount of water is present, and egg deposition occurs during amplexus. There are 50-400 eggs laid, and incubation lasts approximately 8-9 days. Larval development was observed to last between 5-14 weeks depending on the air and water temperature of the captive frogs. Four months is the average life span of *A. c. crepitans*. 
Stomach contents could not be collected because of the delay in euthanization of the frogs. *Acris c. crepitans* generally stay within 20 feet to 100 yards of their original area. No territorialism was observed by either males or females.

Larval sizes were generally the same in length and weight for Lake Louise, Pine Valley, and Ganotown. Ganotown froglets were larger in length and weight compared to those collected at Pine Valley and Lake Louise. Subadults collected at Ganotown were larger in length and weight compared to those measured at Pine Valley. Males and females at both sites were approximately the same length and weight. Adult frogs measured at Ganotown were larger in length and weight than those at Pine Valley. Only at Pine Valley were males typically larger than females.

Vegetation collected all sites were typically the same except for the amount of tree and canopy coverage in sites with no *A. c. crepitans*. Sites with cricket frogs generally had reduced tree and canopy coverage. Hardness, pH, and carbon dioxide were within the same range for each site containing *A. c. crepitans*.
Literature Cited


Websites:
