1-1-2002

The Natural History and Possible Extirpation of Blanchard's Cricket Frog, Acris crepitans blanchardi, in West Virginia

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THE NATURAL HISTORY AND POSSIBLE EXTIRPATION OF BLANCHARD'S CRICKET FROG, *ACRIS CREPITANS BLANCHARDI*, IN WEST VIRGINIA.

Thesis submitted to
The Graduate College of
Marshall University

In partial fulfillment of the
Requirements for the degree of
Master of Science
Program

by

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Huntington, West Virginia
April 2002

ABSTRACT
"THE NATURAL HISTORY AND POSSIBLE EXTIRPATION OF BLANCHARD'S CRICKET FROG, ACRIS CREPITANS BLANCHARDI, IN WEST VIRGINIA "

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Blanchard's Cricket Frogs, *Acris crepitans blanchardi*, historically occurred in Clay, Mason, Putnam, and Wayne counties of West Virginia. It has been since 1948 that a specimen was collected from these counties or any other in this state. The first objective of this study was to gather natural history information on *A. c. blanchardi* based on a population in Lawrence County, Ohio. The second objective of this study was to determine if *A. c. blanchardi* has been extirpated from West Virginia. The third objective was to determine differences between historical, potential, and current population sites based on vegetation sampling, predators, water chemistry, and environmental parameters including ultraviolet light penetration, relative humidity and air, soil, and water temperatures.

ACKNOWLEDGMENTS

I wish to thank a very long list of people. Most importantly I wish to thank my advisor, Dr. Thomas K. Pauley, for the opportunity to do this work under his guidance. Also, I wish to thank him for his patience with my endless questions about my work and in what direction I should take the study. There are very few people in this world that can tolerate a person like myself that loses or drops most of the equipment they use. I wish to thank my remaining committee members, Dr. Strait and Dr. Somerville, for entertaining dozens of my questions during the last few crazy weeks of writing my thesis. I would also like to thank the following professors at Marshall University for their assistance and advice: Dr. Dan K. Evans, Dr. Protip Ghosh, Dr. Tom Jones, and Dr. Donald Tarter. Everyone who helped me during the course of my study has been very accommodating and helpful when I showed up at their door, usually unannounced, with a notebook page full of questions. I wish to also thank Dr. Val Beasley and Jean Bettridge from the University of Illinois at Urbana-Champaign for providing me with literature from previous studies, Jeffrey G. Davis of the Ohio Biological Survey for his knowledge of Blanchard's Cricket Frogs, and Kathy Flegel of Wayne National Forest. I would like to thank Jessica Wooten for being my personal interlibrary loan system and statistician for the two months it took me to write my thesis. Thanks to the 2002 gang in 310 for their support and tolerating my impatience when I was typing away on, and usually hogging, the good computer in our lab. Thanks to my granny, Ruby Foster, for not being hard enough on me as a child when I brought her pocketfuls of frogs from her pond. If she had actually succeeded in making me believe they would give me warts, I may not have ended up studying one in college. Thanks to my mother who is always willing to listen to me ramble about my work even though she doesn't understand things like "pitfall traps" and "GPS units". Of course, I can't leave out my cats, Cricket and Lucy, who tried desperately to keep me from typing my thesis by standing in front of the monitor or sprawling across the keyboard. I would like to thank my uncle, Dan Shinn, and my aunt, Nancy Newton, for their support and encouragement while I have been a graduate student at Marshall University. My greatest support during this work has been my boyfriend, Keith Johnson. We have had our ups and downs over the last five years, but nothing has compared to this trying time over the last few months while I have been writing this manuscript and completing my degree. I can't begin to thank him for helping me through this. Finally, I would like to thank my financial supporters for this project: West Virginia Non Game Heritage Program, Wayne National Forest (USDA), and the Ohio Biological Survey.

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LIST OF SYMBOLS / NOMENCLATURE

Amplexus - In ampibians, the sexual clasp of the female by the male.

Cloaca - The common chamber into which intestinal, urinary, and reproductive ducts discharge their contents.

Sympatric - A term applied to two or more populations that occupy identical or broadly overlapping geographical areas.

Urostyle - In toads and frogs, a rod-like bone formed by several fused vertebrae that makes up the lower part of the vertebral column.

CHAPTER 1. Introduction

Background

Acris crepitans blanchardi, Blanchard's Cricket Frogs (Figure 1.1) are members of the family *Hylidae* and subfamily *Hylinae*. The genus *Acris* was first described by Dumeril and Bibron in 1841 and the species was described by Baird 1954 (Frost 1985). Type species are not listed for these frogs. There are several type localities listed, including the "northern states" with restriction in Albany County, New York, and the "Potomac River at Harper's Ferry, West Virginia" (Frost 1985).

They are one of the smallest frogs found in West Virginia. A shared morphological feature of the members of *Hylidae* is the presence of toe discs used for grasping while climbing. However, toe discs of *A. c. blanchardi* are not as distinct as in other members of the family. The toe discs of this frog are scarcely wider than the toes (Dundee and Rossman 1989) and as a result these frogs are poor climbers. Unlike many Hylids, the larval stage of *A. c. blanchardi* attains a size much greater in length than that of the adult stage (Green and Pauley 1987). *Acris c. blanchardi* has been found to be one of the most aquatic members of *Hylidae* in North America.

Description

The distinctive features of these frogs include a dark triangle-shaped area between the eyes, a longitudinal dark stripe along the rear surface of the thighs, and extensive webbing between the toes of the hind feet. Webbing of the hind toes is extensive, extending to the next to the last joint of the longest toe and to the tip of the first toe (Green and Pauley 1987). Johnson (2000) includes a series of light and dark bars along the upper jaw as a distinct characteristic for these frogs. Unlike other members of the family, *A. c. blanchardi* has a pair of white tubercles below the cloacal vent (Green and Pauley 1987).

The dorsal side is usually dull brown in color, scattered with warts, and may or may not have a green, red, or gray stripe extending from the eyes to the urostyle. The dorsal side of *A. c. blanchardi* is rougher than the skin of all other cricket frogs (Garret and Barker 1987). Pyburn's study (1958) of the color stripe revealed that the relationship was not complex and followed Mendelian traits: red and green are dominant to gray. He concluded that the relationship between the red and green stripe is not clear. In a later study (Pyburn 1961), the number of frogs with a stripe of any color was found to exhibit a seasonal variation. These findings suggest the vegetation color and bare mud at different times of the year play a role in the selection of the different colored and patterned morphs. Figure 1.2 shows the three color morphs of these frogs found during the course of my study.

Blanchard's Cricket Frogs are a comparatively small treefrog, reaching no more than 38 mm snout to urostyle length (SUL) in adults (Green and Pauley 1987). As with many other amphibians, female Blanchard's Cricket Frogs are usually larger than males (Pough et al. 1998). The ventral side is white in males and females, although during the breeding season the chin of males may become yellowish (Collins 1974) and throughout the year is scattered with dark spots (Green and Pauley 1987).

The calls of Blanchard's Cricket Frogs are very distinct. It resembles the sound of rapidly clicking together pebbles (Conant and Collins 1998) and begins at a rate of about one call per second, gradually increases, and finally tapers off again (Garret and Barker 1987). Males begin nightly chorusing before sunset and continue until 0200 or 0300 EST (Perrill and Sheperd 1989).

Distribution

Blanchard's Cricket Frogs are found from Michigan and Ohio to northern Tennessee, westward to eastern Colorado and New Mexico (Green and Pauley 1987). (Figure 1.3). In West Virginia, which is the eastern extreme of the frog's range, it was reported from Clay, Mason, Putnam, and Wayne counties along the Ohio River (Figure 1.4). However, there are voucher specimens from only Mason, Putnam, and Wayne counties in the West Virginia Biological Survey (WVBS) at Marshall University. The first *A. c. blanchardi* was collected for the West Virginia Biological Survey in 1939 and the last specimen in 1948.

Although it as been since 1948 that Blanchard's Cricket Frogs were collected in West Virginia, there are abundant populations in Lawrence County, Ohio. The last location a specimen was collected in West Virginia was a farm pond in Mason County referred to as McCullough's Pond (Gilbert et al. 1941) in 1948. When my study began in July 2000, the closest current population to this historical site in Mason County was Lake Lawco in Lawrence County, Ohio. This population is less than 19 km west of the last place in West Virginia where the frog was found. Figure 1.5 indicates the proximity of the historical population to the current population.

Natural History

Blanchard's Cricket Frogs can be found in many aquatic habitats including ponds, lakes, streams, and floodplain pools (Mount 1975). It most often occurs along the muddy or sandy edges of lakes and ponds. This frog emerges in the spring after hibernation and breeding occurs around lakes, ponds, marshes, roadside ditches, rain pools, springs, and streams (Collins 1974).

The breeding season for *A. c. blanchardi* depends on the location, which begins earlier in the southern ends of the range. Females deposit up to 400 eggs. Eggs hatch in a few days and larvae metamorphose five to ten weeks after hatching occurs (Green and Pauley 1987). After the growing season, Blanchard's Cricket Frogs hibernate terrestrially (Bayless 1966, Gray 1971) and the cycle begins again with emergence in the spring.

My study had three main objectives. First, to gather natural history information on the frogs based on the populations found in Lawrence County, Ohio. Second, to determine if the subspecies has been extirpated from West Virginia. Third, to establish any differences in habitat between the historical sites of West Virginia to current populations and potential habitat sites of the frogs in Ohio. Chapter 1 is an introduction to Blanchard's Cricket Frogs. Chapter 2 includes natural history information based on the populations found in Lawrence County, Ohio. Chapter 3 contains information on the diet of Blanchard's Cricket Frogs. Chapter 4 is the determination of extirpation of the frogs from West Virginia and the current geographic range of the frog in Ohio. Chapter 5 includes data collected to establish differences between historical sites of *Acris c. blanchardi* in Mason County, West Virginia and current populations and potential sites in Lawrence County, Ohio

Description of Study Sites

Six study sites were chosen for this project: 2 in Mason County, West Virginia, and 4 in Lawrence County, Ohio. Sites in Mason County were chosen for their historical populations. Both sites in West Virginia are found in Mason County on the Apple Grove USGS Quadrangle. Of the 4 sites chosen in Lawrence County, Ohio, 2 are locations that have potential habitat for the frogs, but they do not occur at those sites, and 2 sites are where the frogs occur. The sites were chosen based on calling frog and toad surveys I have conducted in Lawrence County since the spring of 1999 for the Ohio Biological Survey (OBS). I have been surveying all 4 study sites in Ohio since that time, and based the selection of the ponds for my study on the results of these surveys. The 4 sites chosen in Ohio are all found in Lawrence County on the Pedro USGS Quadrangle. Figure 1.6 shows the location of all sites. The aspect of all sites of the study is flat. Complete descriptions of all sites are listed below.

<u>Site 1: McCullough' Pond</u> (Figure 1.7)
Elevation: 170 meters
General Description: Farm pond/Open field

Frogs historically occurred at Site 1. This is a farm pond referred to as McCullough's Pond (Gilbert et al. 1941) and is the first and last place the frog was collected for the West Virginia Biological Survey (WVBS). The pond is located 0.47 km north of Ashton. Sixteen Mile Creek flows 0.63 km north of Ashton and Eighteen Mile Creek flows 0.63 km south of the town. Both creeks are tributaries of the Ohio River. At some point in geological time, Sixteen Mile Creek was a tributary of Eighteen Mile Creek, but a natural event changed the course of Sixteen Mile Creek (Gilbert et al. 1941). The course of the former creek bed can be viewed by standing on County Road 41 and looking north across what are now cultivated fields. There are currently 3 ponds that lay in what was once the creek bed of Sixteen Mile Creek. McCullough's pond is the largest of these three. The pond is located 0.15 km east of State Route 2. The pond is slightly L-shaped and just under 1 m at its greatest depth. The longest point of the pond is 61 m and widest point is 22 m. The pond is currently surrounded by 2/3 corn and 1/3 tobacco. Waste from cattle farming also drains into the pond.

Site 2: Plant Pond (Figure 1.8)
Elevation: 164 meters
General Description: Farm pond/Deciduous forest

Site 2 was chosen as a historical population site in my study. It is also a farm pond near State Route 2. It is located 1.0 km NE of site 1. There is a lack of precise location for the collection sites of *A.c. blanchardi* in the West Virginia Biological Survey and therefore a second historical site could not be located with complete certainty. Site 2 was chosen for several reasons. First, it is close to Site 1; it is within the same flood plain of the Ohio River. Second, the habitats would have been similar and both locations have the plant, *Hottonia inflata,* or American Featherfoil. This plant has been found at only two locations within the state of West Virginia: McCullough's Pond (Gilbert et al. 1941) and this pond (Dr. Dan K. Evans personal communication). The earliest record of the plant in the Marshall University Herbarium is 1994 (*Hottonia inflata*: West Virginia. Mason County: 10 May 1994. Dan K. Evans #3834). The pond is located 1 km west of State Route 2 and 0.3 km east of the Ohio River. The pond is surrounded on all sides by deciduous forest. Corn fields border the woods surrounding this pond, but the fields are a minimum of 16 m away from the pond. However, the field is uphill from the pond, and drainage from the field flows down to the pond. Maximum water depth is in excess of 2 m and the site measures 124 m x 28 m at its extremes**.**

Site 3: Route 522 Pond (Figure 1.9)
Elevation: 183 meters
General description: Private pond/Open hillside

Site 3 was chosen as a site with potential habitat for Blanchard's Cricket Frogs. This is a private pond on State Route 522 located 0.5 km east of the intersection of State Route 522 and State Route 650. It is located 20 m southeast of State Route 522. The pond does not have any overhanging vegetation and is egg-shaped. The pond measures 21 m x 43 m at its extremes and the maximum water depth is nearly 2 m.

Site 4 State Route 93 Pond (Figure 1.10)
Elevation: 183 feet
General description: Public fishing pond/Mixed deciduous forest

Site 4 was chosen as a potential site for Blanchard's Cricket Frogs. This is a pond within the boundaries of Wayne National Forest. There are many open and sunny gravel or sandy areas along the banks, which are areas where *A.c. blanchardi* prefers to spend time (Johnson 2000). The pond is surrounded by lush vegetation and many large trees grow along the edges, providing shaded areas. It is located 0.06 km west of State Route 93, 0.31 km northeast of the intersection of State Route 93 and State Route 522. The pond measures 83 m x 23 m at its extremes and maximum water depth is 2 m.

Site 5: Church Pond (Figure 1.11)
Elevation: 177 meters
General description: Beaver pond/Mixed deciduous forest

Blanchard's Cricket Frogs occur at this site. This site is located behind Pleasant Valley Church on County Road 27, 0.75 km east of the intersection with State Route 650. It is also within the boundaries of Wayne National Forest. Blanchard's Cricket Frogs were heard here in 1999 and 2000 in full chorus both years. I am told by members of the church that the original dam creating this pond originated from beaver activity around 20 years ago. Since that time a man-made dam, reinforced with large rock, has been constructed approximately 30 m downstream of the first pool created by the beavers. I concentrated my study on this second pool created by the addition of the rock dam. This pond is surrounded on 2 sides, the east and the west, by lush vegetation. The northern edge of the pond is made up of the original beaver dam and the south side is the reinforced rock dam, which is covered with thick briars. The pond measures 21 m x 27 m at its extremes and maximum water depth is 0.8 m.

Site 6: Lawco Lake (Figure 1.12)
Elevation: 183 meters
General Description: Fishing lake/Open land

Site 6 is also a current population of Blanchard's Cricket Frogs. This is a private fishing lake within the boundaries of Wayne National Forest. *Acris c. blanchardi* was recorded here in full chorus in 1999 and 2000. The lake is of considerable size, spanning 0.31 km along State Route 522. The lake is 42 m at its greatest width and nearly 3 m at the greatest depth. *Acris c. blanchardi* occurs on the northern tip of the lake in a large area of dense cattails. This area measures 31 m x 32 m and frogs have been found throughout the area. Standing water within this area is scarce, but when stepping through it one sinks nearly to the knees in wet mud. The lake is located 0.63 km northwest of the intersection of State Route 522 and State Route 93.

CHAPTER 2. Natural History

Introduction

Blanchard's Cricket Frogs occur in a variety of habitats. They can be found on the sandy edges of shallow ponds with abundant emergent vegetation or along the sunny banks of a stream (Garrett and Barker 1987). *Acris c. blanchardi* is not commonly found in temporary pools. They also avoid areas with thick, vegetation that is close to the ground surface (Mount 1975). Burkett (1969) noted that this species avoided deep water. Fitch (1958) stated that the frog will move great distances away from the water in wet and dry weather conditions, and that many of these wandering frogs die as a result. *Acris c. blanchardi* spends its time on the ground (Dundee and Rossman 1989) where it remains active among the vegetation of the shoreline (Garrett and Barker 1987). It is active during the day in the spring and fall, but is active day and night during the warmer weather (Green and Pauley 1987).

Frogs avoid predators by a series of quick, erratic hops into or out of the vegetation (Johnson 2000). *Acris c. blanchardi* is able to leap great distances, up to 1 m, to avoid predation (Dundee and Rossman 1989). Often when startled, the frog will jump into the water, only to quickly return to the shore nearby. (Stebbins and Cohen 1995) (Figure 2.1).

Malformations have been reported for frogs in the United States, including Northern Leopard frogs (Helgen et al. 1998), the Pacific treefrog (Sessions 1999), and Blanchard's Cricket Frogs (Smith and Powell 1983, Beasley et al. in press).

Wells (1977) described two different types of reproductive patterns in anurans: explosive and prolonged breeders. Blanchard's Cricket Frogs are a prolonged breeder. Anurans which breed in this manner depend less on seasonal precipitation and, as a result, the breeding season may last several months. Males, which outnumber females, reach the breeding site before females and they select and defend areas. Males advertise their position to females by continuous calling from the shore or from mats of floating vegetation (Perrill and Shepherd 1989). According to Wells (1977) females will arrive at the breeding site at irregular intervals throughout the course of the breeding season. Female cricket frogs use calls of males as a basis for choosing a mate (Ryan and Wilczynski 1988, Ryan et al. 1992).

Breeding in Blanchard's Cricket Frogs takes place in the same manner as many other anurans. After emergence in the spring, males begin calling at the breeding site to attract a female. Chorusing by males is stimulated by warm air and water temperatures (Johnson 2000). Males climb onto the back of the receptive females and clasp them in a posture referred to as amplexus. In this position, males are able to release sperm onto the eggs as they are extruded from females (Stebbins and Cohen 1995).

Perrill and Magier (1988) found that non-calling males could breed successfully. In this study, satellite males were defined as non-calling males within 50 cm of calling males. Satellite males intercepted females as they approached calling males. Satellite males amplexed females and all attempts of calling males, even butting, failed to remove satellite males from females. Interception of females by satellite males has also been observed in the green treefrog, *Hyla cinerea* (Perrill et. al 1978). There are two advantages to being satellite males that breeds successfully. First, males expend much less energy by not chorusing with other males. Second, males are less likely to become a food item for another animal, such as the American Bullfrog, because they are less conspicuous to predators (Perrill and Magier 1988).

Acris crepitans (Blanchard's and the Eastern Cricket Frog) and *Acris gryllus*, the Southern Cricket Frog, are sympatric throughout the southeastern United States (Conant and Collins 1998). Studies by Nevo (1969) and Capranica (1972) have indicated that the females of the two species preferentially respond to the breeding calls of their same species. Capranica et al. (1973) showed that mating calls of *Acris crepitans* and *Acris gryllus* are not only species specific, but are also geographically specific. This was accomplished by exposing females to a recording of males from their own population and a recording of males from different areas simultaneously. Females responded to recordings of males from their own population, but not to the call of males from different populations.

Many anurans utilize one call to attract females and a different call to ward off rival males (Wells 1977). *Acris c. blanchardi* uses the same call for both purposes (Wagner 1989). Perrill and Shepherd (1989) suggested that some males are site specific. Territoriality in males was studied by Burmeister et al. (1999) and Wagner (1989). In the study by Burmeister (1999), a recording of calling males was played within 30 cm of calling males in Travis County, Texas. Although some males abandoned their calling site or ceased calling while the recording played, many males approached the speaker and performed the stereotypical aggressive action of leg extensions in the direction of the speaker. Other males also climbed on and around the speaker in search of the intruding male.

Location determines the breeding season for *Acris c. blanchardi*. It begins as early as February in Texas (Garrett and Barker 1987) or as late as mid May in Wisconsin (Robert Hay, personal communication). Females deposit between 250 and 400 eggs (Dundee and Rossman 1989, Green and Pauley 1987). Eggs are laid singly or in clusters up to 7 eggs attached to submerged vegetation (Johnson 2000) or sink to the bottom where they hatch in 3-4 days (Collins 1974). Mount (1975) states that some eggs have also been discovered floating on the water surface. Based on finding gravid females from April to July, Burkett (1969, 1984) suggested that females may breed twice during the breeding season. In contrast to Burkett's (1969, 1984) findings, Brenner (1969) came to the conclusion that the young-of-the-year must overwinter before becoming sexually mature. Pyburn (1961) also found a population of Blanchard's Cricket Frogs breeding in the fall in Texas. Frogs which were breeding hatched earlier that spring.

Larvae metamorphose 5to 10 weeks after hatching. Tadpoles of Blanchard's Cricket Frogs are secretive and solitary. They have a district black-tipped tail (Collins 1974) that may be broken off, assisting the tadpole in predator avoidance (Johnson 2000). Larvae of *Acris c. blanchardi* attain a much greater size in proportion to the metamorphosed frog than do other tadpoles (Green and Pauley 1987). These tadpoles can reach a total length of 40-50 cm, however, newly transformed frogs measure around 15 mm (Matson 2000).

Burkett (1984) stated the average life span of adult Blanchard's Cricket Frogs is four months. Approximately 5% of the population survives the winter and these are mostly juveniles, which transformed in the late months of the season. Burkett also estimated that complete population turnover occurs in about 16 months.

It has been suggested by Bayless (1966), Gray (1971), and Irwin et al. (1999) that Blanchard's Cricket Frogs hibernate in terrestrial refugia. In central Illinois, Gray (1971) discovered frogs congregating in cracks and crevices on the banks of a pond in late October. Stomping on the cracks with his feet motivated frogs to emerge. In one instance, 166 frogs were produced from a single crack. By December, persistent stomping failed to produce any frogs. Blair (1951) discovered 15 juveniles in a cave in January of 1951 in Oklahoma. He reported that frogs were moderately active and must have migrated "some distance" to overwinter in the cave. This species remains active year round in the southern part of its range where winters remain mild (Gray 1971, Mount 1975).

Parasites have been reported in Blanchard's Cricket Frogs from several states including Ohio (Odlaug 1954), Arkansas (McAllister and Trauth 1995), Kansas (Burkett 1984), and Illinois (Beasley et al. in press).

Two populations (Sites 5 and 6) were chosen in Ohio to be studied for natural history information. Gathering information proved too difficult at Site 6, Lawco Lake. This area is privately owned by a fishing club and I had to become a member of the club in order to carry out my work on the property, but I my presence was frequently questioned by other members. After this continued for the first month of the study, I abandoned my attempts to work at Lawco Lake because I spent more time answering questions than gathering data. Therefore, all natural history data reported from this work was collected from Site 5.

Methods and Materials

<u>Morphology</u>

Frogs were captured from Site 5 between March and December of 2001 by walking along the edge of the site and trapping them in an aquarium net when they abandoned their positions. Frogs were recorded as male, female, or juvenile. During each capture the following measurements were taken: cranial width, weight, snout-to-urostyle length, and tibia length. All frogs were held in hand while length measurements were taken to the nearest 0.1 mm using vernier calipers according to procedures in Table 2.1**.** Weight measurements were taken by weighing a sealable sandwich bag with a

Pesola 5 gram scale. The frog was then placed in the bag and the weight of the frog determined by subtracting the weight of the bag from the reading on the scale. Nonparametric Mann-Whitney Rank Sum Test was used to compare cranial width, weight, SUL, and tibia length between females and males.

Activity

Frogs were observed from March to December 2001 during both day and night times. The site was visited a minimum of one day per week, but usually 2 or 3 per week. The focus of their activity was spring emergence, daily activity during changing seasons, and their return to hibernation with the onset of cold weather. I began visiting the site on a regular basis during early March. Presence of frogs in the early part of the season was noted by walking the edge of the site and watching for any movement in the vegetation or water. This method was again used at the end of the season when males stopped calling. During the mid season, I observed their activity by sitting on the banks of the site or moving as close to an individual as possible. At night, I was able to observe frogs by taping red plastic wrap over a flashlight as this lighting did not seem to disturb them.

Population size and movement

A total of 236 frogs was tagged with a visible implant fluorescent elastomer from Northwest Marine Technology (www.nmtinc.com). The latex was injected between the skin and the largest muscle of the hind leg on the dorsal side with a 0.3 cc syringe (Figure 2.2). This is a near-liquid substance when injected, but hardens within one day if kept at room temperature. Even after the material has hardened it is still very workable and does not impede the movement of the frog. Heyer et al. (1994) warns of the dangers of marking animals with fluorescent pigments because this may make the individual more noticeable to predators. However, the implant used in my study is not visible to the unaided eye (Figure 2.3) and is visible only under black light (Figure 2.4). This aspect of the marking technique does not increase the chance of predation on the frogs. The amount of latex injected into each frog measured about 1 mm in diameter. I used 3 colors, red, yellow, and orange. Elastomer combinations were injected at two positions, the posterior and anterior ends of the femur. This resulted in four possible locations for elastomer. Figure 2.5 illustrates possible locations for elastomer injections. Using the 3 color combinations in this manner allowed for marking 264 animals. This method allows frogs to be marked with an individual number and avoids the negative effects of the toe-clipping method (Clarke 1972). This method of tagging was previously used for marking small anurans (Schlaepfer 1998) as well as climbing and aquatic salamanders (Longenecker 2000, Waldron 2000, Felix 2001). Jolly-Seber method (Heyer et al. 1994) was the intended method to be used for population estimate.

Movement of individuals within the population was also recorded. This was only applied to animals captured on land. When each frog was captured, a small piece of plastic was placed on the ground where the frog had been initially observed. The piece of plastic was numbered with a permanent marker. The number on the plastic corresponded to the number of the frog caught at that spot. A toothpick was then driven through the center of the plastic to mark the spot of the frog’s capture. Superglue was used to anchor the plastic label to the toothpick so the plastic would not blow away. Figure 2.6 shows the spot marked for the original capture of frog Number 1. When an individual was recaptured, the distance between the initial point of capture and the recapture point was measured.

Breeding and development

Times that frogs mated were determined by the presence of amplexed pairs at the site. The number of pairs was recorded and attempts were made to allow frogs to remain amplexed while they were measured and tagged with the elastomer. For obvious reasons, the frogs were separated briefly for weight measurements. When an amplexed pair was discovered a small metal rod with a flag attached to the tip was placed at the location in the water where the pair was first observed. The distance from the rod to the shoreline was recorded.

Boxes (50 x 50 x 20 cm) for observation of larval growth were constructed of 2 x 2 inch pieces of wood which were enclosed with screen. Boxes could only be opened through a lid which was positioned on the top of the box. Lids were made of screen to allow penetration of sun rays. A pick was used to dig a small trench on the bank of the site so the box could be positioned in a way that 75% of the area within the box was water and 25% of the area within the box was occupied by the shore (Figure 2.7).

Two clusters of 3 and 6 eggs attached to vegetation were found at the site during my study. After eggs were found, they were moved to the observation boxes where development could be monitored. When a clutch was found, each egg was measured and one egg was added to each box so there would be no confusion of the specimens. All measurements of eggs and tadpoles were taken to the nearest 0.1 mm with vernier calipers according to procedures described in Tables 2.2 and 2.3. Tadpoles were monitored from the larval stage until their emergence from the water onto land. Key larval developments included in my study were the presence of back legs, appearance of front legs, and completed development of front legs. Individuals were considered froglets when their tails were completely absorbed and were no longer visible. After tails were reabsorbed, the boxes were reversed so that only 25% was in the water and 75% was on land. A lid was fastened to the top of the box to avoid predation and escape of the juveniles. Small holes (5 cm^2) were cut in the screen to allow prey items to enter the enclosure. Juvenile growth was recorded for 2 months before frogs were released. Juveniles were measured according to procedures described in Table 2.1.

Parasites

Ten frogs (5 males, 5 females) were dissected for the purpose of determination of internal parasites. Frogs were killed by pithing. Digestive tracts were removed and stomachs were separated from the intestines and the latter were placed in a small glass Petri dishes filled 3 mm high with distilled water. Parasites were captured with pipets as they escaped from the digestive track into the water. Parasites were identified by Dr. James E. Joy of Marshall University.

Malformations

All captured frogs were examined for any malformations of the body. Anomalies were recorded and photographed with a digital camera.

Results

Morphology

Width of the cranium is significantly wider (P = <0.001) in females than males (Figure 2.8). Females weigh significantly (P = <0.001) more than males (Figure 2.9). The SUL length is significantly (P = <0.001) longer in females than in males (Figure 2.10). Females also have a significantly (P = <0.001) longer tibia than males (Figure 2.11). Table 2.4 shows averages of measurements taken for males, females, and juveniles.

Activity

First frogs captured during my study were a male and a juvenile on 27 March. Females were not captured until 10 April. One male was heard calling on 16 April and about one dozen were heard on 23 April. On 8 May a full chorus was heard at the site. Calls were heard only during the daytime until 29 April when they began to call at night as well. Day and night calls continued until 14 July when calls were heard only at night. Daytime calling rejoined nighttime calling on 3 September. Day and night calls were heard until 29 September when only daytime calls were heard after that time. Males were heard calling at night until 14 October.

The latest time I was on site was 0200 on 26 May. About a dozen males were still chorusing at the time of my departure. This was a small fraction of the number of males I had heard calling at the peak of chorusing. At the height of calling (May and June), I would estimate there were 100 to 125 males calling at once.

Frogs were caught during the day or night along the shore of the site. When approached, they might remain still until I was within centimeters before attempting to escape, if they attempted to do so at all. In most cases, frogs escaped into the water and quickly returned to shore in the manner described by Stebbins and Cohen (1995). This pattern involves the frog jumping into the water in a direction that is perpendicular to the shoreline followed by returning to the shore in an arcing path (Figure 2.1). Some frogs did not follow this pattern, and escaped by disappearing into the lush vegetation or diving into the water and submerging.

Frogs were observed at night by taping red plastic wrap over a flashlight lens. I was able to observe calling males from floating vegetation in the pond or from the shoreline. On 19 April I had the opportunity to witness competition between two males for a calling site. I was watching a male (established male) calling from a small sandy area on the shore less than a meter away. Another male (challenging male) of nearly the same size emerged from a patch of vegetation on the other side of the established male. Both males had neither green nor red stripes and I was unable to tell them apart from my position. The challenging male hopped within several centimeters of the established male and was calling in his direction. The established male then turned toward the challenging male, and the two frogs continued calling toward one another for several minutes. The challenging male then approached the established male and a wrestling match began when the challenging male leapt onto the established male. The competition was broken several times when one male was thrown from the other. The thwarted male would regain his sitting position and remain there for only several seconds before attacking the other male. I observed a male being thrown from the other 7 times. The entire episode lasted less than one minute and ended when one of the males, after being thrown from the other male, did not turn in the direction of the other male after righting himself, but instead retreated. The frogs covered an area of about 10 cm^2 during their combat. Since the males appeared identical from my position, I do not know if the established male or the challenging male won the competition.

Only 6 frogs were captured in the first month of the study. However, as the warmer temperatures continued frogs became more abundant. There was a decline in frogs captured at the site during late summer. The number began to rise again with the onset of fall. Table 2.5 indicates the number of frogs caught each month of the study. Figure 2.12 indicates the relationship of females, males, and juveniles captured during each month of the study.

Frogs were active at the site until the first week of December when air temperatures still averaged in the low 50s. After 2 December when air temperatures dropped to lower 40's and upper 30's, frogs were not found by walking the shore of the site. At this time, it was assumed that the frogs were entering their hibernation or had expired.

Population size and movement

Of the 236 frogs captured and tagged during the study, 98 were males, 56 were females, and 81 were juveniles. Only 5 frogs were recaptured during my study and this sample size is insufficient for calculating the size of the population. Table 2.6 indicates the frogs that were recaptured and the distances of their movements.

Breeding and development

The first calling male of the season was heard on 16 April. Gravid females were observed as early as 16 April and as late as 17 June. The first pair of amplexed frogs was discovered on 19 April and the last pair on 16 June. Eighteen pairs of frogs were observed in amplexus at the site. Their distance out in the water from the shoreline is listed in Table 2.7**.** The average distance from the shore for the pairs of amplexed frogs was 32.1 cm.

Despite extensive searching, only 2 clutches of eggs were found during the breeding season. A clutch of 3 eggs was discovered on 18 May and a second clutch of 6 eggs on 30 June. Table 2.8 and Figure 2.13 indicate the measurements of the eggs when they were found. Both clutches were attached to vegetation less than 1 cm below the water surface. The nine eggs averaged 0.95 mm diameter vitellus and 2.76 mm diameter envelope. Eggs discovered in May averaged 0.85 mm diameter vitellus and 2.38 mm diameter envelope. Eggs found at the end of June averaged 1.0 mm diameter vitellus and

2.95 mm diameter envelope (Figure 2.14). Diameters of vitellus and envelope of eggs found in May were significantly smaller than those found in June (t test, P=0.015).

All nine eggs were placed in separate observation boxes for monitoring of the larval period. All eggs hatched within one day after placement in the boxes. Figure 2.15 shows a preserved tadpole of Blanchard's Cricket Frog. Even in the preserved state the black tip of the tail is visible. Figures 2.16 to 2.24 show the growth of the nine larvae. Table 2.9 indicates the total length the larvae attained and the length of the resulting froglet. The average tadpole length was 36.2 mm and the average froglet length was 15.3 mm. Key larval developments (Table 2.10) varied between the two clutches. Overall it required 44 days for back legs to form, 51 days for front legs to appear, and 56.1 days for front legs to complete development. For tadpoles from May eggs it required 30.6 days for back legs to form, 40 days for front legs to appear, and 46.7 days for front legs to complete development. For tadpoles from June eggs, it required 50.7 days for back legs to form, 56.5 days for front legs to appear, and 60.8 days for front legs to complete development.

Tadpoles from eggs discovered in May reached metamorphosis significantly faster than tadpoles from eggs discovered in June (t test, P=0.029) (Figure 2.25). The greatest length obtained by the tadpole and the SUL of froglets (Figures 2.26 and 2.27) were not significantly different (t test, P=0.065 and P=3.61).

Measurements recorded from juvenile growth indicated that juveniles grow at a uniform pace. Table 2.11 indicates the initial measurement of the juveniles versus the final measurements after the 2-month monitoring period. Table 2.12 and Figure 2.28 indicate the average daily growth of each juvenile. When comparing all juveniles monitored at Site 5, the average daily growth rates were 0.01 mm cranial width (Figure 2.29), 0.007 gram weight (Figure 2.30), 0.1 mm SUL (Figure 2.31), and 0.05 mm tibia (Figure 2.32). Morphological measurements of the two groups after a 2-month growing period were compared. Weight, cranial width, SUL, and tibia length did not differ significantly between juveniles from eggs found in May to juveniles from eggs found in June (t test, P=0.316; Mann-Whitney Rank Sum Test, P=0.262;t test, P=0.278; t test, P=0.278).

<u>Parasites</u>

Three species of parasites were discovered in 9 of the 10 frogs collected from Lawrence County, Ohio. These included two protozoans, an *Opalina* sp. and *Nyctotherus cordiformis*, and one digenetic trematode, *Megalodiscus temporatus*. Two frogs contained only 1 parasite, 7 frogs contained 2 parasites, and 1 frog contained 3 parasites. Table 2.13 lists the parasite prevalence of infection and the sex of dissected frogs.

<u>Malformations</u>

One frog captured during my study was found to have a malformation. This was a juvenile caught on 3 November 2001. The orbit of the right eye lacked a pupil. Otherwise, the frog had developed normally. Figure 2.33 is a picture of this individual.

Although the focus of the photo is poor, the reflection of light from the right orbit exhibits the missing pupil.

Discussion

Morphology

Statistical analysis indicated that all morphological features of females were greater than those of males. This follows the general rule that females are larger than males in most amphibians (Pough et al. 1998).

In my study, captured males outnumbered captured females 98 to 56. Burkett (1984) also found that males outnumbered females in his Kansas study. He stated that in Blanchard's Cricket Frogs over 3 months old, males are usually more abundant. Of his 2131 captures, 57.6% were males. The amount of captured males in my study constituted 63.9% of the captured adults. However, Pyburn (1958) collected males and females in a nearly 1:1 ratio during April in Texas.

Activity

In my study, Blanchard's Cricket Frogs emerged from winter hibernation in late March. Johnson (2000) stated that frogs in Missouri emerge from winter hibernation in late March as well. Males were observed at the site for 14 days before females arrived. This occurrence corresponds with Wells (1977) statement that males arrive first at the breeding site. Males did not begin to call at my site for nearly 3 weeks after spring emergence. This interval of several weeks between emergence and calling was also stated by Green and Pauley (1987). Males were heard calling only during the day between 16 April and 8 May. This could be because temperatures during the night were too low and unfavorable for amphibian activity. Increased calling activity in relationship to warming weather during the spring was also found by Burkett's (1969) in Kansas. Fitch (1958) found 82 °F to 87 °F to be the preferred air temperature for activity of *A. c. blanchardi* in Kansas. These frogs have been noted to be active at 42 °F to 100 °F in the same area (Clarke 1958). Frogs in Ohio were active on the ground between 51°F and 92 °F during my study.

Green and Pauley (1987) stated that chorusing males could be heard throughout the hottest parts of the day during June and July. However, frogs in my study were last heard calling during the day on 15 July. Air temperature on this day at the site was 91 °F. The frogs had been heard calling on the previous day when the air temperature at the site was 88 °F. Average daytime air temperature for the month of July at the site was 89 °F. The frogs did not resume daytime calling again until 3 September. The daytime temperature when males were again heard calling during the day on 3 September was 84 °F.

The latest time I heard males calling at the site was 0200 EST on 26 May 2001. At this time, calling activity was beginning to dwindle for the evening and it was assumed that it would soon cease for the night. Frogs in Indiana were found to conclude calling activity between 0200 and 0300 EST (Perrill and Shepherd 1989).

Calls were heard at the site until mid October. The breeding season lasts until late July in Kansas (Collins 1974), July or August in Alabama (Mount 1975), September in Louisiana (Dundee and Rossman 1989), and October in Texas (Garrett and Barker 1987). Because only 2 clutches of eggs were discovered, the latest clutch on 30 June, it is difficult to pinpoint when the breeding season ended in the Ohio population. Despite the fact that males called until mid October, Collins (1974) states that chorusing of *A. c. blanchardi* does not always indicate that frogs are breeding. He further explains that males continue calling after the breeding season for unknown and unexplained reasons. Males can be heard calling during any month of the year in Louisiana (Dundee and Rossman 1989); however, this is near the southern extreme of their range. Males may have called so late in the year in Ohio due to the warm temperatures experienced during the fall. The average daytime temperature during October was 71 °F.

The mode of escape described by Stebbins and Cohen (1995)(Figure 2.1) was often seen in the frogs of Ohio. Blanchard's Cricket Frogs also exhibited this escape route frequently in frogs found in Indiana (Perrill and Shepherd 1989). This activity was observed in calling males and it was noted that they often return to a site within 30 cm of their original location.

The wrestling match between two males on 19 April demonstrates the territoriality for calling sites. Frogs would not attack and drive others from areas if they were not territorial. Combat between Blanchard's Cricket Frog males was reported by Perrill and Shepherd (1989) in a population of Blanchard's Cricket Frogs in Indiana.

The low number of frogs collected in the first month of the study can be associated with the emergence of the frog late in the month (27 March). Frogs became most abundant during April, May, and June. These months are also, presumably, the peak of the breeding season for the frogs and when they are most active. Johnson and Christiansen (1976) suggest that since this is the height of the breeding season, frogs are more active because they are feeding more than they would be outside the breeding season. Numbers of adult frogs available for capture at the site began to decline in mid July. It is presumed that by late June and early July the adults, which had emerged in the spring as juveniles, were beginning to fall prey to predators or simply expire. This drop in the adult population would correspond with Burkett's (1984) statement that the average adult lifespan is only 4 months. The majority of the population at the time when frogs were scarce on the land would be the larvae in the pond. As the adults became difficult to find, the number of juveniles began to drastically increase in late July. From 22 July to 30 September juveniles comprised 34 of the 42 captures. This is equal to 81% of the total captures during a 9 week time period. In contrast to this, in the 9 week period prior, 6 May up to 15 July, juveniles made up only 6% of the total captures for that period. Johnson and Christiansen (1976) discovered the same phenomenon in their study in Iowa. In their study, the juvenile population began to increase the first week in August and they found no adults at their site until 11 October. However, I captured 8 adults (4 male and 4 female) during the time in which the juveniles made up the major portion of the population. Figure 2.12 also supports Wells (1977) suggestion that males outnumber females at any given time during the season. In every month of the study, except for August when the numbers are equal, more males were captured than females at the site.

In agreement with Burkett's (1984) observation that only 5% of the population survives the winter – mostly juveniles – 62.4% of the captures beginning in mid July were juveniles, 13.8% were females, and 23.9% were males. This supports his theory that there would be more juveniles than adults present when the cold weather approached and the frogs retreated into hibernation.

Another point can be made from Figure 2.12. Collins (1974) states that Blanchard's Cricket Frogs have two distinct growing periods. The first is just after metamorphosis and the second occurs between spring emergence and the breeding season. Figure 2.12 suggests this is the case in the frogs in Ohio as well. Only 2 juveniles were captured in the first month out of the total 6 captures (33.3% of total captures). In the following month the number is up to 8, but this is only 20.5% of the total captures for the month. At this time, most of the captures were males (53.8% of total captures). Then in May the number of juveniles decline drastically to only 2.1% of the total captures for the month. April, May, and June are the breeding months for the frog, so from this it can be concluded juveniles that emerged in March were becoming sexually mature during April and May.

Numbers of juveniles begin to increase again in June. It is assumed that juveniles present this late in the breeding season would have been hatched from eggs laid in April or May and not an individual which had over-wintered the previous season. In July, numbers of adults begin to decline and juveniles begin to increase. By September, juveniles dominate the population. It can be concluded from this that most eggs laid during the breeding season are deposited in May and June and most tadpoles transform before September.

Frogs were active at the site very late in the year. Of course, this could again be attributed to the warm weather experienced during the fall of 2001. The air temperature on the day frogs were last captured (2 December) was 61 °F. The latest documented date for active Blanchard's Cricket Frogs is 27 October 1972 (Johnson and Christiansen 1976) in Iowa. This takes into account only frogs in areas where they are known to hibernate, and not such areas as Louisiana and Alabama where the frog may be active during every month of the year (Dundee and Rossman 1989, Mount 1975).

Population Size and movement

Unfortunately, not enough frogs were recaptured during my study to make an estimate of the population's size. Lack of recaptured frogs also makes it impossible to analyze movements between capture episodes. Males in Indiana were found to return to locations within a 30 cm radius of the site they used for calling on the previous night (Perrill and Shepherd 1989). One male in Indiana was found to return to the same calling site on 13 consecutive evenings. In my study, two males that were adults at the time of their first capture moved 43 and 58 cm at the time of recapture. The only female to be recaptured moved 72 cm between captures. Two frogs, initially captured as juveniles, moved the greatest distances, 210 and 301 cm. Studies by Burkett (1984) and Pyburn (1958) suggest that many *A. c. blanchardi* exhibit an affinity for only one area of a study site. Frogs captured initially as adults did not move great distances when compared to the frogs initially captured as juveniles. Because the two frogs initially captured as juveniles were males, it can be suggested that these animals moved long distances because males are territorial (Perrill and Shepherd 1989, Wagner 1989, Burmeister et al. 1999) and these young males were forced to move until they located an area not occupied by another male.

<u>Breeding and development</u>

The time when males began to call in Ohio corresponds with Green and Pauley (1987), Mount (1975), and Johnson (2000) for the beginning of the breeding season in West Virginia, Alabama, and Missouri, respectively. I was unable to find in the literature any other studies which took measurements of the distances from the shore for amplexed pairs of frogs. It is assumed that amplexed pairs that were closer to the shore would be less likely to become prey items for predators in the pond.

Eggs were only found in clusters of 3 and 6 during my study. Many authors indicate that the eggs of *A. c. blanchardi* are also laid singly (Mount 1975, Green and Pauley 1987, Johnson 2000). Eggs discovered on 18 May were found to be statistically smaller in size than eggs found on 30 June. The idea that the eggs found in May were larger than eggs found in June because they had been laid earlier (and would have had more time to absorb water) is discounted here because both clutches hatched within 1 day of placement in the larval box. This suggests that the eggs had equal time of development. Johnson and Christiansen (1976) stated egg mass sizes in Iowa increased from May to June, but decreased again in July. My data in correspond to that of Johnson and Christiansen (1976); however, their sizes were of the entire clutch and in my study eggs were measured individually. Also, the sample size of my study is very small and it is questionable whether this hypothesis can be applied to all eggs of Blanchard's Cricket Frog.

Comparing length of tadpoles to froglets indicates the larval form of Blanchard's Cricket Frog is approximately twice the size of froglets. The greater size of tadpoles to the froglets was also stated by Green and Pauley (1987) and Dundee and Rossman (1989). I found that tadpoles from May eggs reached metamorphosis nearly 2 weeks faster than those from June eggs. The fact that tadpoles grew more quickly toward metamorphosis in the earlier months of the year supports Pyburn's (1961) suggestion that frogs that develop earlier in the year mature quickly in order to breed in the fall. Rapid growth of tadpoles from May eggs is contrasted to tadpoles from eggs found in late June reached metamorphosis more slowly. Perhaps after a certain portion of the breeding season has passed larvae do not grow as quickly into froglets as tadpoles hatched early in the season because there is not enough time left in the growing season to reach maturity. Again, this idea is based on a very small sample.

Despite the more rapid growth toward metamorphosis of eggs found in May, the size of tadpoles and froglets were not significantly different between eggs found in May and eggs found in June. This suggests that even if tadpoles hatched earlier in the year reached metamorphosis more quickly, they did not grow to a smaller or larger size than tadpoles hatched later in the year – only faster.

The first tadpole of the nine studied in Ohio metamorphosed on 8 July and the last on 16 September. This corresponds with Burkett's (1984) findings of metamorphs as early as 10 July and incomplete metamorphs as late as 29 September. Wright and Wright (1949) stated that transformation into frogs takes about 2 days. Only 5 of the 9 tadpoles of my study were observed frequently enough to agree with Wright and Wright (1949). Tadpole 1 was observed on 7 July with most of the tail remaining, and on 8 July the complete transformation had taken place. This observation also occurred over a 3-day period with Tadpoles 4, 7, 8, and 9.

There is very little information in the literature on the growth of juvenile *A. c. blanchardi*. Hybrids of *Acris gryllus* and *A. crepitans* were reported by Mechan (1964) to have reached sexual maturity the spring following their metamorphosis. *Acris crepitans* in Louisiana reached adult size within 2 months after metamorphosis (Bayless 1966). However, Bayless (1969) suggests that using tibia length of > 11.0 mm may have resulted in inaccurately referring to many frogs as sexually mature when they were not yet so. Bayless (1969) discounts using the SUL measurement for juveniles for two reasons. First, the measurement can vary depending on the position of the frog at the time of measurement. Second, this measurement is difficult to determine on frogs which have not totally reabsorbed the tail.

In his study of Blanchard's Cricket Frogs in Texas, Bayless (1969) found the mean tibia length for newly transformed froglets was 7.0 mm with a range of 5.3 mm to 8.5 mm. In the 9 juveniles studied in Ohio, mean tibia length after transformation was 7.8 mm with a range of 6.6 mm to 8.6 mm. Tibia length of Texas frogs increased an average of 0.1 mm per day. However, average daily tibia growth in Ohio frogs was 0.05 mm per day. It is possible that frogs grew more slowly in my study because they were in an enclosure and were unable to forage successfully to achieve maximum growing potential despite efforts to alter the enclosure for the entrance of prey items.

Bayless (1969) suggested that frogs growing at the rate of 0.1 mm per day could reach sexual maturity in about 40 days. This would be by the end of their first growing season. If juveniles were growing at the rate of 0.05 mm per day, it is unlikely that they would reach sexually maturity in time to breed at the end of their first season. This would dispute the idea that young-of-the-year are able to breed at the end of their first growing season (Pyburn 1961, Bayless 1969).

Burkett's (1984) study revealed that few young-of-the-year males developed chin spotting in the fall. However, it is March or April of the following year before vocal sacs of frogs form. Chin spotting was found on all 21 males captured in the fall of my study, but the yellow color associated with the breeding season (Bayless 1969) was not found in males in the fall.

Parasites

Odlaug (1954) discovered *Opalina obtrigonoidea* in the large intestines of frogs collected from north central and northeastern Ohio. It is possible that this same protozoan was discovered in the frogs from southern Ohio, but species level could not be identified in my study because of the numerous species in this genus. McAllister and Trauth (1995) discovered a protozoan *Myxidium serotinum* in the gall bladder of Blanchard's Cricket Frogs in Arkansas. Dissection of frogs from Kansas by Burkett (1984) revealed a fluke, probably *Zeugorchis megacystis*, in nearly 100% of frogs. Beasley et al. (in press) discovered larval parasites (family *Echinostomatidae*) in the kidneys of frogs in Illinois.

To the best of my knowledge, my study is the first report of *Megalodiscus temporatus* in *Acris crepitans blanchardi*.

Malformations

Reports of malformations in Blanchard's Cricket Frogs are few. Smith and Powell (1983) found two malformations in frogs collected from separate populations in Missouri. One lacked the left eye and orbit, a deformity attributed to a congenital defect, and the second frog a bloated appearance and, after dissection, it was revealed that gases had been released into the subcutaneous area. The gas originated from a herniated area of the small intestine. A malformation was also reported from a population in Illinois (Beasley et al. in press). One adult from this population was reported to possess an extra forelimb. Only one malformation was discovered in my study in southern Ohio. This deformity was lack of a pupil in the right eye.

CHAPTER 3. Diet

Introduction

Stewart and Sandison (1972) and Brown (1974) have shown that utilization of prey items differs among anurans. Characterizations of a group have been made by assessing patterns of prey exploitation (Clarke 1974). Heatwole and Heatwole (1968) and Houston (1973) demonstrated affinity for prey of specific sizes within the patterns of prey exploitation (Labanick 1976). Schoener (1969, 1971) theoretically discussed selection of certain size prey.

Blanchard's Cricket Frogs feed day and night and consume large numbers of prey. A study in Iowa estimated that 1,000 cricket frogs living around a small pond would consume about 4.8 million small arthropods, mostly insects, in one year (Labanick 1976). The type of insects that frogs consume has had conflicting suggestions. Garman (1892) and Jameson (1947) concluded that the diet of *A. crepitans* was mostly aquatic insects. Jameson (1947) reported on the stomach contents of 63 *Acris* collected from Kansas. His study, based on finding many bottom dwelling insects in the stomachs, concluded that frogs fed on the surface of the water and on the bottom. Gehlbach and Collette (1959) stated that out of 8 *A. c. blanchardi* collected from Nebraska "2 contained carabids, 2 pyralid larvae, and one each contained mirids and small spiders".

Several authors have suggested that the diet of Blanchard's Cricket Frogs is a terrestrial one. Hartman (1906) stated that the contents of 7 stomachs from *Acris gryllus* contained "ants, a caterpillar, lady bugs, snapping beetles, a spider, one small crayfish, and small beetles unidentified". Thirty-six *A. gryllus* from Florida were reported to have mainly ants and beetles in their stomachs (Duellman and Schwartz 1958). Johnson and Christiansen (1976) found that arthropods made up 97.6% of the diet of a population in Iowa. Frogs in Indiana were found to have only 5 % by volume of surface dwelling aquatic insects in their diet (Labanick 1976). The objective of this portion of my study was to determine if the prey items of Blanchard's Cricket Frogs in Lawrence County, Ohio were aquatic or terrestrial.

Methods and Materials

Twenty-seven specimens of *A. c. blanchardi* (N=12 juveniles, 15 adults) were collected during the course of my study to determine the diet of the frog in southern Ohio. Frogs were captured using fish tank dip nets and stored in a zip lock bag for no more than 1 hour after capture. Frogs were killed by dropping them in a 20% ethanol solution in a plastic container for 5 minutes. Frogs were then transferred to 10% formalin solution for 24 hours for fixing. An 80% ethanol solution was used for permanent storage. All specimens will be stored at the Cincinnati Museum of Natural History. Specimens were dissected beneath a dissecting microscope and the stomach removed from the abdominal cavity. The contents of the stomach were emptied into a Petri dish filled with distilled water. Prey items were identified to the level of order. Stomach contents are presented as percent of their occurrence, the percentage of stomachs that contained the prey item, and percent total, percentage of total food items one category comprised.

Results

Stomachs of Blanchard's Cricket Frogs collected from Lawrence County, Ohio contained an average of 7.0 prey items. Only 2 stomachs were empty. One-hundred and twenty six items were recovered from the stomachs. Table 3.1 and Figure 3.1 indicate results of gut analysis. The prey item found most often wase coleopterans, which comprised 30 of 126 items found. The second most frequent to occur were hymenopterans, making up 19 of the total items found. The four most important groups in terms of total number of prey items and percent occurrence were coleopterans, dipterans, hymenopterans, and arachnids. Table 3.2 compares the results of my study to the results of 3 previous studies.

Discussion

Three of the four most important food item groups for the frogs of my study were terrestrial, suggesting the frogs' diet is terrestrial even though it is found around water. A terrestrial diet for the Ohio population corresponds with the findings of Hartman (1906), Duellman and Schwartz (1958), Johnson and Christiansen (1976), and Labanick (1976), but dispute the findings of Garman (1892) and Jameson (1947). A terrestrial diet would indicate that frogs feed mainly out of the water. Individuals at my study site have been observed feeding on land up to 1.3 m from the shoreline.

Whitaker (1971) reported that shed frog skins made up approximately 11% of the volume of the stomach contents of *Pseudacris* during their breeding season. Shed skin was found to be the most commonly consumed food item in the stomachs of *Hyla* from March to May (Oplinger 1967). Frost (1932) found this was also the case in another population of Spring peepers. Shed frog skins were not found in the stomachs of any of the frogs from Ohio. Labanick (1976) and Johnson and Christiansen (1976) reported that skins were not found in any of the stomach contents of *Acris c. blanchardi* in their studies.

Fewer coleopterans (59.3%) were found in Ohio frogs than were found in Kansas (79.5%) and Iowa (92.1%) frogs (Table 3.2), but this percentage was greater than Indiana frogs (9.1%). More hymenopterans (11.1%) were found in Ohio frogs than were found in Kansas (6.4%) and Indiana (2.9%) frogs, but this amount was less than the occurrence of the order in Iowa frogs (35.2%). Dipterans were found to occur less frequently in frogs from Kansas (23.8%) and Indiana (23.5%), but more frequently in Iowa frogs (59.5%). Fewer arachnids (33.3%) were found to be in stomachs of frogs in Ohio than were found in stomach of Kansas (41.3%) and Iowa (39.7%) frogs, but this percentage was more than were found in Indiana (3.6%) frogs. These differences in percentages could be due to the small sampling size of the frogs from Ohio or abundance of the prey items vary with geographical location.

Only the size of one prey item was recorded in my study because of its comparatively large size to the frog which consumed it. The hymenoptera which the frog ingested was 38.3 % of the frog's total length. Labanick (1976) and Johnson and Christiansen (1976) discovered that mean prey length increased with frog SUL. Small prey such as ants, springtails, and mites were found less often in frogs with greater SUL when compared to frogs of smaller SUL (Labanick 1976). The author also stated the number of prey items per stomach decreased with increased frog size. This correlation was also suggested by Brooks (1964) and Houston (1973). Labanick (1976) indicated consumption of terrestrial prey items was positively correlated to prey availability and consumption of aquatic prey was negatively correlated.

Rocks and plant matter were found in 5 stomachs in my study. Inorganic matter was reported in 0.4% by volume of the stomachs from frogs in Iowa (Johnson and Christiansen 1976). This would suggest that this frog is an aggressive feeder and inadvertently consumes extraneous items when capturing prey. From the results of my study and of others (Garman 1892, Jameson 1947, Hartman 1906, Duellman and Schwartz 1958, Johnson and Christiansen 1976, Labanick 1976) it is concluded that Blanchard's Cricket Frogs are an opportunistic feeder. Based on the impressive size of one hymenoptera consumed in my study, which was more than 1/3 of the total body length of an Ohio frog, and the works of Labanick (1976) and Johnson and Christiansen (1976) this frog will consume any prey item compatible to the size of the frog's mouth.

CHAPTER 4. Extirpation of Blanchard's Cricket Frogs from West Virginia and Its Current Range in Ohio.

Introduction

Historically, Blanchard's Cricket Frogs occupied a wide geographic range in the mid-western states of North America (Figure 1.3). It was found from Wisconsin, south to Texas, west to Colorado, and West Virginia was the eastern extreme of the range (Conant and Collins 1998). Green and Pauley (1987) stated the range of this frog in West Virginia as Clay, Mason, Putnam, and Wayne counties (Figure 1.4). The first entry date for a specimen in the West Virginia Biological Survey housed at Marshall University is 17 July 1935. Blanchard's Cricket Frogs were first collected in this state from McCullough's Pond (Gilbert et. al. 1941) on 12 May 1939. There are 6 entries in the West Virginia Biological Survey for Blanchard's Cricket Frogs from 3 locations: Shoals (Wayne County), McCullough's Pond (Gilbert et. al. 1941) (Mason County), and Winfield (Putnam County). Collection dates spanned from 12 May 1939 until 16 June 1948. McCullough's Pond (Gilbert et. al. 1941) was the first and last location where *Acris c. blanchardi* was collected in the state of West Virginia.

According to the records of the Ohio Biological Survey, the current eastern extreme edge range of the frog in Ohio is Elizabeth Township in Lawrence County. The most recent, actually the only dated entry, for a collection of the frog in this township is 1999. This would have been the same year I began conducting calling frog and toad surveys in the area and reported the presence of the frog at 3 sites along a survey route in Elizabeth Township. A voucher specimen was placed in the Ohio Biological Survey. The other 4 collections for the frogs in the township are not dated. There is also an entry for Hamilton Township, the township south of Elizabeth, but it is also undated. It is presumed because the frog was found as far east as the Ohio River counties of West Virginia the frog would occur in the counties between Elizabeth Township and the Ohio River.

Since the last record of this frog in West Virginia was in June 1948 and it is found as close as Lawrence County, Ohio, this portion of my study was devoted to determine the potential extirpation of these frogz from West Virginia as well as its current range in southern Ohio.

Methods and Materials

West Virginia

Voucher specimens in the West Virginia Biological Survey have only been collected from Mason, Putnam, and Wayne counties. Because there is not a voucher specimen for Clay County, this county was not included in this portion of the study. The three counties where *Acris c. blanchardi* was historically found (Mason, Putnam, and Wayne) were searched. With the aid of a West Virginia gazetteer, a GPS unit, and topographic maps nearly every passable road within each of these counties was traveled between June 2000 and November 2001. Surveying for this frog included slowly driving the roads of each county with the windows down in my vehicle while listening for calling males. Also, bodies of water visible on topographic maps were accessed by foot if a vehicle was not permitted on the land or the terrain prohibited its progress. Searching for current populations in West Virginia coincided with the calling of males in Ohio, meaning that males called only during the day during a portion of the year and then both day and night during another. Because Blanchard's Cricket Frogs occur in a wide variety of habitats (Green and Pauley 1987, Johnson 2000) from ponds and lakes to streams and ditches, this approach was chosen over visiting only bodies of water visible on road and topographic maps.

Ohio

The same approach was used to search for the frog in Ohio. Counties covered in Ohio included Lawrence, Galia, and Meigs.

Results

Extirpation from West Virginia

An estimated 85% of all roads within the counties of Mason, Putnam, and Wayne were covered between June 2000 and November 2001. Extensive searching by driving roads within these 3 counties where *Acris c. blanchardi* historically occurred did not reveal a current population of these frogs in West Virginia. This is to say that males were not heard calling from any of the roads traveled by vehicle, nor were they heard at any of the sites reached by foot.

Current Distribution in Ohio

As in West Virginia, an estimated 85% of all roads in Lawrence, Meigs, and Galia counties were covered by vehicle. I did not find the frog in Galia or Meigs counties in Ohio. However, beginning May 2001 the frog was present at all 4 study sites in Ohio, meaning that ponds chosen as potential habitats for the frog in 2000 were occupied by the frog in 2001. Presence of the frog at Site 4, the easternmost study site in Ohio, extends the known range east by 0.5 km east. In June 2001, approximately 20 *Acris c. blanchardi* were discovered in a railroad yard northeast of the town of South Point (Lawrence County) by my Ohio Biological Survey supervisor, Jeffrey G. Davis. His discovery of the frog at this location extends the range of the frog by 15.5 km to the east. This population occurs within 0.13 km of the Ohio River and within 3.12 km of the town of Shoals, which is south of South Point, where *Acris c. blanchardi* was collected in May 1939. Jeffrey G. Davis also discovered a population in Raccoon Township, Galia County. This population is 25 km northeast of the easternmost population of my study sites. This population in Galia County is 9.32 km west of McCullough's Pond in Mason County, West Virginia. I found several populations of the frog within Lawrence County, but these did not extend the population of the frog farther to the east.

Discussion

Extirpation from West Virginia

Despite extensive searching during the course of my study, a current population of Blanchard's Cricket Frogs was not found in West Virginia. More extensive searches could have been employed. An example would be to search each individual body of water and ditch on a topographic map or searching every ditch along the road within each county where the frogs were historically found. However, this approach would have been very time consuming and most likely impossible. The method employed was chosen because it was believed this approach could cover a wider area over the course of the study period. Based on my approach to searching for the frog, and to the best of my knowledge, *Acris crepitans blanchardi* has been extirpated from the state of West Virginia. Ohio is now the easternmost extreme of the geographic range of Blanchard's Cricket Frogs.

Decline of this frog is documented frequently in the literature. Historically it was found in Ontario on Point Pelee National Park and Pelee Island in Lake Erie. During the 1950's they were a common inhabitant of these areas. Frogs were reportedly found at 20 sites on Pelee Island between the years of 1970 and 1977 (Oldham and Campbell 1986). Oldham (1983) reported that a complete search of these 20 sites revealed the frog only to be found at 1 site. Oldham (1992) reported that frogs have not been observed at this site since 1987.

Blanchard's Cricket Frogs were commonly encountered in the southern half of Wisconsin until declines were noted in the 1960's. By the 1980's only a few counties in the southwestern portion of the state had confirmed populations of the frog. In 1997, it was estimated less than 1,000 remained in the state (Christoffel and Hay 1997). Although, Wisconsin has not lost the frog yet it seems that it is well on its way to extirpation in Wisconsin.

In the more western areas of its range, Blanchard (1923) reported *Acris c. blanchardi* in Dickinson County, Iowa during a survey of the Iowa Lakeside Laboratory in 1920. However, Lannoo and others (1994) failed to locate the frog during the summers of 1991 and 1992.

The reasons for the decline of Blanchard's Cricket Frogs are not so clear. Surface-to-volume ratio of frogs plays an important role in the rate of water loss from the body (Thorson and Svilhla 1943). A study of 8 members of *Hylidae* (Farrell and MacMahon 1969) indicated a strong correlation between the weights and their rate of water loss. Based on weights, smaller frogs exhibited a greater rate of desiccation than larger frogs. Blanchard's Cricket Frogs have been shown to be more vulnerable to desiccation than many other Hylids (Ralin and Rogers 1972).

Habitat alteration could also play a key role in the decline Blanchard's Cricket Frogs. A study in southern Wisconsin showed that a population was thriving in a small cattle pond. The pond water was consumed or trampled around the edges of the pond. After the cattle no longer used the pond, the vegetation recovered and the edges of the pond transformed into a different microhabitat. After the change in vegetation richness, *Acris c. blanchardi* individuals decreased and the number of green frogs, *Rana clamitans melanota*, increased (Jung 1993). *Rana clamitans melanota* is a much larger frog than *Acris c. blanchardi* and it is possible that this frog may have preyed upon the cricket frog population until they could no longer sustain their numbers.

Beasley et al. (in press) also demonstrated alteration to the habitat was an important factor in the decline of a population of Blanchard's Cricket Frogs in a farm pond in Illinois. An initial survey in 1994 indicated that creeping water primrose and cricket frogs were commonly encountered at the site. When the pond was visited later in the same year the habitat had been altered. Herbicides had been added to the pond to rid it of creeping water primrose and as a result most of the plants died. Also, the land owner had used water from the pond for irrigation. A 2-day search of the pond revealed only 7 tadpoles. Unlike the population Jung (1993) studied in Wisconsin, this population was able to recover. In 1995, the pond was again surveyed and creeping water primrose and cricket frogs were found to be abundant at the site once more. This ability to recover from habitat alteration is not always the case.

Flood events may contribute to declines in populations. Flooding would affect all stages of development of Blanchard's Cricket Frogs. Eggs attached to vegetation or floating on the water surface would be washed away. Tadpoles, adults, and juveniles could be carried away by the flood waters as well. When the waters recede after an event, it is possible that that these animals could be carried great distances away from their original location and nowhere near suitable habitat for frogs to survive. The flooded, temporary areas where they are deposited eventually dry. Eggs and tadpoles would be most easily affected by this event because it would be only a matter of hours, if not minutes, before they perished without water. Juveniles and adults would have a greater chance of survival because they are more mobile and could seek out new habitat. Because *Acris c. blanchardi* is susceptible to desiccation (Ralin and Rogers 1972), wandering animals may not make it to new habitats. Frogs not washed away by flood waters may remain at the original site. The short life span (Burkett 1984) may make it impossible for the remaining population to recover if the flood event takes place during key times of the year such as the breeding season. If large numbers of eggs and tadpoles are carried away by waters, these stages will be lost from the recruitment into the population for that year.

Possibly the most important factor in the declines of Blanchard's Cricket Frogs could be the short lifespan. Burkett (1984) stated that the adult life span expectancy is about 4 months. Because of this, Blanchard's Cricket Frogs must breed every year in order to ensure continuation of the species. If a drought occurs during the breeding season of Blanchard's Cricket Frog, they must breed in permanent bodies of water. If, however, the only available permanent bodies of water are unsuitable for breeding by habitat alteration, cricket frogs will not be able to breed during the season (Lannoo 1998). Because their lifespan is so short and they are susceptible to desiccation, this would be devastating to a population. This is also supported by the comparison of the northern geographic range of Blanchard's Cricket Frogs to their southern range. Declines of populations in the south are not being reported at the rates of the northern geographic ranges. The majority of northern habitats are comprised of prairie potholes in the Midwest while southern habitats are mainly continuous riparian habitats (Lannoo 1998).

Exact reasons for the loss of *Acris c. blanchardi* in West Virginia are not known. Several factors would make West Virginia populations extremely vulnerable to extirpation. First, the geographic range of the frogs within the state was very limited. Only 3 populations from 3 counties are known from the records of the West Virginia Biological Survey. This is not to say that these were the only populations within West Virginia. It is entirely possible, in fact probable, that more populations occurred in the state than those recorded in museum records. Low numbers of populations would make it possible for even slight disturbances to eradicate those populations. Second, West Virginia was the historical eastern extreme of the geographic range and all populations within the state are isolated from populations in Ohio by the Ohio River. This river poses an incredibly large barrier to frogs that could potentially recolonize the lost populations of West Virginia. Third, the closest population known to occur in Ohio is Raccoon Township in Galia County. This population is 9.32 km from the last known population across the river in Mason County and 7.5 km from the Ohio River. It is possible that if a population occurred in Ohio close enough to the Ohio River frogs could be carried to West Virginia in a flood event, but to the best of my knowledge populations of Blanchard's Cricket Frogs do not occur less than 0.13 km from the Ohio River as is the case of the population discovered in South Point Ohio. These frogs occur within several hundred yards of the river and could be caught in a flood event. However, this population is only 0.37 km upstream of the West Virginia border and it is unlikely that these frogs could be carried to West Virginia shores in such a short distance.

Current Distribution in Ohio

The discovery of 4 new populations of Blanchard's Cricket Frogs in Ohio which extend its range south and east is encouraging for the long-term survival of the frog. Because these new populations have been found in recent years, it suggests that the geographic range of *Acris c. blanchardi* is moving, but in an extension instead of a retraction in this case. Based on these findings, the distribution of the frog may be extending to the south and east toward the Ohio River.

CHAPTER 5. Comparison of Historical Sites, Current Sites, and Potential Sites of Blanchard's Cricket Frogs.

Introduction

Six sites were chosen for my study for previously mentioned reasons (see Description of study sites). Temperature is an important component of limnology because it has a direct effect on lake stability, gas solubility, and biotic metabolism (Lind 1985). Based on worldwide studies, dissolved ionic compounds such as the cations Calcium (Ca^{+2}), Magnesium (Mg^{+2}), Sodium (Na^{+}), Potassium (K^{+}), and the anions Bicarbonate (HCO_3^-), Sulfate (SO_4^{-2}), Chloride (Cl^-), and Nitrate (NO_3^-) comprise a major portion of most surface and ground waters. Minor cations found in water include Aluminum (Al^{+3}), Ammonium (NH_4^+), Arsenic (As^+), Iron (Fe^{+2}), and Manganese (Mn^{+2}). Minor anions include Fluoride (F^-), Phosphates ($H_2PO_4^-$ and HPO_4^-), Sulfide (S^{-2}) and Sulfite (SO_3^{-2}). Most of these major and minor ions found in water are a result of contact of the water with mineral deposits (Tchobanoglous and Schroeder 1985).

In addition to these major and minor species, heavy metals may be detected in water. These would include the cations Arsenic (As^{+3}), Barium (Ba^{+2}), Cadmium (Cd^{+2}), Chromium (Cr^{+3} and Cr^{+6}), Lead (Pb^{+2}), Mercury (Hg^{+2}), Selenium (Se), Silver (Ag^{+2}), and Zinc (Zn^{+2}) and the anion Cyanide (CN^-). In most cases, these substances are in water supplies through discharge of industrial waste. These elements are of particular interest because they are toxic to plants and animals (Tchobanoglous and Schroeder 1985).

Carbonate and noncarbonated hardness are two different types of hardness in water and in most cases, the sum of Calcium (Ca^{+2}) and Magnesium (Mg^{+2}) concentrations represent the hardness of water. Carbonate hardness is associated with ions HCO_3^- and CO_3^{-2} while noncarbonated hardness is associated with other ions, which are usually Cl^- and SO_4^{-2} (Tchobanoglous and Schroeder 1985).

The pH of water is controlled by the carbonate system which is the most important acid-base system in natural waters. The carbonate system is comprised of gaseous carbon dioxide [$(CO_2)_g$], aqueous carbon dioxide [$(CO_2)_{aq}$], carbonic acid (H_2CO_3), bicarbonate (HCO_3^-), carbonate (CO_3^{-2}), as well as solids which contain carbonate. Two of these ions, carbonate (CO_3^{-2}) and bicarbonate (HCO_3^-), and the hydroxyl (OH^-) ions are responsible for nearly all of the alkalinity in natural waters (Tchobanoglous and Schroeder 1985).

Dissolved oxygen is a common component in the atmosphere and is present in water in contact with the atmosphere (Tchobanoglous and Schroeder 1985). Solubility of this gas depends on two laws of gases: Henry's and Boyle's. Henry's law states that the concentration of a gas in a solution is proportional to the pressure of gas over the solution. Boyle's law states that at constant temperature the product of the volume and pressure of a given amount of a gas is constant (Brown et. al. 1994).

The rate of water loss across amphibian skin is determined by the combination of air humidity and temperature. As a result, the combination of these two factors can strongly influence the activity patterns of amphibians (Heyer et al.1994). Temperature is one of the most important factors in amphibian activity.

Damaging UV-B radiation has recently been increasing at ground levels due to depletion of the ozone layer (Hader 1997). Because amphibian species are disappearing from many parts of the world, this increase in radiation has been investigated along with other environmental alterations (Starnes et. al. 2000). Studies have shown that damage to amphibian embryos by ultraviolet radiation varies among species (Blaustein et al. 1998, Kiesecker and Blaustein 1995, Lizana and Pedraza 1997, Anzalone et al. 1998). Embryonic sensitivity varies among conspecific populations (Starnes et al. 2000) and the risk of damage to embryos can be influenced by breeding sites of species (Schindler et al. 1996). Such factors would include water turbidity and canopy closure at the breeding site.

Strausbaugh and Core (1997) divided the vegetation of West Virginia into three units which correlate to the physiographical provinces of the state. The area of my study sites are included in the Western Hill Section, which is classified as part of the Central Hardwood Forest. Plants that comprise this section vary greatly and are found in xeric, mesic, and hydric places within the division. Study sites in Ohio could also be classified under the Cove Hardwoods or Mixed Mesophytic Forests. This can be further subdivided into cover types; however, these are not in all cases clearly defined. Cove Hardwoods or Mixed Mesophytic Forests are dominated by a large number of species including: American Beech (*Fagus grandifolia*), Tulip tree (*Liriodendron tulipifera*), Black sugar maple (*Acer nigrum*), American chestnut (*Castanea dentata*), Sweet Buckeye (*Aesculus octandra*), and others. About 25 trees dominate the canopy of this subdivision. Trees that generally do not achieve height to become canopy trees are Flowering Dogwood (*Cornacea canadensis*), Umbrella Magnolia (*Magnolia tripetala*), Sourwood (*Oxydendrum arboreum*), Striped maple (*Acer pensylvanicum*), Redbud (*Cercis canadensis*), American Holly (*Ilex opaca*), and Common Serviceberry (*Amelanchier abrorea*). The shrub layer is dominated by Spicebush (*Lindera benzoin*), Witch-hazel (*Hamamelis virginiana*), Pawpaw (*Asimina triloba*), Wild Hydrangea (*Hydragenea arborescens*), and Alternate-leaf Dogwood (*Cornus alternifolia*). Ferns found in this division include Marginal Shield Fern (*Dryopteris marginalis*), Christmas Fern (*Polystichum acrostichoides*), Northern Lady Fern (*Athyrium angustum*), and Maidenhair (*Pteridium aquilinum*), in addition to others.

Predation is the number one cause of mortality in amphibians and may occur at any stage of development from the tadpole to the adult. Many amphibians do not survive long enough to become sexually mature. In many cases, even if adulthood is attained, the amphibian does not survive to reproduce (Zug et. al 2001). Stebbins and Cohen (1995) stated that high rates of mortality in amphibian eggs can be attributed to bacterial and fungal infections. Juvenile amphibians have small predators including many arthropods such as insects, spiders, and centipedes. Large predators would include fishes, mammals, and birds (Zug et al. 2001).

The objective of this portion of my study was to determine differences in historical habitats, current habitats, and potential habitats of Blanchard's Cricket Frogs. To accomplish this, water chemistry, heavy metals, environmental parameters, vegetation types at each site, and predators at each site were evaluated.

Methods and Materials

Water Chemistry

The 6 study sites were visited monthly from July 2000 until December 2001. A Hach kit was used to measure grains per gallon (gpg) total acidity, alkalinity, carbon dioxide, and total hardness of water. These results were converted to milligrams per liter (mg/L). A TSI model 95 meter was used to measure dissolved oxygen in mg/L. Measurements from this instrument are recorded in mg/L. Water pH was recorded with Oakton pH Testr 2 waterproof meters. All measurements recorded in the field were entered into Microsoft Excel for analysis.

Water samples from each site were collected during fall of 2001. An Inductive-coupled plasma emission spectrometer was used to analyze the presence of heavy metals. A Rapid Quantitative test was conducted to compare relative amounts of metals in the water, not an actual amount. Metals of interest in my study were Aluminum, Cadmium, Cobalt, Iron, Manganese, Nickel, and Selenium because in high levels these elements are toxic to aquatic animals.

Environmental

Air and soil temperatures were measured with Reotemp stainless steel bi-metal thermometers. Water temperature was recorded with Enviro-Safe armored thermometers. Relative humidity was measured with digital max/min thermohygrometers. Ultraviolet light penetration (UV-B) was recorded in $\mu W/cm^2$ with a handheld Goldilux meter. All measurements recorded in the field were entered into Microsoft Excel for analysis.

Vegetation

Plants were collected from each site during summer and fall of 2000 and spring, summer, and fall of 2001. Vegetation was collected from within and adjacent to each site. Plants were collected no farther than 5 m from each site. For plants collected in 2000, the entire plant (or portions required to identify the plant if it was a large specimen) was collected and pressed before placement in a plant dryer for 48 hours. Specimens were identified by Dr. Dan K. Evans of Marshall University. During 2001, the plants were identified in the field by myself. Floristic affinity among the 6 study sites was determined with coefficients of similarity according to Sorenson (1948). This method of comparing habitats has been used by many authors (Evans 1979, 1975; Mohlenbrock 1975).

Predators

Medium-sized and small-sized mammals were trapped during summer and fall of 2000 and spring, summer, and fall of 2001 with Sherman Special and Tomahawk traps. All traps were baited with peanut butter or sunflower seeds and left overnight. All animals found in traps were identified and released the following morning. Dead animals found in or around the site were also included in this portion of the study.

Fish and turtles at each site were captured with hoop nets and catfish traps. Traps were placed 1 to 4 m from the shoreline. Hoop nets and catfish traps were baited with canned sardines and left overnight. Minnow traps baited with bread or cheese were used to capture fish too small for the large net traps. Animals caught in the traps were identified and released the next morning.

Aquatic insects, which may prey upon tadpoles and adults, were collected with fish tank dip nets from each site and identified to the level of genus.

Results

Water Chemistry

Figures 5.1, 5.2, 5.3, and 5.4 list the results of measurements taken with the Hach kit. Graphs present measurements expressed in mg/L. Figure 5.5 shows monthly measurements of dissolved oxygen. Figure 5.6 shows the results of pH testing.

Rapid Quant testing revealed that levels of heavy metals present in water of each pond did not exceed acceptable levels. In fact, resulting measurements were virtually zero. As previously mentioned, these are not actual amounts, only a quantitative amount. Table 5.1 shows the results of Rapid Quant testing.

Environmental

Figures 5.7, 5.8, and 5.9 present the seasonal fluctuations of air, soil, and water temperatures. Statistical analysis indicates a strong correlation between air and soil, air and water, and water and soil temperatures (Mann - Whitney Rank Sum Test, $P=0.335$, $P=0.438$, $P=0.874$). Relative humidity levels are indicated in Figure 5.10. UV-B at each site is shown in Figure 5.11.

Vegetation

One-hundred and sixteen species of plants were collected from the study sites (Table 5.2). Forty-five species were collected from Site 1. Thirty-eight species were collected from Site 2. Twenty-eight species were collected from Site 3. Twenty-two species were collected from Site 4. Twenty-eight species were collected from Site 5. Twenty-five species were collected from Site 6. Figure 5.12 shows the dendogram generated from the coefficients of similarity following Sorenson (1948).

Predators

Table 5.3 shows the species of mammals captured at each site during the course of my study. Tables 5.4 and 5.5 show the fish and turtles trapped at the study sites. The number of animals captured or observed at study sites was 5 species of mammals, 9 species of fish, and 3 species of turtles. Forty-four aquatic insect genera were collected from the 6 study sites. Table 5.6 shows the species of aquatic insects collected from study sites. Number of genera included 28 for Site 1, 25 for Site 2, 25 for Site 3, 20 for Site 4, 25 for Site 5, and 31 for Site 6.

Discussion

Water Chemistry

Figure 5.1 shows the seasonal trend of total acidity in the ponds. This trend, a peak in the winter followed by depressed levels during spring, summer, and fall, corresponds with carbon dioxide levels of the ponds (Figure 5.3). Biological activity accounts for lower levels of H^+ ions in ponds during warmer months, resulting in lower acidity levels during these times. An example of this biological activity would be hydrogen pumping by bacteria to maintain internal pH levels. These bacteria are not active during the colder months of the season to pull H^+ ions from the water. Also, during colder months debris falling into the ponds from surrounding vegetation and organisms are not active to break down this matter. As a result, organic acids build up in water when there is little or no biological activity. The relationship between total acidity and carbon dioxide levels can also be explained by plant activity. Plants use carbon dioxide during respiration and release oxygen. Carbon dioxide levels are highest in the ponds during winter months when plants are not active. Sites 3 and 4 experience a peak in carbon dioxide levels later in the winter than do other sites (Figure 5.3). This could be explained in part by the abundance of cattails present at these two sites. Cattails comprise nearly all the vegetation in these ponds and are more cold-hardy than many other plants. Cattails will respire (utilizing carbon dioxide) later in the year than many other plants.

Alkalinity of natural waters is related to carbonate and buffering effects. Ponds in my study proved to be weakly buffered (Figure 5.2). Alkalinity is also related to soil types from which soil of a body of water is derived. Because these ponds exhibit low alkalinity, they are probably derived from sandstone. Sites 3 and 4, which show the lowest levels of alkalinity, also indicate the widest ranges in pH shifts.

Total hardness is commonly related to amount of calcium ions in water. Levels of total hardness in my study (Figure 5.4) indicate that waters of the ponds are classified as moderately hard (Tchobanoglous and Schroeder 1985). This also indicates that these ponds do not contain large amounts of calcium.

Dissolved oxygen levels in the West Virginia ponds were very low (Figure 5.5) compared to Ohio ponds. Levels below 4 mg/L are stressful for fish. Site 1 exceeded 4 mg/L only once during the study and Site 2 exceeded 4 mg/L 3 times. These low levels could be explained by the order in which ponds were visited. West Virginia sites were always visited first, and samples were taken usually before 10:00. Dissolved oxygen levels are lower during the morning than afternoon because plants begin to respire after sunrise. Later in the afternoon dissolved oxygen levels are higher because plants have been respiring for longer periods of time.

Environmental

Air, soil, and water temperatures followed seasonal trends as expected. Water temperatures exhibited a lag behind air and soil temperatures. This can be explained by the fact that water absorbs and loses heat slower than does air. Relative humidity levels at the sites varied from month to month. Relative humidity levels were higher in the warmer months of the year and lower in the colder months of the year. Values did not differ greatly between sites with or without larger amounts of canopy cover.

UV-B levels during my study varied greatly (Figure 5.11). This could be explained in part by the canopy cover at study sites. Sites 1 and 3 have no canopy cover along the banks of the site. Sites 4, 5, and 6 have minimal canopy cover and Site 2 is well covered around the edges of the pond. Ponds with less canopy cover experienced greater variation in UV-B penetration levels. Differences in penetration levels could also be explained by weather conditions on the day of the visit. The time of day at which measurements were taken could also have an affect on UV-B levels detected by the device.

Vegetation

Blanchard's Cricket Frogs did not occur at sites with highest species diversity of plants (Table 5.2). Coefficients of similarity revealed Sites 2 and 4 were most similar to one another (0.360) of all study sites (Figure 5.12). However, this similarity is relatively low. Based on the fact that the highest coefficient of similarity was 0.360, sites of my study were not considered floristically similar to one another.

Predators

Despite numerous trapping attempts, very few mammals were captured. Medium-sized mammals were not captured at all. Records are from observations of dead animals. Opossums and raccoons were the most common encountered mammals.

Blanchard's Cricket Frogs were found at sites where higher numbers of predators were trapped (Tables 5.3, 5.4, and 5.5). Blanchard's Cricket Frogs were present at Site 5 and Site 6 where 7 and 6 species of fish were trapped, respectively. Also, frogs were present at sites where all 3 species of turtles were captured. Frogs were absent from ponds with lower numbers of fish and turtles. This suggests that numbers of predators in the water does not affect the survival of Blanchard's Cricket Frogs.

Genera of benthic insects present at each study site (Table 5.6) varied from 20 (Site 4) to 31 (Site 6). Unlike numbers of predators or vegetation samples, the variation of results was not as pronounced. This could be due to the taxonomic level to which individuals were keyed. Had insects been keyed to the species level, perhaps the resulting numbers would have differed greatly. However, as it stands a correlation between number of genera and the presence or absence of Blanchard's Cricket Frogs could not be established.

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Table 2.1 Character descriptions for morphological measurements of juveniles and adults.

Character	**Description**
Cranial width	Width (mm) of the widest point of the head behind the eyes.
Snout-to-urostyle	Length (mm) from the tip of the snout to the cloacal vent.
Tibia length	Length (mm) from the anterior to the posterior extreme of the tibia.

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Table 2.2 Character descriptions for morphological measurements of eggs.

Character	**Description**
Vitellus width (VW)	Width (mm) of the portion of the egg minus the gelatinous material (yolk).
Vitellus length (VL)	Length (mm) of the portion of the egg minus the gelatinous material (yolk).
Envelope width (EW)	Width (mm) of the egg as a whole.
Envelope length (EL)	Length (mm) of the egg as a whole.

Table 2.3 Character descriptions for morphological measurements of tadpoles.

Character	**Description**
Total length	Length (mm) from the tip of the snout to the tip of the tail.

Table 2.4. Averages for morphological measurements for frogs at Site 5. Standard deviations are included in parentheses.

Sex	**Weight (g)**	**SUL (mm)**	**Cranial (mm)**	**Tibia (mm)**
Females (N=56)	1.9 (0.33)	27.2 (2.13)	8.6 (0.43)	14.0 (1.18)
Males (N=98)	1.3 (0.18)	25.0 (1.65)	8.2 (0.36)	12.8 (0.58)
Juveniles (N=82)	1.0 (0.20)	16.6 (2.25)	6.7 (0.79)	8.7 (1.53)

Table 2.5 Number of frogs captured per month at Site 5.

Month	**Number of frogs**	**Month**	**Number of frogs**
March	6	August	11
April	39	September	23
May	48	October	31
June	28	November	25
July	17	December	8

Table 2.6 Distance moved by recaptured frogs at Site 5.

Frog No.	Sex	Days between captures	Distance moved
9	M	29	58 cm
64	J (M)	31	210 cm
90	M	14	43 cm
101	J (M)	143	301 cm
171	F	17	72 cm

Table 2.7 Distance in the water from the shoreline for amplexed pairs at Site 5.

Pair Number	Date	Distance from shoreline (cm)
1	19 April	37
2	19 April	34
3	29 April	22
4	29 April	36
5	8 May	41
6	8 May	24
7	12 May	32
8	12 May	37
9	12 May	29
10	13 May	39
11	13 May	38
12	13 May	19
13	19 May	28
14	19 May	43
15	26 May	26
16	26 May	39
17	2 June	22
18	16 June	31

Table 2.8 Measurements of eggs (mm) when found at site 5.

Date	VW	VL	EW	EL
18 May	0.8	0.9	2.2	2.9
18 May	0.9	1.0	1.4	2.5
18 May	0.7	0.8	2.3	2.5
30 June	1.1	1.0	3.0	3.1
30 June	1.0	1.1	2.7	2.9
30 June	0.9	1.1	2.8	3.0
30 June	1.2	1.0	3.2	3.3
30 June	0.8	0.9	2.6	2.7
30 June	0.9	1.0	3.0	3.2

Table 2.9 Total length of larvae versus SUL of froglet.

Frog Number	Larval length (mm)	SUL of froglet (mm)
1	38.2	16.8
2	39.9	14.9
3	38.0	15.9
4	34.9	16.3
5	37.1	14.3
6	34.1	13.9
7	31.1	13.1
8	39.1	16.1
9	33.3	16.2

Table 2.10 Measurement in days for key larval developments.

Tadpole Number	Back legs	Front legs Appeared	Front legs Completed
1	28	42	49
2	29	35	42
3	35	43	49
4	50	56	62
5	42	49	55
6	50	57	62
7	50	56	57
8	56	57	62
9	56	64	67
Overall Average:	**44**	**51**	**56**

Table 2.11 Growth of juveniles over a 2-month period at Site 5.

	Beginning of monitoring				End of monitoring			
Frog No.	**Weight (g)**	**Cranial (mm)**	**SUL (mm)**	**Tibia (mm)**	**Weight (g)**	**Cranial (mm)**	**SUL (mm)**	**Tibia (mm)**
1	0.8	6.7	16.8	8.0	1.2	7.5	22.4	11.3
2	0.8	6.9	14.9	8.1	1.2	7.8	21.5	10.8
3	0.9	6.9	15.9	8.6	1.3	7.9	22.5	11.6
4	0.8	7.3	16.3	8.1	1.2	8.0	22.3	11.2
5	0.6	5.6	14.3	7.3	1.0	6.3	19.8	9.8
6	0.6	5.5	13.9	7.0	1.0	6.1	18.8	9.7
7	0.6	5.6	13.1	6.6	1.0	6.5	19.8	10.0
8	0.8	6.4	16.1	8.2	1.3	7.4	22.9	11.7
9	0.8	7.0	16.2	8.3	1.3	7.8	22.0	11.2

Table 2.12 Average daily growth of juveniles at Site 5. Averages are calculated by dividing total growth over the 2-month monitoring period by number of days tadpoles were monitored.

Frog Number	Weight (g)	Cranial (mm)	SUL (mm)	Tibia (mm)
1	0.006	0.01	0.09	0.06
2	0.006	0.01	0.10	0.04
3	0.006	0.02	0.10	0.05
4	0.007	0.01	0.10	0.05
5	0.006	0.01	0.09	0.04
6	0.007	0.01	0.08	0.05
7	0.006	0.01	0.10	0.05
8	0.008	0.02	0.10	0.06
9	0.008	0.01	0.10	0.05
Overall Average:	**0.007**	**0.01**	**0.10**	**0.05**

Table 2.13 Parasites of frogs collected from Site 5.

Parasite	Prevalence of Infection	Sex of Infected Frog
Opalina sp.	90%	5 males, 4 females
Nyctotherus cordiformis	70%	4 males, 3 females
Megalodiscus temporatus	10%	1 female

Table 3.1 Results of stomach content analysis of adult (N=15) and juvenile (N=12) *A. c. blanchardi* collected from Lawrence County, Ohio.

Food Item	Percent of Total Items	Percent Occurrence
Arachnida	11.1	33.3
Coleoptera	23.8	59.3
Collembola	5.6	14.8
Diptera	14.3	44.5
Gastropoda	3.2	11.1
Hemiptera	4.0	11.1
Homoptera	2.4	7.4
Hymenoptera	15.1	37.3
Isopoda	7.1	14.8
Lepidoptera	1.6	3.7
Odonata	0.8	3.7
Orthoptera	1.6	7.4
Unidentified	3.2	14.8
Plant material	4.8	7.4
Rocks	1.6	7.4

Table 3.2 Comparison between frogs from Ohio and those of previous studies. Amounts expressed are percentage of stomachs containing the listed Order.

Order	Jameson 1947 (Kansas, N=63)	Johnson and Christiansen 1976 (Iowa, N=218)	Labanick 1976 (Indiana, N=279)	Dickson 2001 (Ohio, N=27)
Arachnida	41.3	39.7	3.6	33.3
Coleoptera	79.5	92.1	9.1	59.3
Collembola	4.8	19.7	17.8	14.8
Diptera	23.8	59.5	23.5	22.2
Gastropoda	----	1.4	0.2	3.7
Hemiptera	20.6	8.4	6.4	11.1
Homoptera	3.2	21.5	6.1	7.4
Hymenoptera	6.4	35.2	2.9	11.1
Isopoda	----	1.9	0.3	14.8
Lepidoptera	----	----	1.0	3.7
Odonata	----	1.0	1.1	3.7
Unidentified	9.5	2.5	----	14.8
Plant matter	4.8	----	----	7.4

Table 5.1 Rapid Quant testing results measured in parts per million (ppm).

Site	Aluminum	Cadmium	Cobalt	Iron	Manganese	Nickel	Selenium
1	1.668	0.027	0.046	3.576	0.718	0.055	1.250
2	0.182	0.0300	0.081	1.252	0.188	0.044	1.317
3	1.680	0.039	0.047	0.930	0.050	0.033	2.586
4	0.396	0.025	0.029	0.643	1.006	0.085	3.782
5	0.150	0.036	0.030	0.667	0.551	0.034	1.716
6	0.493	0.116	0.056	0.511	0.207	0.042	2.482

Table 5.2 Vegetation collected from study sites.

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Acalypha rhomboides	X	X		X		
Acer negundo	X	X		X		X
Acer rubrum	X					
Acer saccharinum		X				
Actinomeris alternifolia	X	X		X		
Aesculus glabra	X					
Agrostis hyemalis	X					
Ailanthus altissima		X	X			X
Alisma subcordatum		X			X	
Ambrosia artemisifolia	X	X	X		X	
Amphicarpa bracteata			X			
Apios americana	X					
Apocynum cannabinus						X
Arctium minus	X					
Aster lateriflorus		X	X	X		X
Bidens frondosa			X	X		
Bidens tripartite	X					
Boehmeria cylindrica		X		X	X	
Brassica nigra			X			
Campsis radicans	X					
Carex lupulina				X		X
Carex lurida						X
Cassia herbecarpa			X			
Cephalanthus occidentalis				X	X	
Ceratophyllum demersum		X				
Cercis canadensis					X	X
Chenopodium ambrosioides	X					
Cirsium arvense	X					
Cyperus strigosus	X		X			
Daucus carota			X			

Table 5.2 Continued

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Desmodium canescens			X			
Digitaria sanguinalis		X	X			
Echinochloa crusgalli	X					
Eleocharis obtusa			X		X	
Eupatorium perfoliatum					X	X
Eupatorium rugosum					X	
Eupatorium serotinum				X	X	
Euphorbia obtusata					X	
Filipendula ulmaria					X	X
Floerkea proserpinacoides		X			X	
Fraxinus americana					X	
Fraxinus pennsylvanica					X	X
Galinsoga ciliate	X					
Hibiscus militaris		X				
Hibiscus moscheutos				X		X
Hypericum virginicum					X	
Impatiens capensis	X	X		X	X	X
Juglans nigra	X					
Juncus acuminatus			X		X	
Juncus tenuis						X
Lactucca floridana		X				
Leersia oryzoides		X	X		X	
Leersia virginica		X				
Lemna minor	X					
Ligustrum vulgare		X				
Linum virginianum	X	X		X		
Liriodendron tulipifera						X
Lobelia siphilitica						X
Lonicera japonica	X			X	X	
Lonicera morrowi	X					
Ludwigia palustris			X			X
Lycopus americanus	X				X	X
Lysimachia nummularia				X		
Mentha spicata						X
Mimulus alatus					X	
Nelumba lutea						X
Nuphar advena	X	X				
Onoclea sensibilis					X	
Oxalis corniculata			X	X		
Oxalis europaea	X				X	
Oxalis grandis		X	X			X
Panicum clandestinum	X	X				
Panicum dichotomiflorum			X			
Panicum microcarpon	X					

Table 5.2 Continued

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Parthenocissus quinquefolia				X		
Phalaris arundinacea			X			
Phalaris canariensis	X					
Phytolacca americana	X			X		
Plantago lanceolata			X			X
Plantago rugelii		X				
Platanus occidentalis	X				X	X
Polygala sangiunea			X	X	X	
Polygonum cespitosum	X		X			
Polygonum coccineum		X				
Polygonum hydropiperoides	X		X			
Polygonum pensylvanicum		X				
Polygonum persicaria		X	X			
Polygonum sagittatum		X				
Prunus serotina	X	X				
Quercus palustris	X					
Rhus copallina						X
Rhus glabra	X					
Rhus radicans	X					
Robinia pseudo-acacia		X				
Rosa multiflora	X	X				
Rotala ramosiora			X			
Rubus occidentalis	X	X			X	X
Rudbeckia laciniata				X	X	
Rumex obtusifolus		X				
Salix nigra			X			
Sambucus canadensis	X	X				
Saururus cernuus	X					
Scirpus americanus					X	
Setoria glauca	X					
Sida hermaphrodita		X				
Solanum nigrum	X					
Solidago canadensis	X					X
Sonchus asper			X	X		
Spirodela polyrhiza		X				
Taraxacum officinale			X			
Trifolium pretense			X			
Ulmus rubra				X		
Vernonia altissima	X					
Vitis aestivalis	X	X	X	X		

Table 5.3 Mammals captured or observed at study sites.

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Castor canadensis		X				
Didelphis virginiana	X	X	X	X	X	X
Peromyscus leucopus	X	X		X	X	X
Procyon lotor	X	X	X	X	X	X
Rattus norvegicus	X	X		X	X	
Tamias striatus				X	X	X

Table 5.4 Fish captured at study sites.

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Chaenobryttus gulosus		X			X	
Cyprinus carpio						X
Ictalurus melas					X	
Ictalurus natalis					X	X
Ictalurus punctatus			X	X		
Lepomis cyanellus					X	X
Lepomis macrochirus		X	X	X	X	X
Lepomis megalotis					X	
Micropterus dolomieui		X	X	X	X	X
Micropterus salmoides				X	X	
Pomoxis annularis			X			X

Table 5.5 Turtles captured at study sites.

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Chrysemys picta marginata	X		X	X	X	X
Chelydra s. serpentina			X	X	X	X
Sternotherus odoratus		X	X	X	X	X

Table 5.6 Benthic insects collected from study sites.

Genera	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Allocapnia	X		X		X	X
Allonarcys		X	X	X		X
Amaletus	X	X			X	X
Amphinuemura		X	X		X	
Baetis	X	X		X	X	
Belostoma	X		X			X
Boyeria		X	X	X		X
Brachycentrus	X	X			X	X
Caenis				X	X	
Callibaetis	X	X			X	X
Capnia			X	X	X	X
Chaoborus	X	X			X	
Chauliodes			X			
Chironomus		X			X	X
Corydalus		X	X		X	
Dineutus	X	X	X	X	X	X
Dolophilodes	X	X	X	X	X	X
Dytiscus	X				X	X
Ephemera	X	X	X		X	X
Ephemerella		X	X			
Erythemis	X		X	X		X
Gerris		X	X	X	X	X
Glossosoma						X
Hexagenia	X					X
Hydrophilus	X	X	X			X
Hydropsyche				X	X	X
Isonychia	X			X		X
Isoperla		X	X	X	X	X
Leptophlebia	X	X				
Lestes	X		X		X	X
Macromia	X	X	X	X	X	X
Nigronia			X	X		
Notonecta	X	X				X
Ophiogomphus	X					X
Parameletus	X	X		X	X	X
Psephenus	X		X	X	X	
Pycnopsyche	X	X	X			X
Rhyacophila	X		X	X	X	
Ranatra	X	X				
Sigara		X				
Simulium	X		X	X		X
Stenonema			X	X	X	X
Taeniopteryx	X					X
Tipula	X	X	X	X	X	X

FIGURE 1.1 ADULT *A. C. BLANCHARDI* FROM LAWRENCE COUNTY, OHIO.

Photo by Nancy J. Dickson.

FIGURE 1.2 THE THREE COLOR MORPHS OF *A. C. BLANCHARDI* COLLECTED FROM SITE 5.

Photo by Nancy J. Dickson

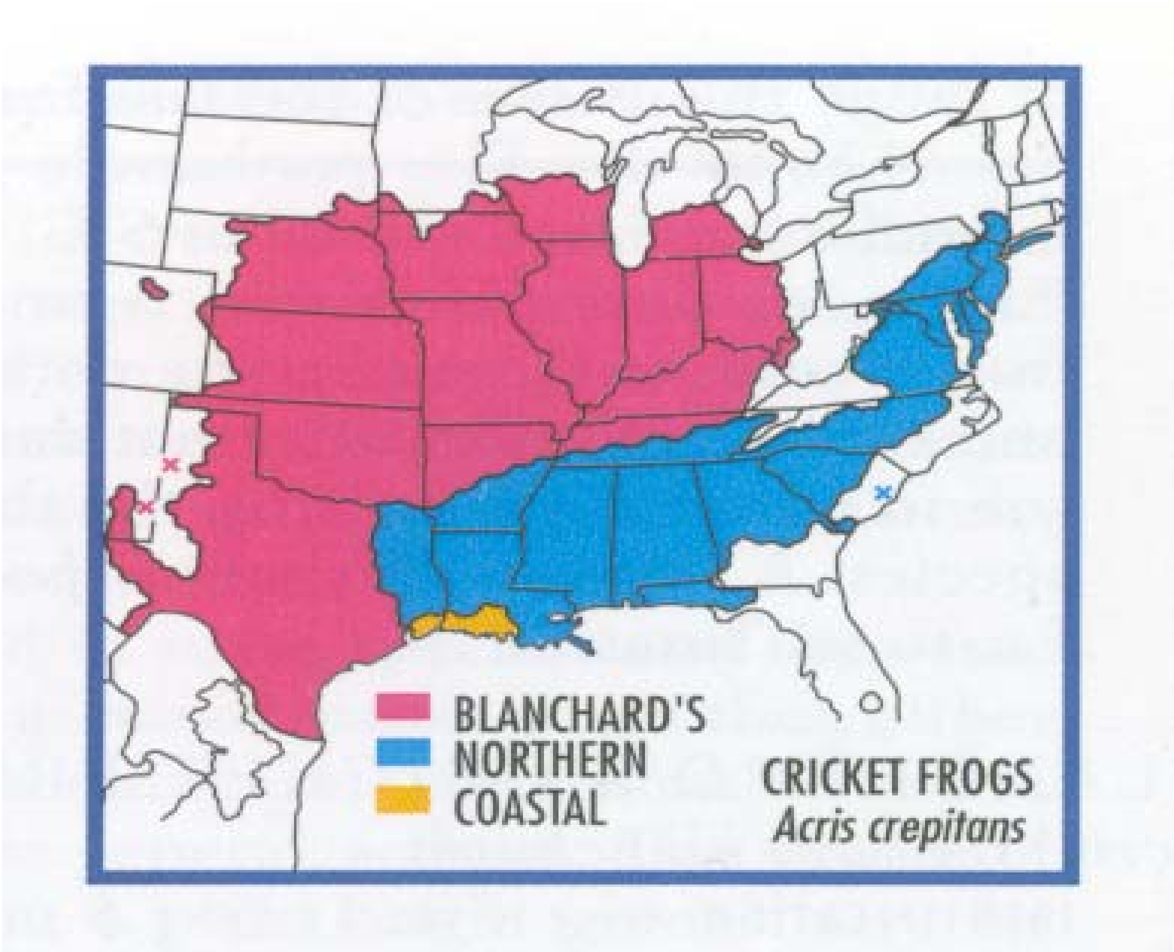


FIGURE 1.3 THE DISTRIBUTION OF *A. C. BLANCHARDI* IN NORTH AMERICA ACCORDING TO CONANT AND COLLINS (1998).

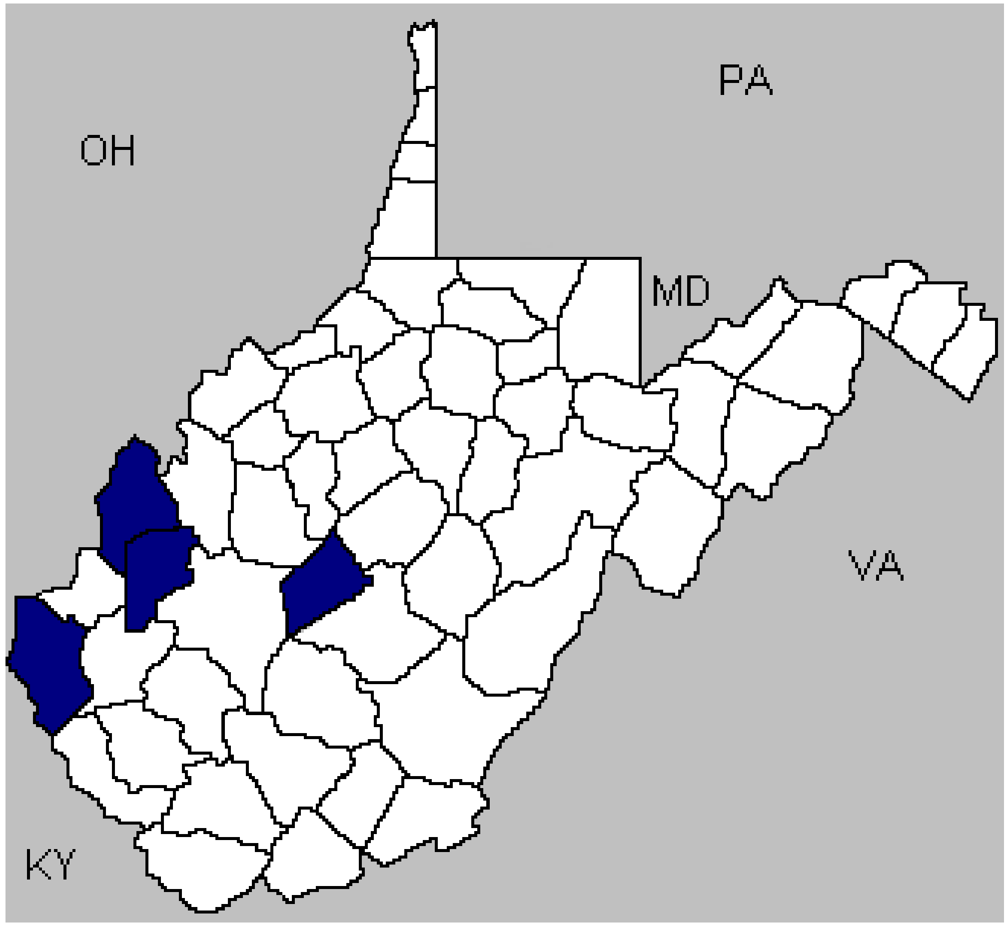


FIGURE 1.4 THE DISTRIBUTION OF *A. C. BLANCHARDI* IN WEST VIRGINIA ACCORDING TO GREEN AND PAULEY (1987).

FIGURE 1.5 THE DISTANCE FROM THE LAST HISTORICAL SITE OF *A. C. BLANCHARDI* IN WEST VIRGINIA (RED ARROW) TO THE NEAREST CURRENT SITE IN OHIO (BLUE ARROW) IN JULY 2000.

FIGURE 1.6 LOCATION OF ALL STUDY SITES.

Historical sites are red, current sites are blue, and potential sites are yellow.

FIGURE 1.7 SITE 1 IN MASON COUNTY, WEST VIRGINIA.

Photo by Nancy J. Dickson.

FIGURE 1.8 SITE 2 IN MASON COUNTY, WEST VIRGINIA.

Photo by Nancy J. Dickson.

FIGURE 1.9 SITE 3 IN LAWRENCE COUNTY, OHIO.

Photo by Nancy J. Dickson.

FIGURE 1.10 SITE 4 IN LAWRENCE COUNTY, OHIO.

Photo by Nancy J. Dickson.

FIGURE 1.11 SITE 5 IN LAWRENCE COUNTY, OHIO.

Photo by Nancy J. Dickson.

FIGURE 1.12 SITE 6 IN LAWRENCE COUNTY, OHIO.

Photo by Nancy J. Dickson.

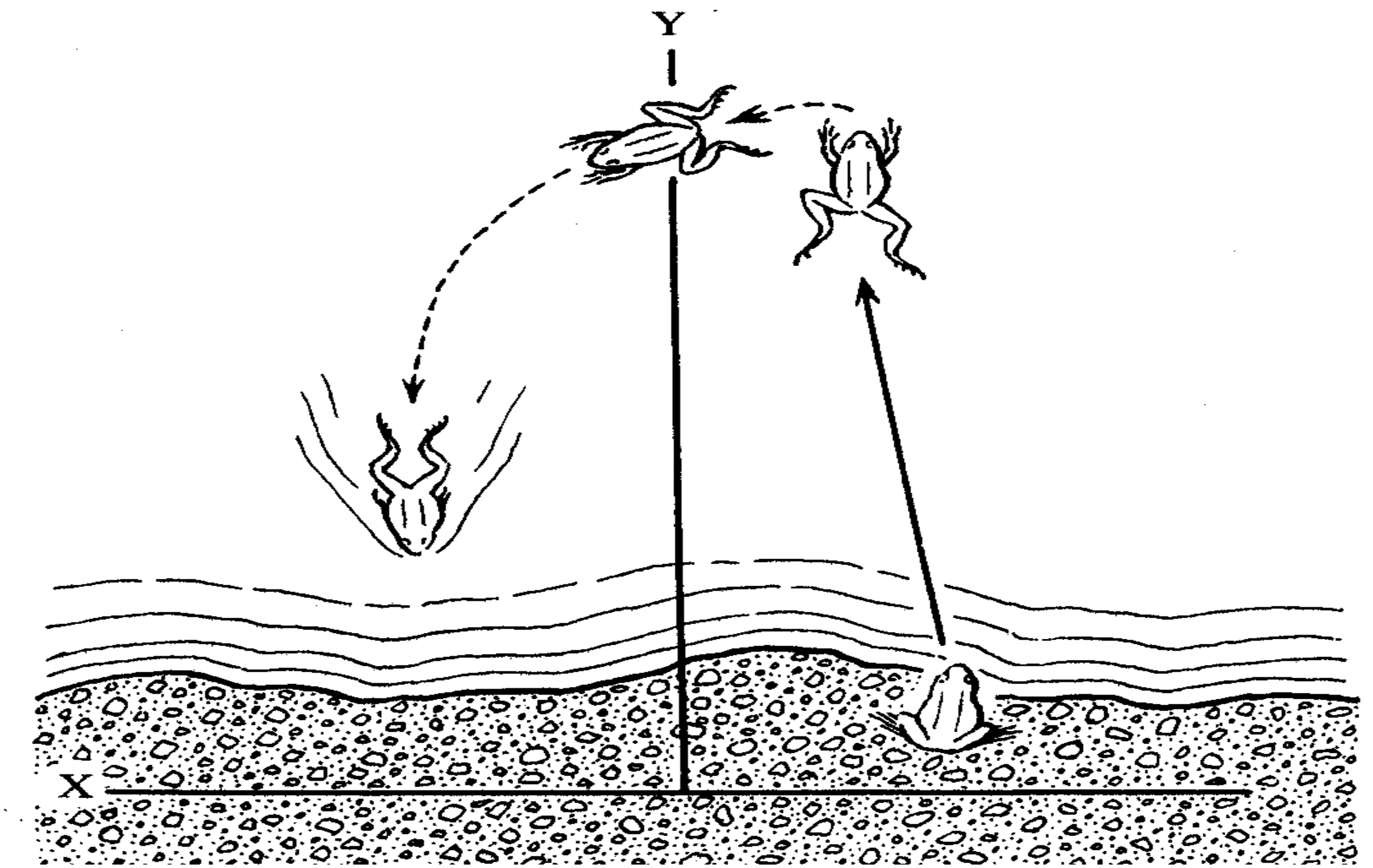


FIGURE 2.1 PATTERN OF ESCAPE EXHIBITED BY MANY FROGS ACCORDING TO STEBBINS AND COHEN (1995).

FIGURE 2.2 INJECTING A FROG WITH ELASTOMER.

Photo by Nancy J. Dickson.

FIGURE 2.3 ELASTOMER INJECTED INTO THE LEFT LEG.

Photo by Zach Felix.

FIGURE 2.4 INJECTED ELASTOMER UNDER BLACK LIGHTING.

Photo by Nancy J. Dickson.

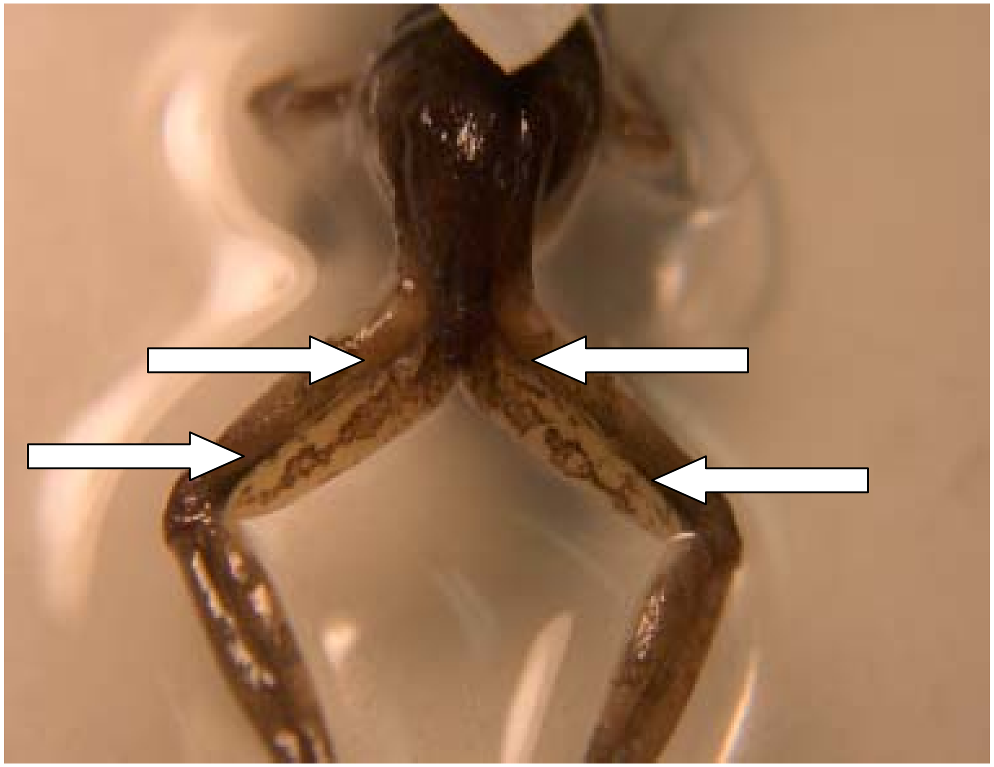


FIGURE 2.5 THE 4 POSSIBLE LOCATIONS FOR ELASTOMER INJECTIONS.

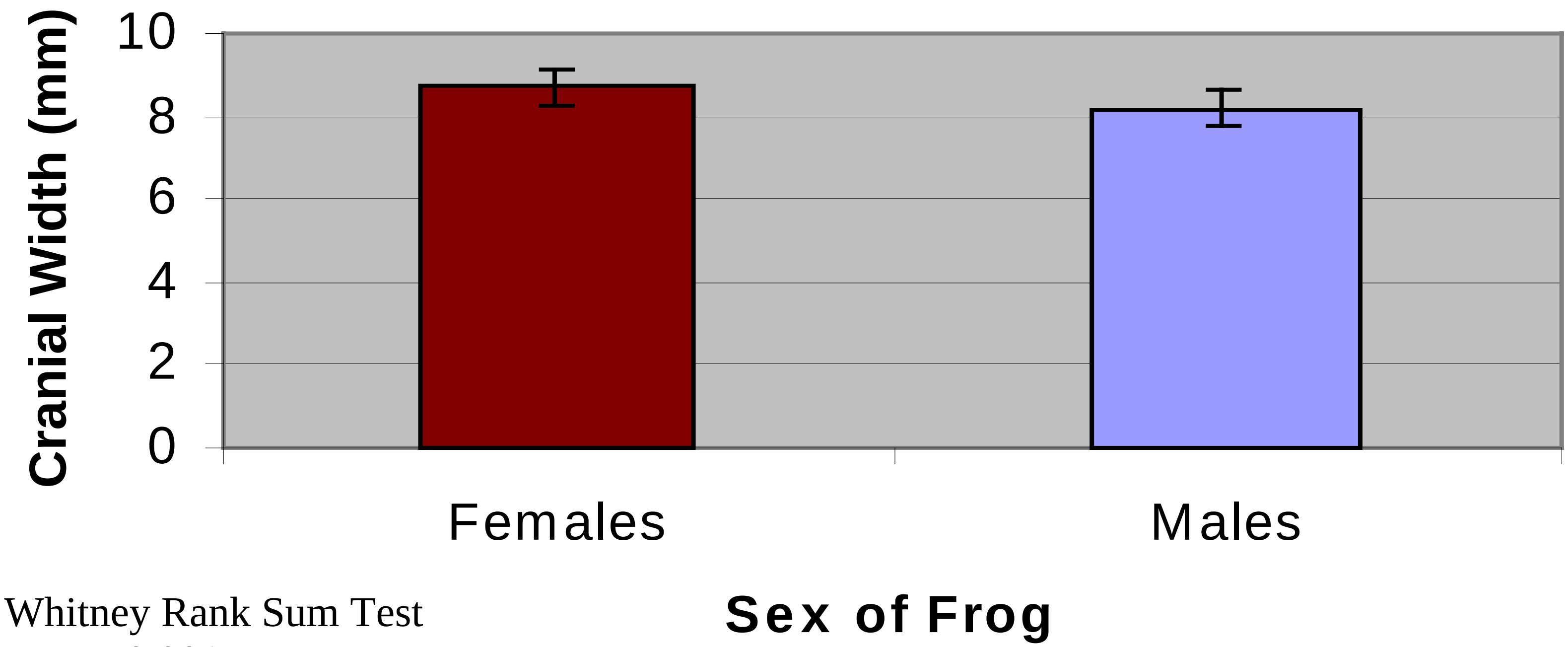
Photo by Nancy J. Dickson.

FIGURE 2.6 FLAGGING SYSTEM USED TO MARK THE LOCATION OF THE CAPTURE SITES FOR FROGS.

Capture site for frog Number 1 shown.
Photo by Nancy J. Dickson.

FIGURE 2.7 SCREEN BOX USED FOR MONITORING LARVAL GROWTH.

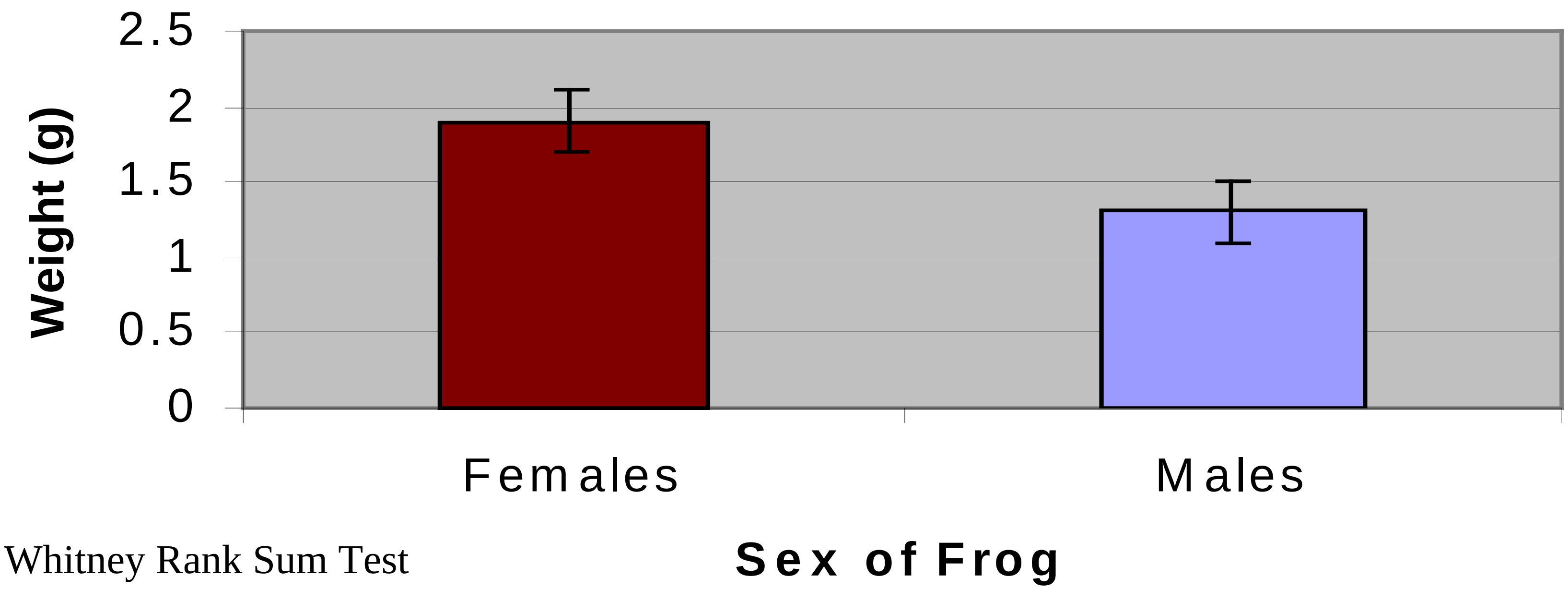
Photo by Nancy J. Dickson.



Mann Whitney Rank Sum Test
P=<0.001

FIGURE 2.8 AVERAGE CRANIAL WIDTHS OF FEMALES (N=56) AND MALES (N=98) CAPTURED AT SITE 5.

Y error bars represent standard deviations



Mann Whitney Rank Sum Test
P=<0.001

FIGURE 2.9 AVERAGE WEIGHT OF FEMALES (N=56) AND MALES (N=98) CAPTURED AT SITE 5.

Y error bars represent standard deviations.

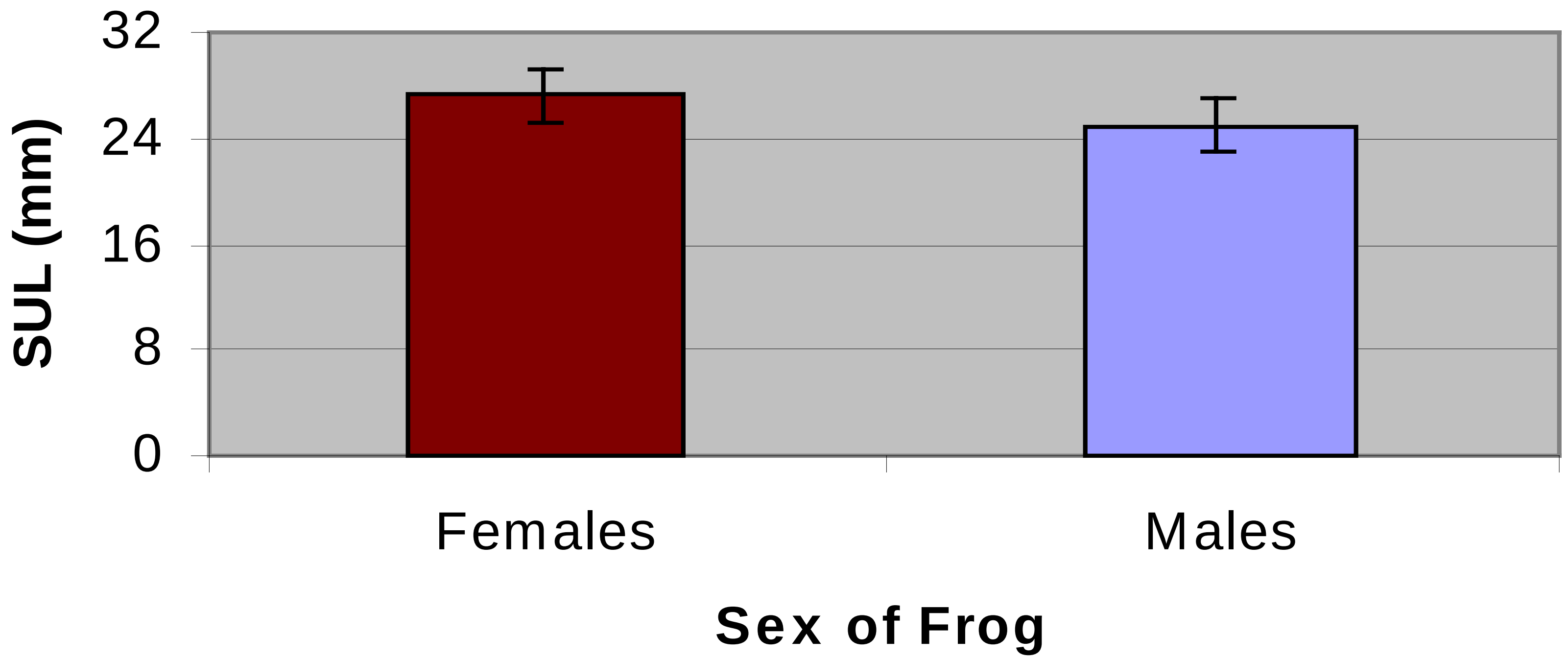
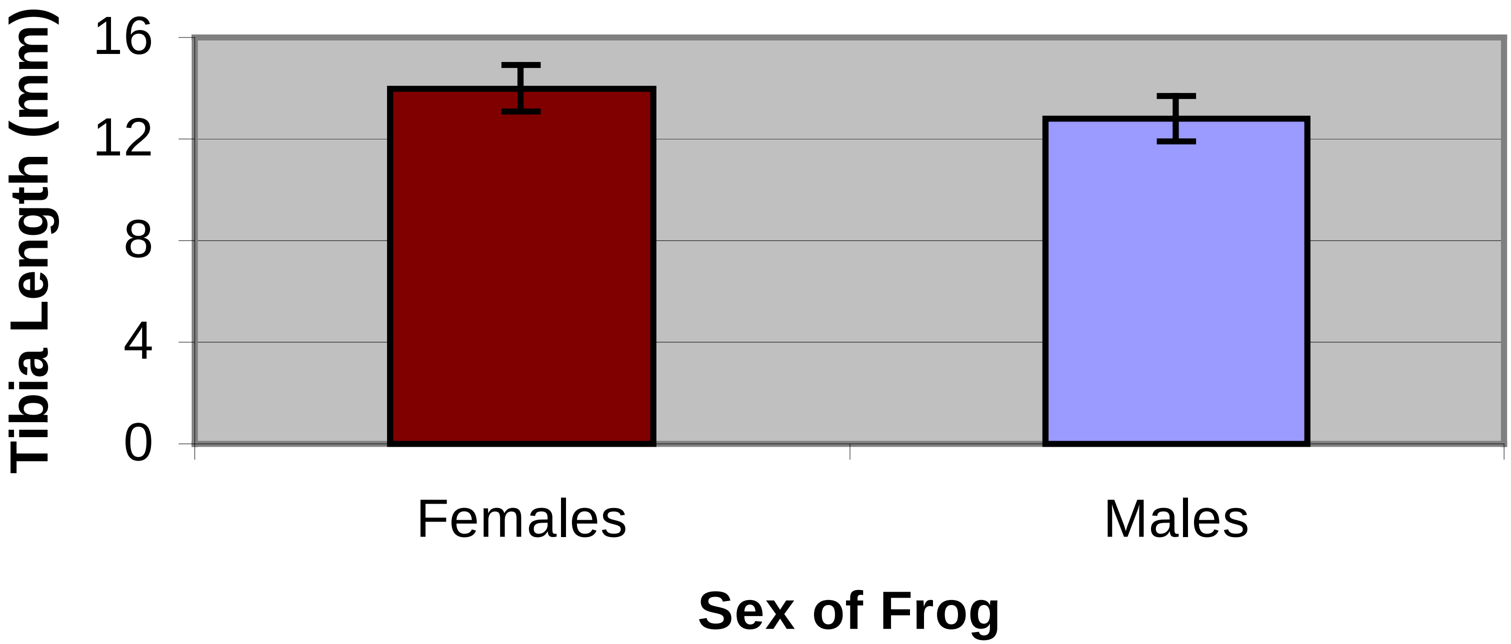


FIGURE 2.10 AVERAGE SNOUT-TO-UROSTYLE LENGTH OF FEMALES (N=56) AND MALES (N=98) CAPTURED AT SITE 5.

Mann Whitney Rank Sum Test
P=<0.001

Y error bars represent standard deviations.



Mann Whitney Rank Sum
P=<0.001

FIGURE 2.11 TIBIA LENGTH OF FEMALES AND MALES CAPTURED AT SITE 5.

Y error bars represent standard deviations.

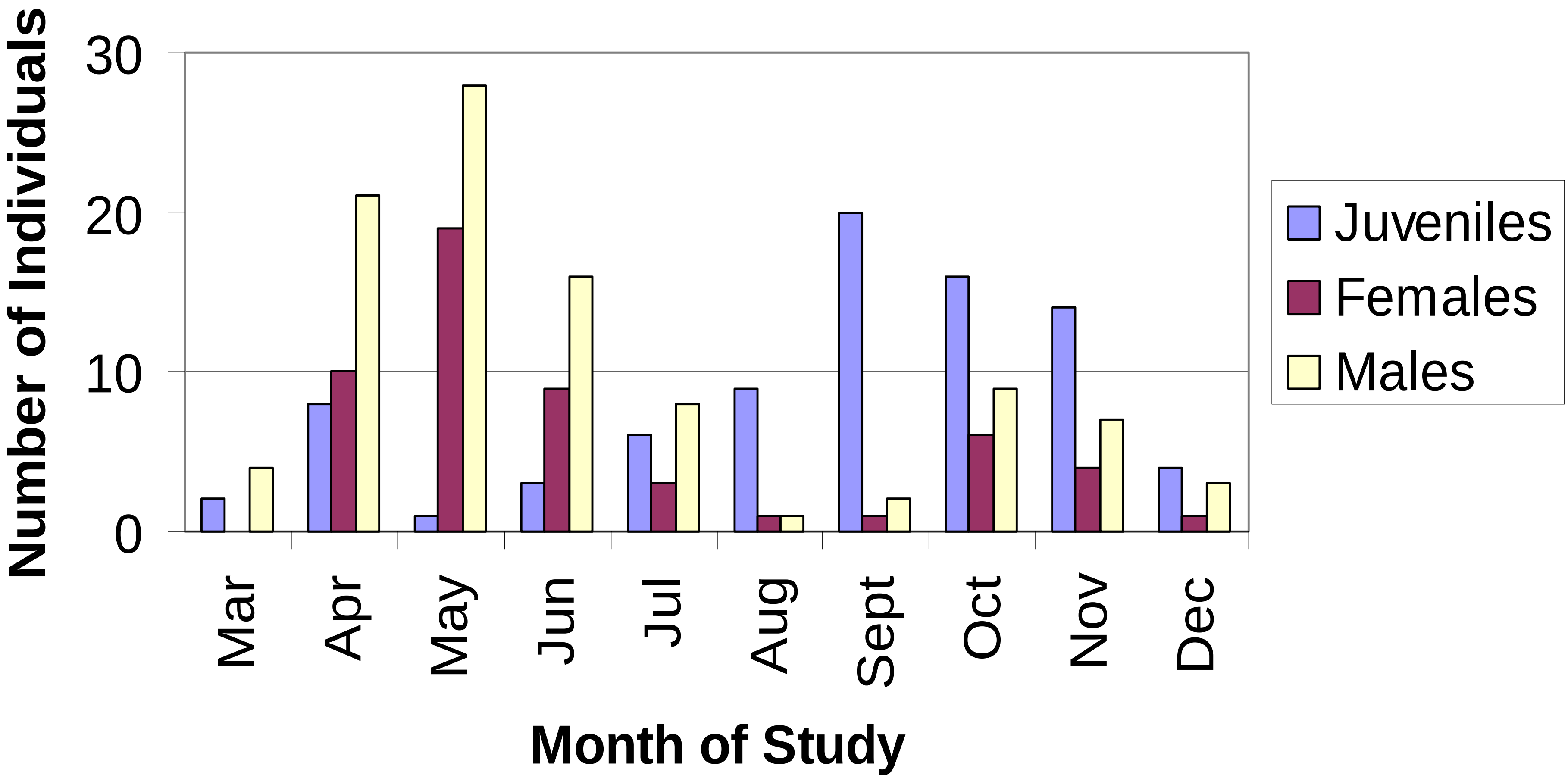


FIGURE 2.12 NUMBER OF JUVENILES, FEMALES, AND MALES CAPTURED PER MONTH FROM SITE 5.

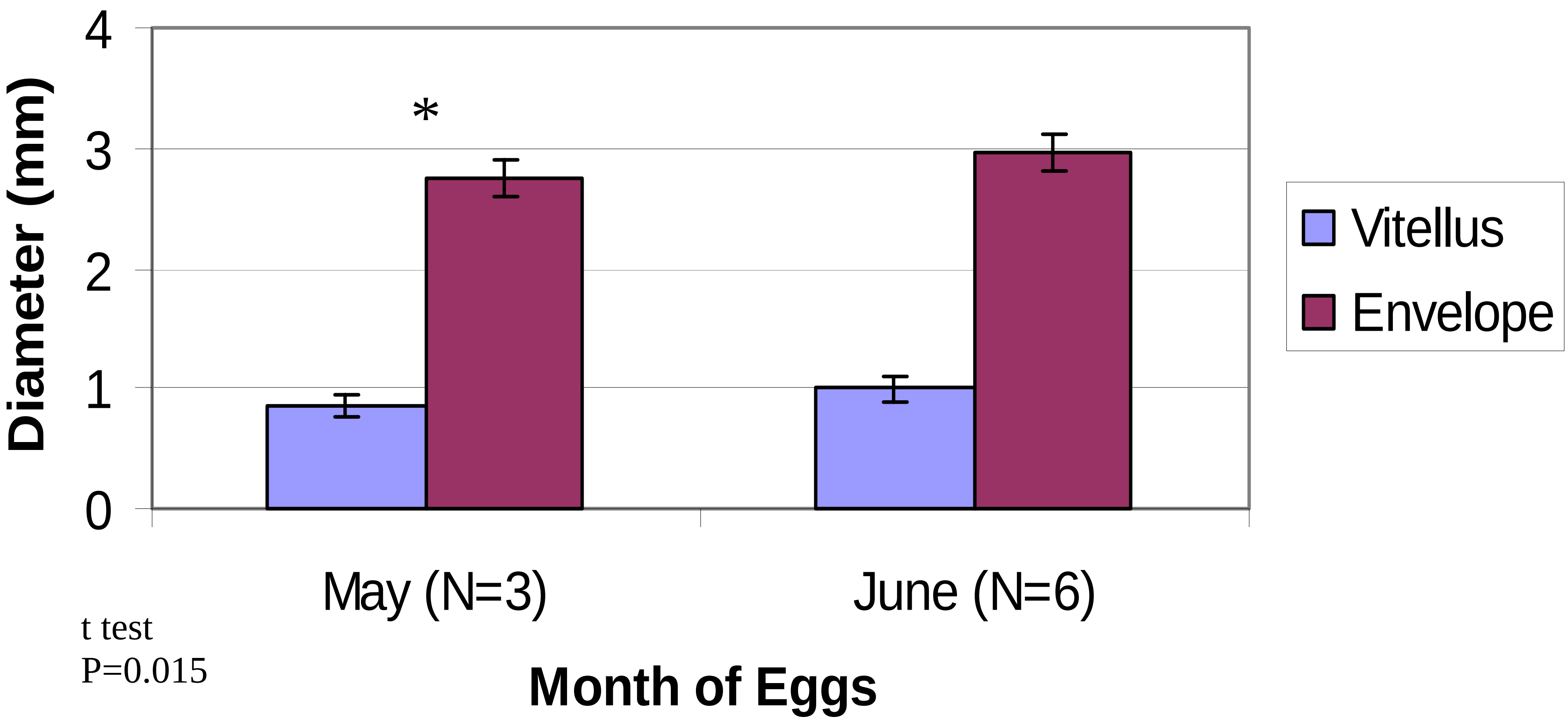


FIGURE 2.13 AVERAGE MEASUREMENTS OF EGGS (N=9) WHEN DISCOVERED.

Y error bars represent standard deviations.

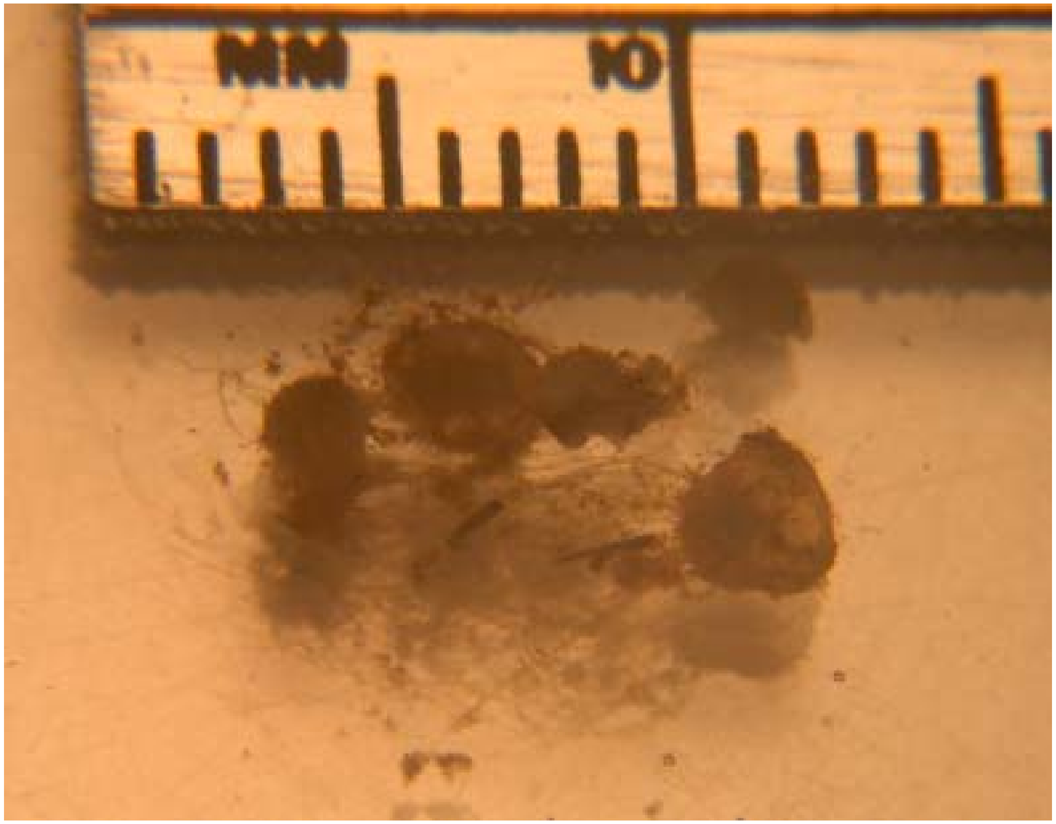


FIGURE 2.14 EGGS OF *ACRIS CREPITANS*.

Photo by Nancy J. Dickson.

FIGURE 2.15 PRESERVED TADPOLE OF *ACRIS CREPITANS*.

Photo by Nancy J. Dickson.

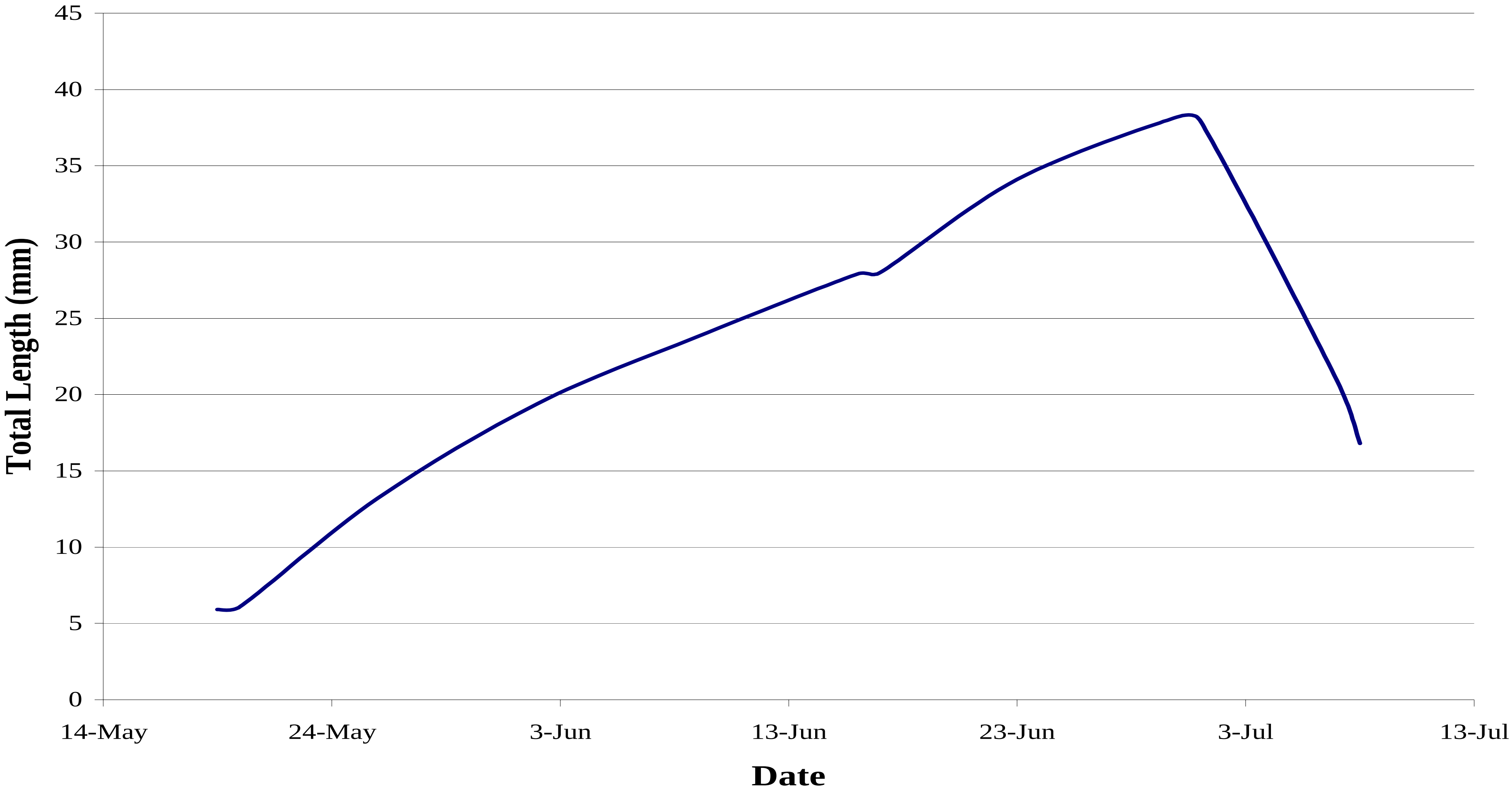


FIGURE 2.16 GROWTH OF TADPOLE NUMBER 1.

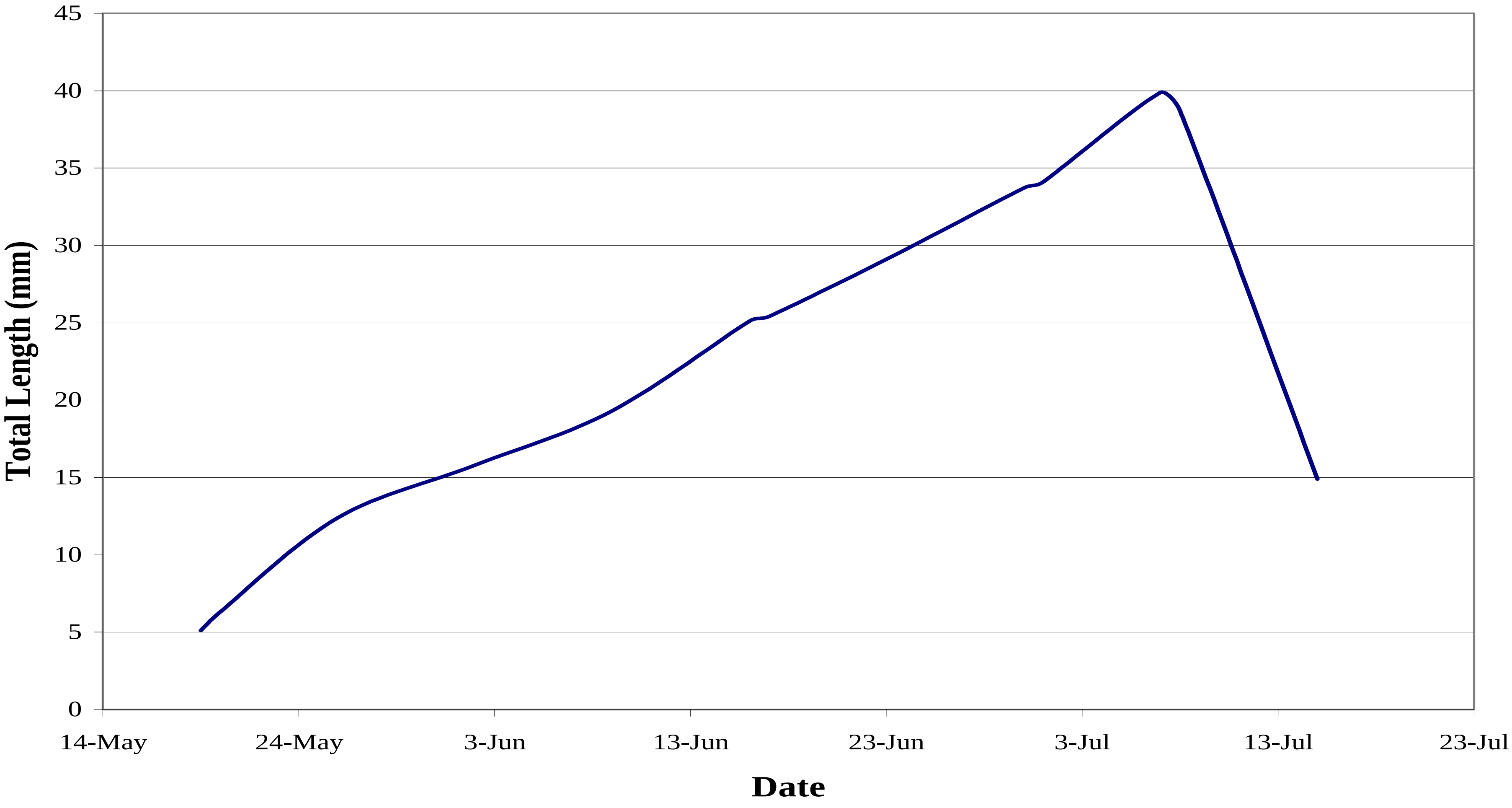


FIGURE 2.17 GROWTH OF TADPOLE NUMBER 2.

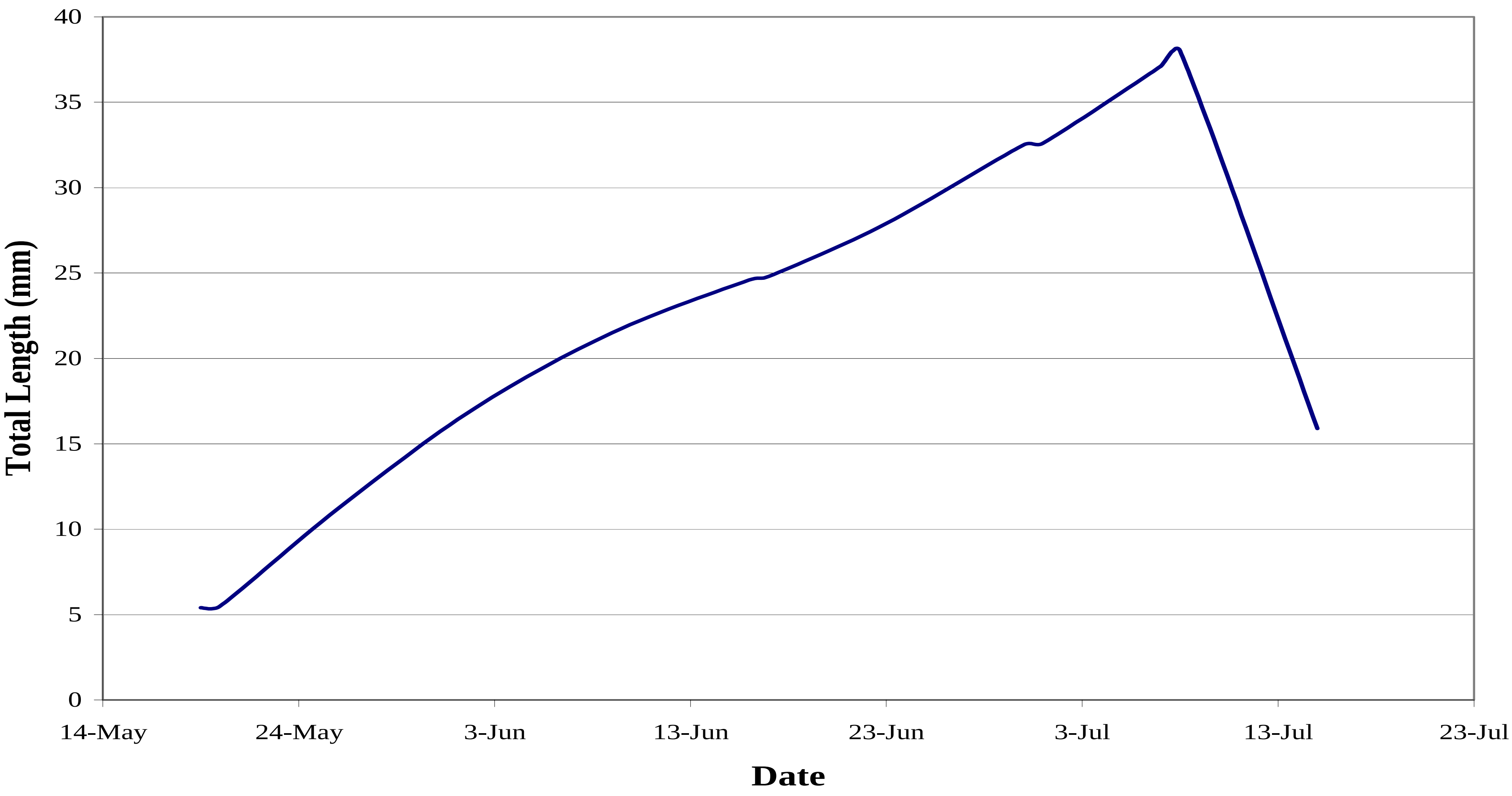


FIGURE 2.18 GROWTH OF TADPOLE NUMBER 3.

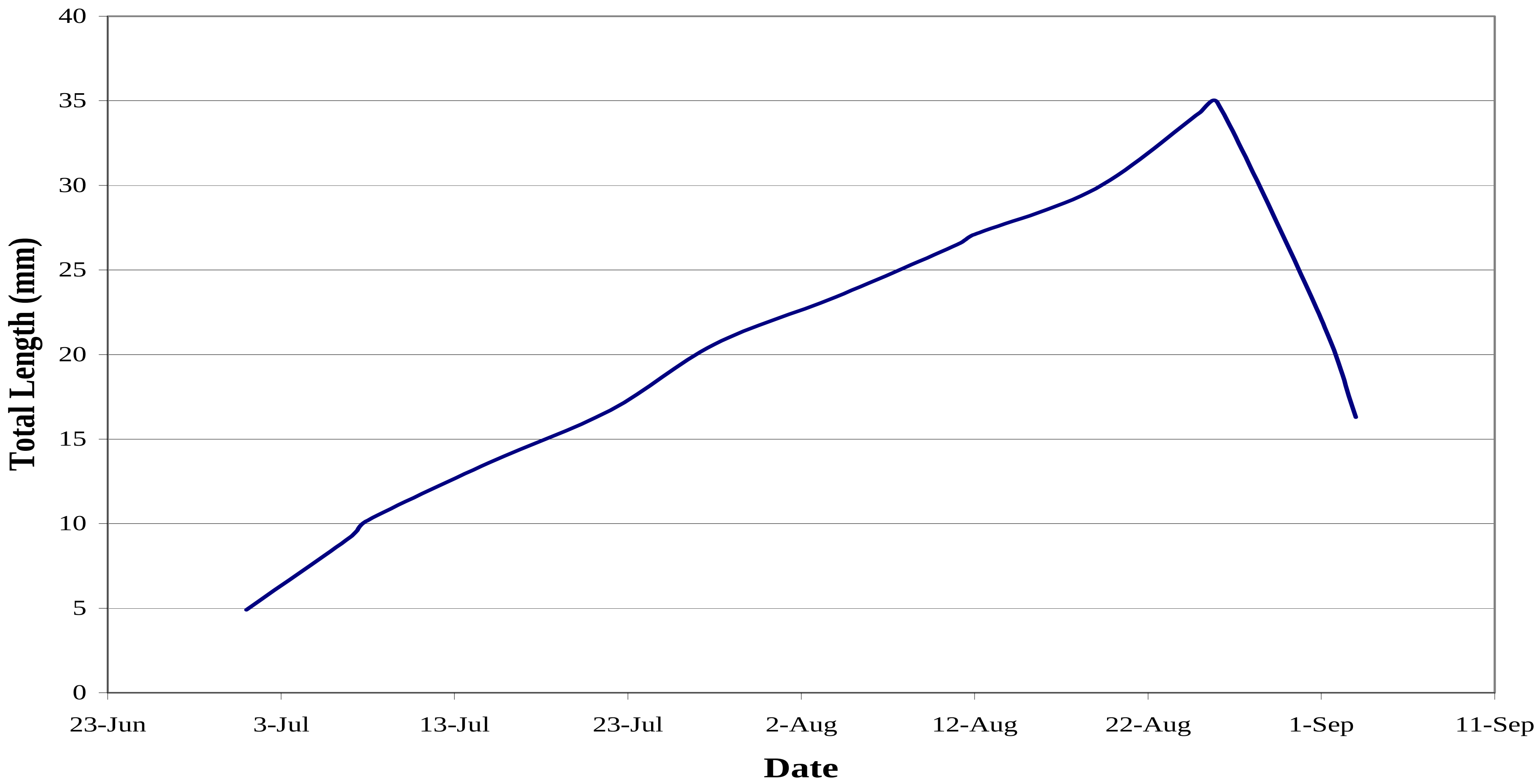


FIGURE 2.19 GROWTH OF TADPOLE NUMBER 4.

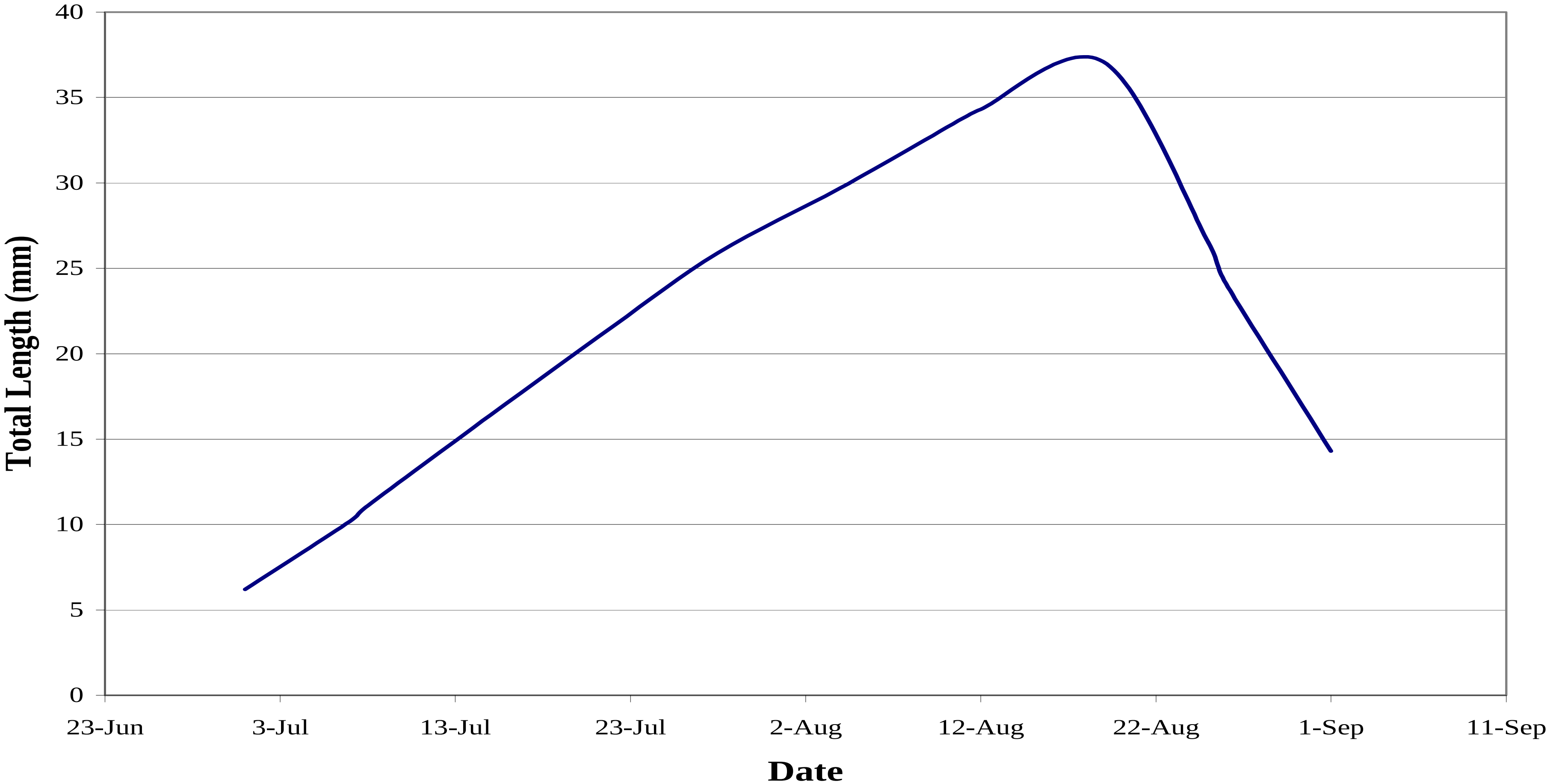


FIGURE 2.20 GROWTH OF TADPOLE NUMBER 5.

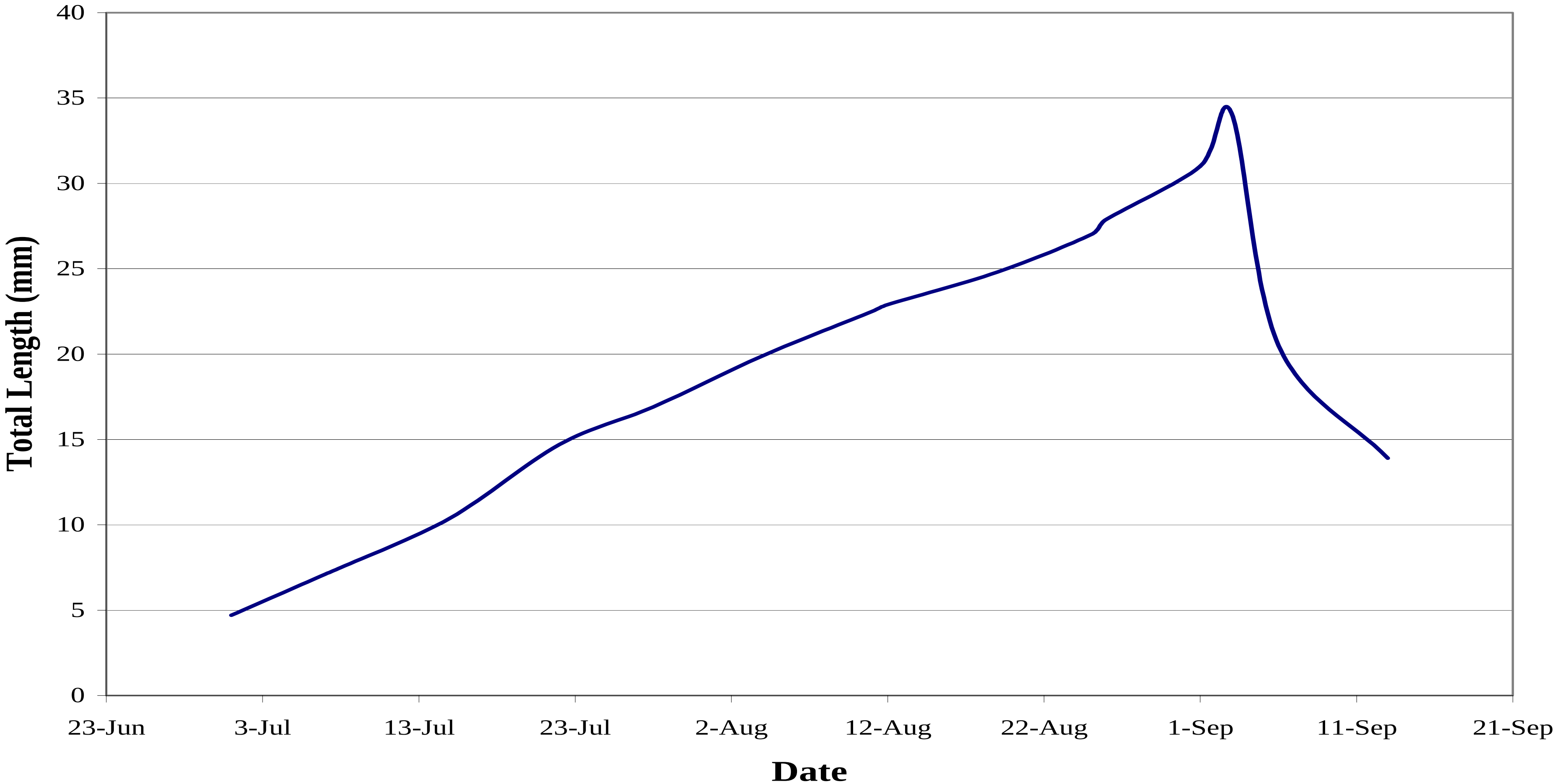


FIGURE 2.21 GROWTH OF TADPOLE 6.

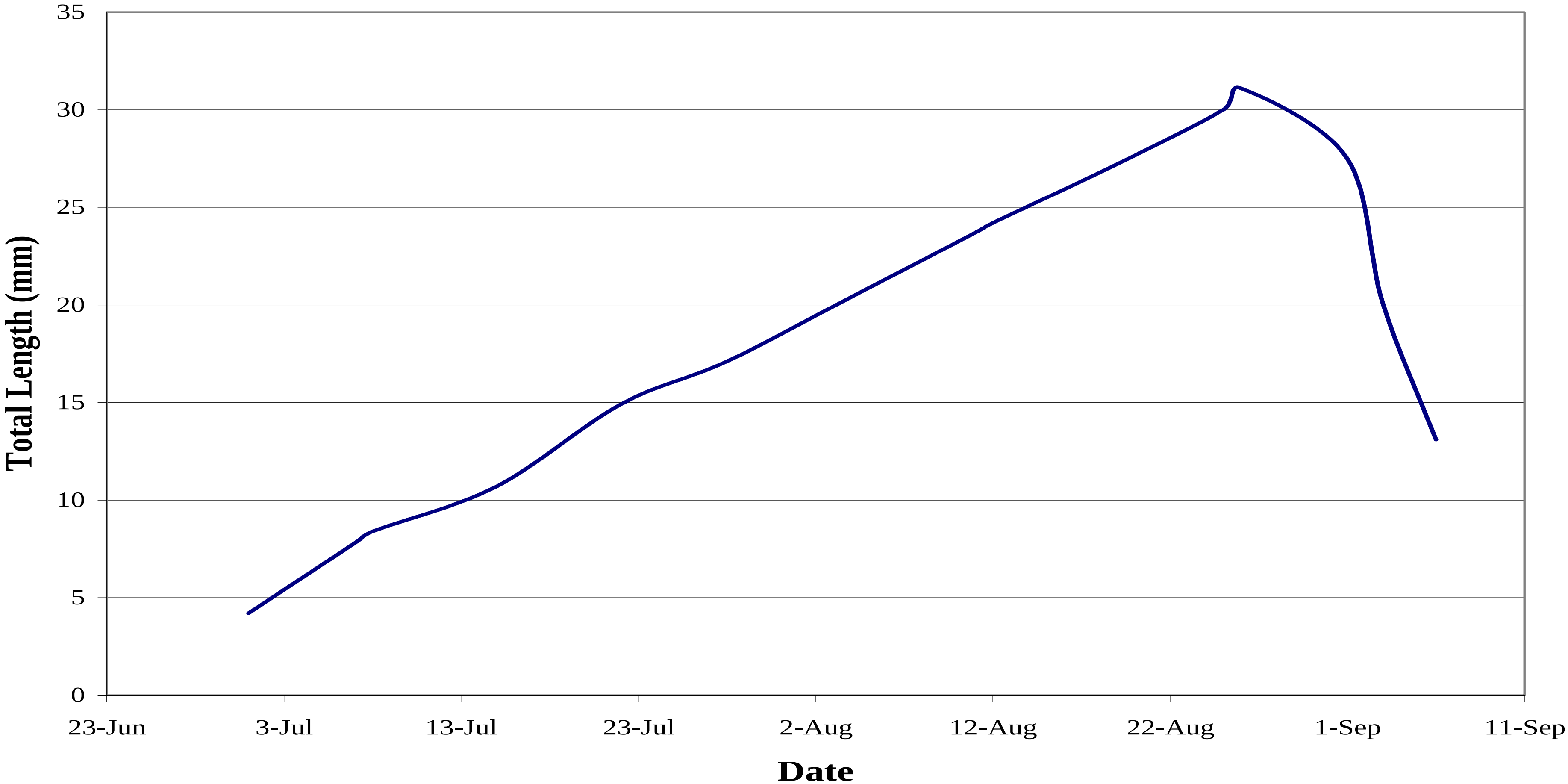


FIGURE 2.22 GROWTH OF TADPOLE NUMBER 7.

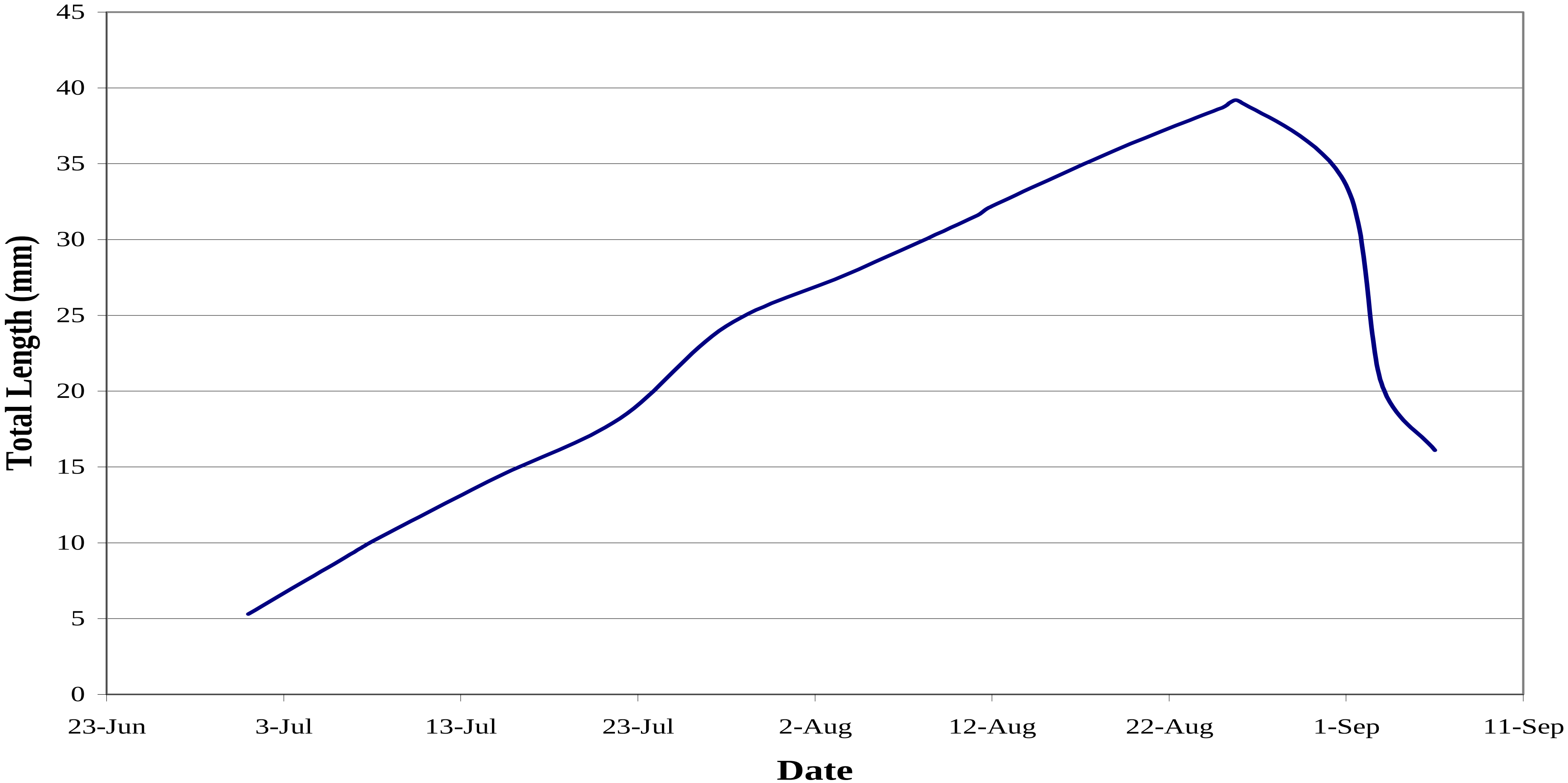


FIGURE 2.23 GROWTH OF TADPOLE NUMBER 8.

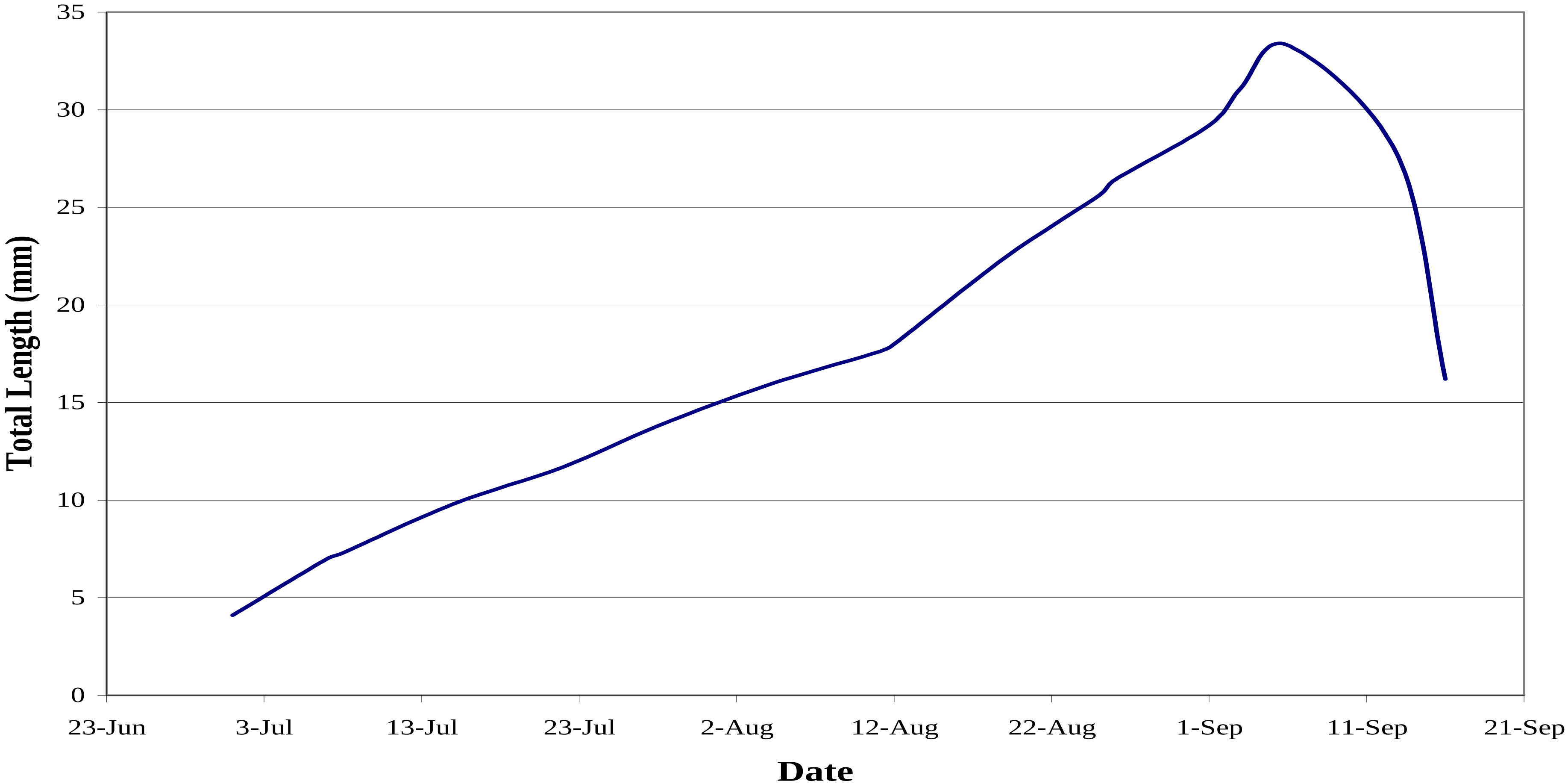
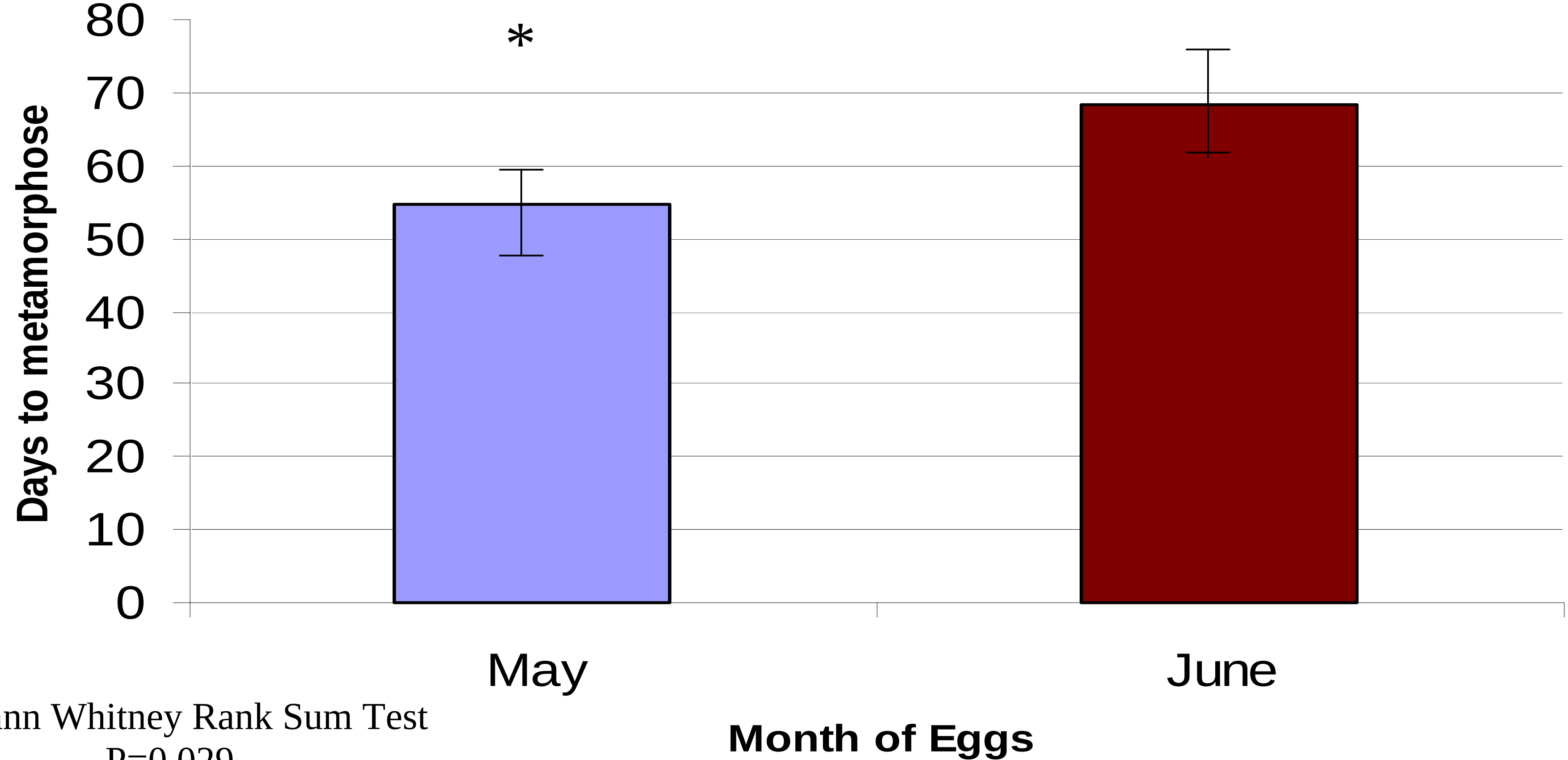


FIGURE 2.24 GROWTH OF TADPOLE NUMBER 9.



Mann Whitney Rank Sum Test
P=0.029

FIGURE 2.25 AVERAGE NUMBER OF DAYS REQUIRED TO METAMORPHOSE FOR TADPOLES FROM MAY EGGS (N=3) AND TADPOLES FROM JUNE EGGS (N=6) MONITORED IN SCREEN BOXES. Y error bars represent standard deviations.

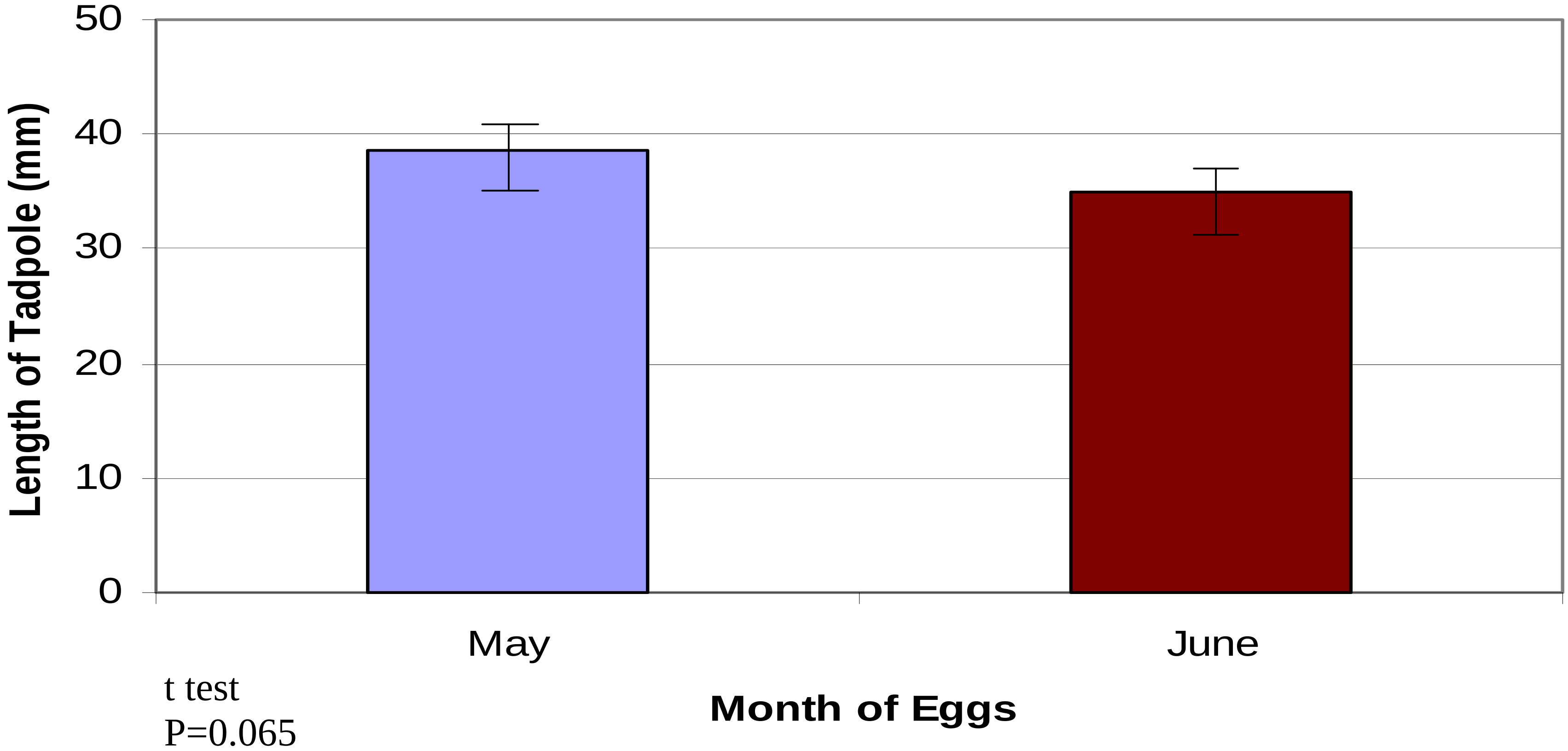
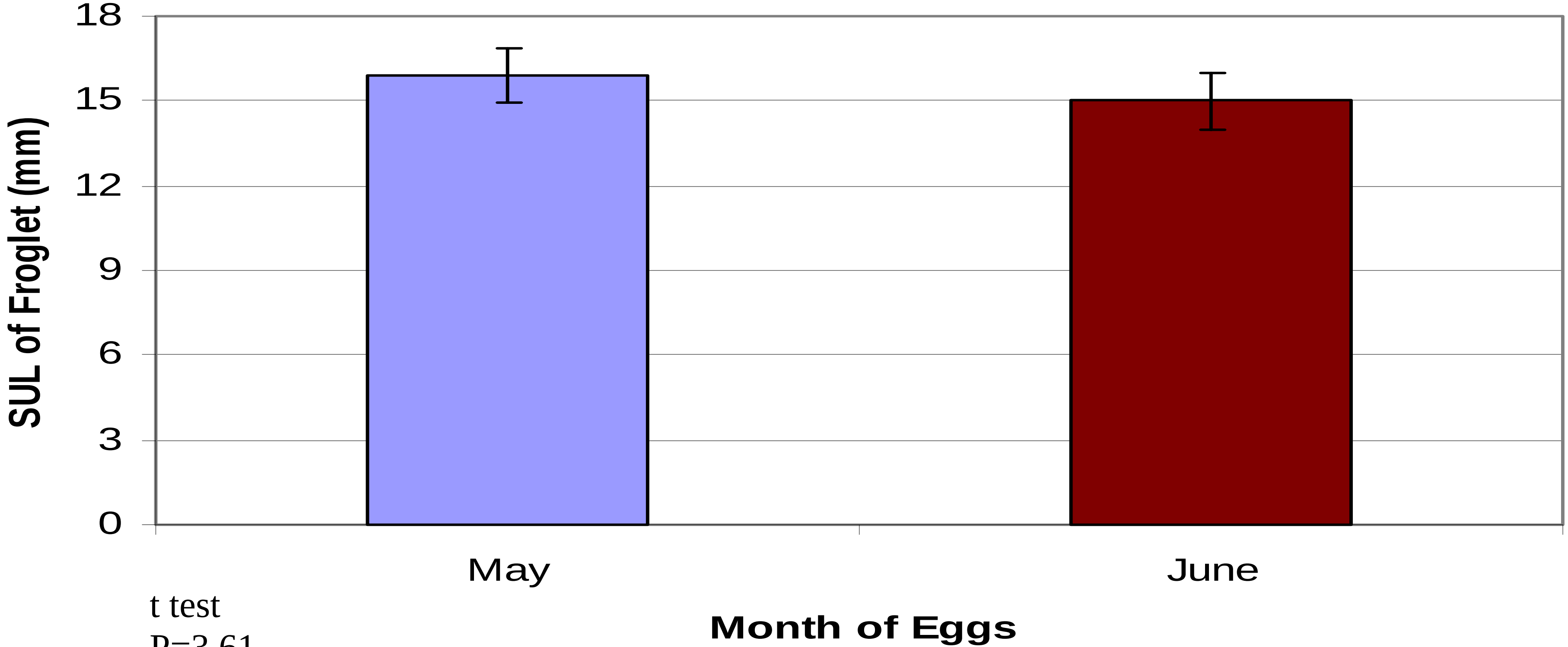


FIGURE 2.26 GREATEST LENGTH ATTAINED BY TADPOLES FROM EGGS DISCOVERED IN MAY (N=3) AND TADPOLES FROM EGGS DISCOVERED IN JUNE (N=6) MONITORED IN SCREEN BOXES.
Y error bars represent standard deviations.



t test
P=3.61

FIGURE 2.27 SUL OF FROGLETS FOR TADPOLES FROM MAY EGGS (N=3) AND TADPOLES FROM JUNE EGGS (N=6) MONITORED IN SCREEN BOXES.
Y error bars represent standard deviations.

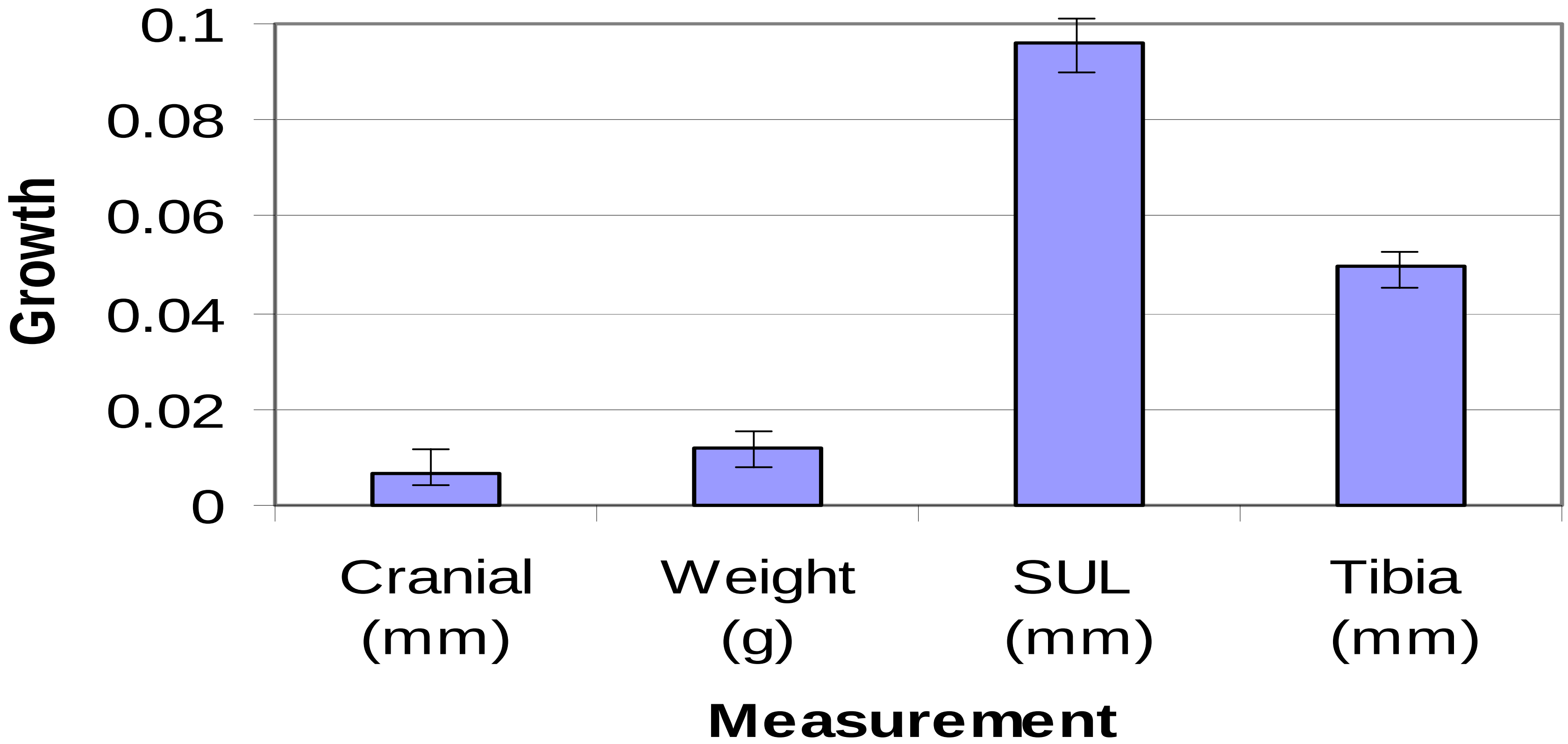
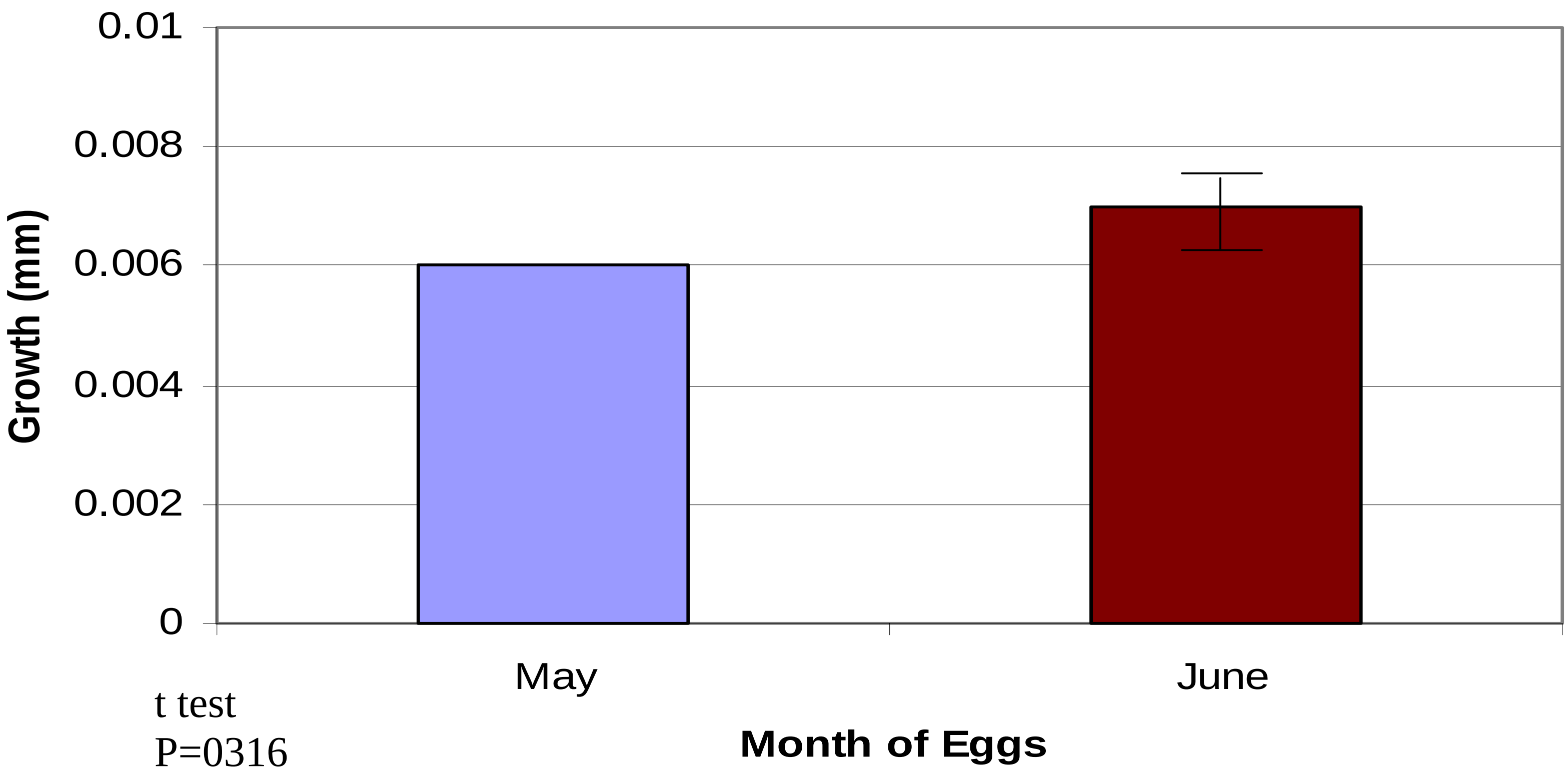


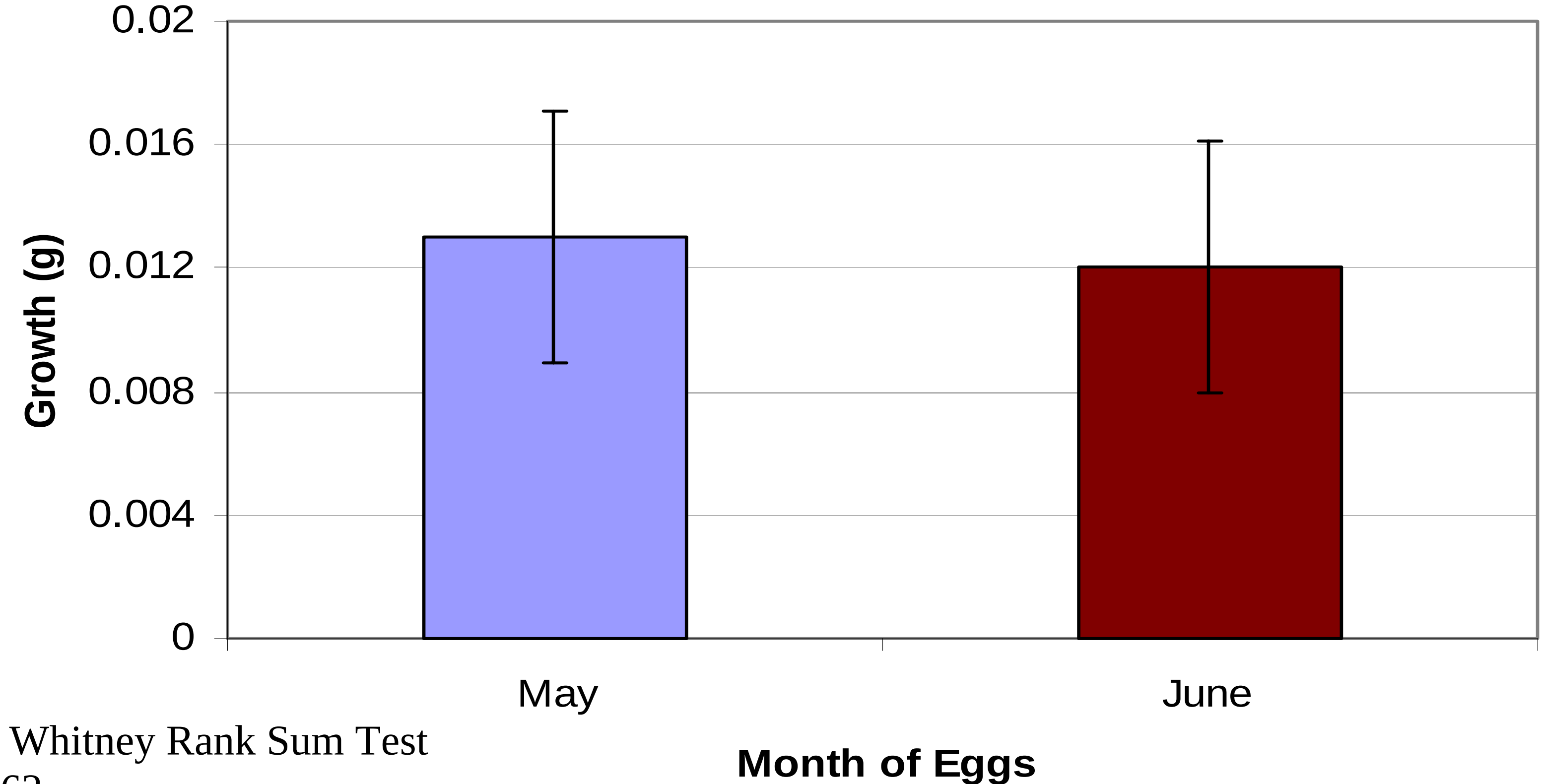
FIGURE 2.28 AVERAGE DAILY CRANIAL, WEIGHT, SUL, AND TIBIA GROWTH OF JUVENILES MONITORED IN SCREEN BOXES.

Averages are calculated by dividing the total growth by number of days monitored.
Y error bars represent standard deviations.



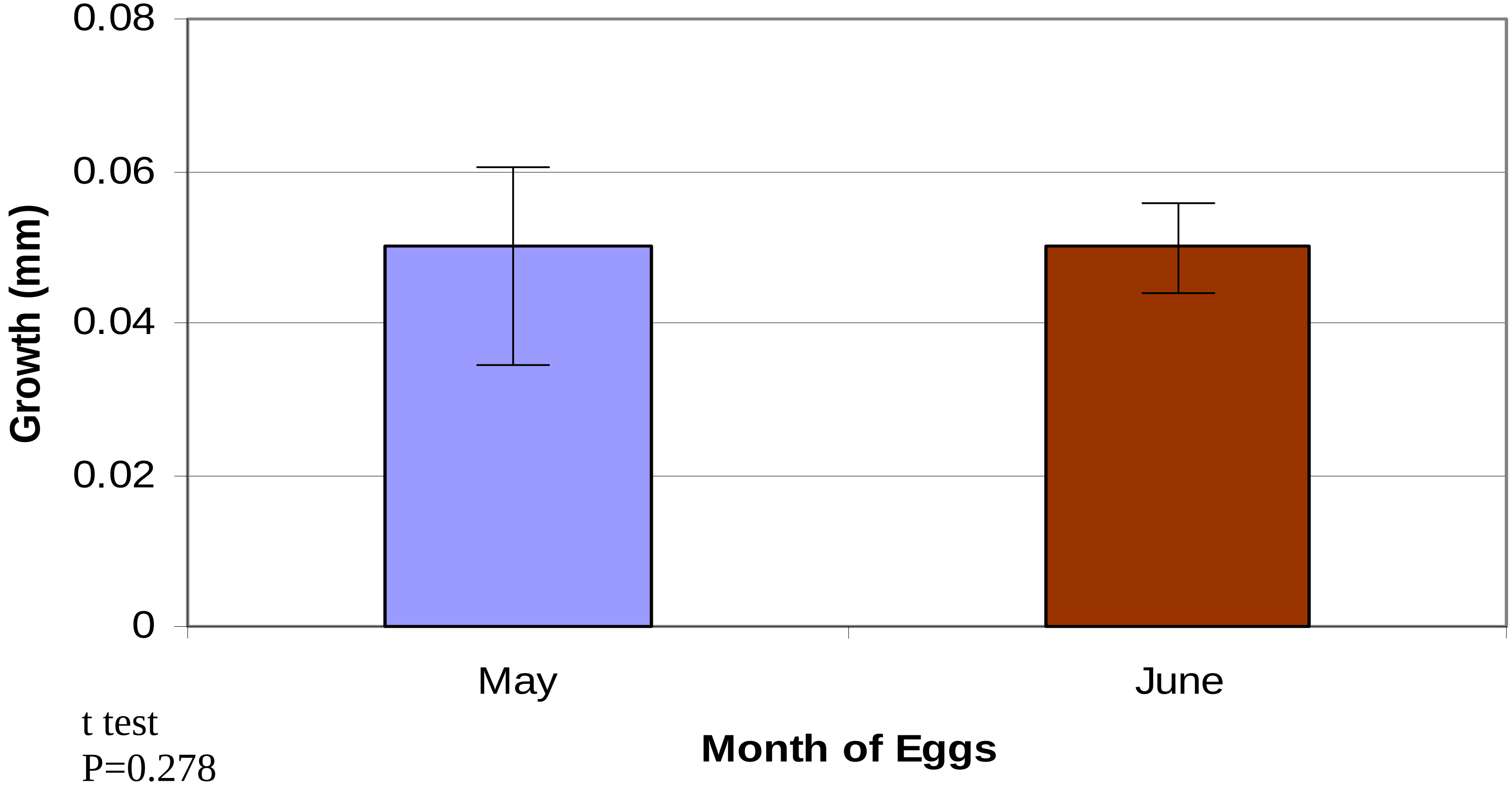
t test
P=0316

FIGURE 2.29 AVERAGE DAILY GROWTH IN CRANIAL WIDTH OF JUVENILES FROM MAY EGGS (N=3) AND JUNE EGGS (N=6) MONITORED AT SITE 5.
Averages are calculated by dividing the total growth by number of days monitored.
Y error bars represent standard deviations.



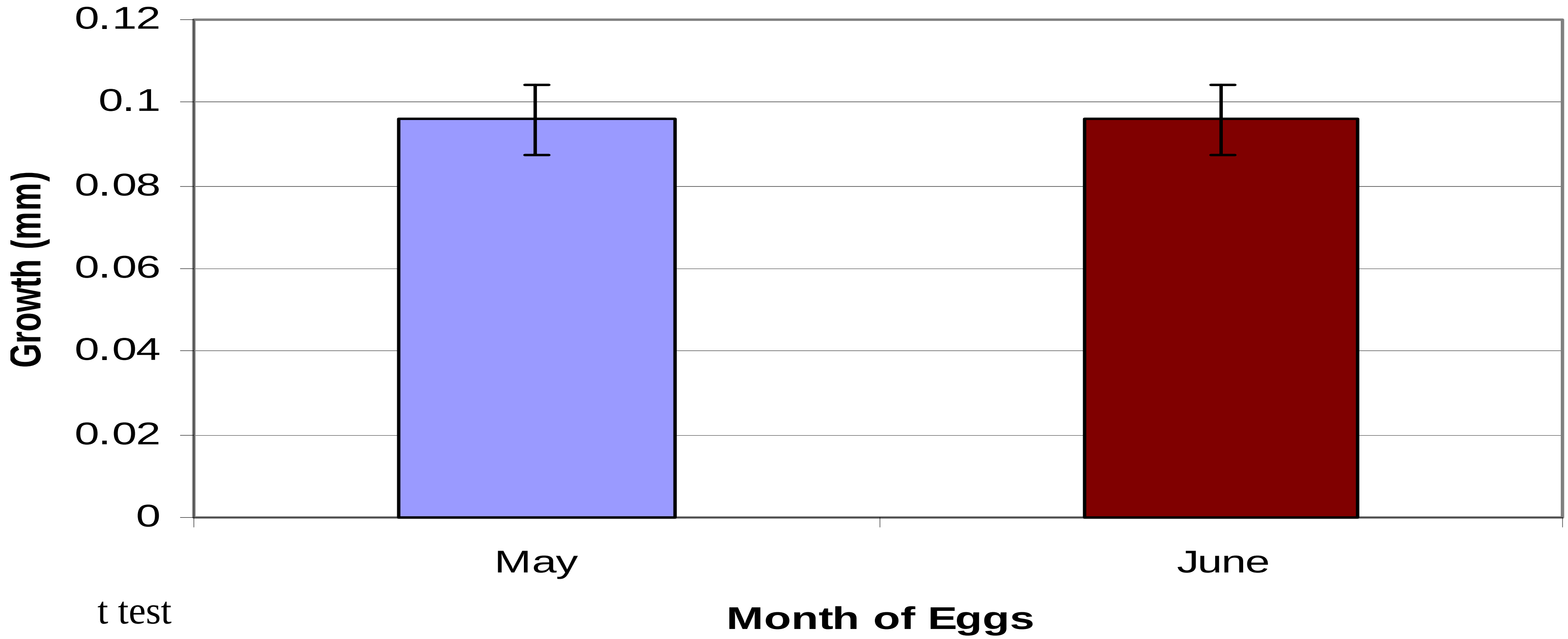
Mann Whitney Rank Sum Test
P=0.262

FIGURE 2.30 AVERAGE DAILY WEIGHT GAIN OF JUVENILES FROM MAY EGGS (N=3) AND JUNE EGGS (N=6) MONITORED AT SITE 5.
Averages are calculated by dividing the total growth by number of days monitored.
Y error bars represent standard deviations.



t test
P=0.278

FIGURE 2.31 AVERAGE DAILY GROWTH IN SUL OF JUVENILES FROM MAY EGGS (N=3) AND JUNE EGGS (N=6) MONITORED AT SITE 5.
Averages are calculated by dividing the total growth by number of days monitored.
Y error bars represent standard deviations.



t test
P=0.278

FIGURE 2.32 AVERAGE DAILY TIBIA GROWTH IN JUVENILES FROM MAY EGGS (N=3) AND JUNE EGGS (N=6) MONITORED AT SITE 5.
Averages are calculated by dividing the total growth by number of days monitored.
Y error bars represent standard deviations.

FIGURE 2.33 JUVENILE COLLECTED FROM SITE 5 LACKING THE PUPIL OF THE RIGHT EYE.

Photo by Nancy J. Dickson.

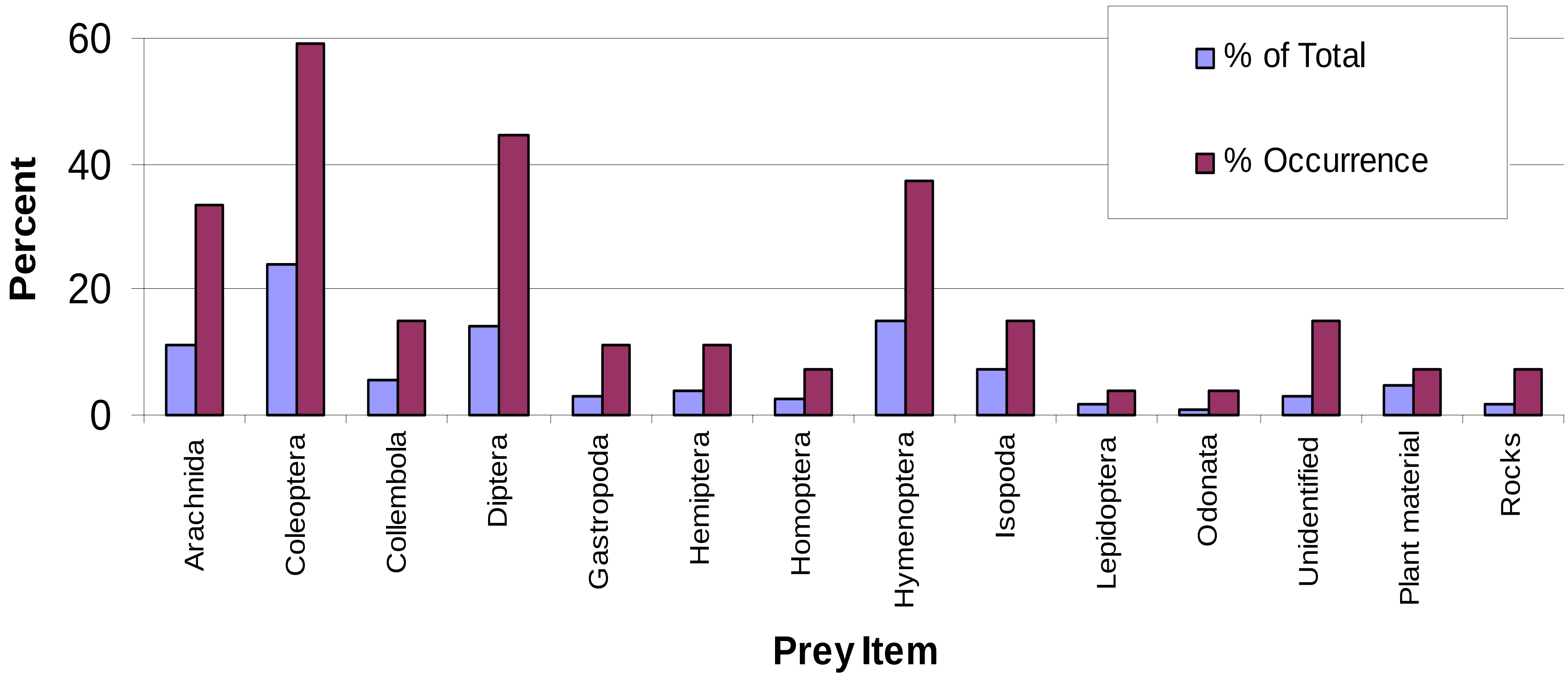


FIGURE 3.1 RESULTS OF GUT ANALYSIS OF FROGS (N=27) COLLECTED FROM OHIO.

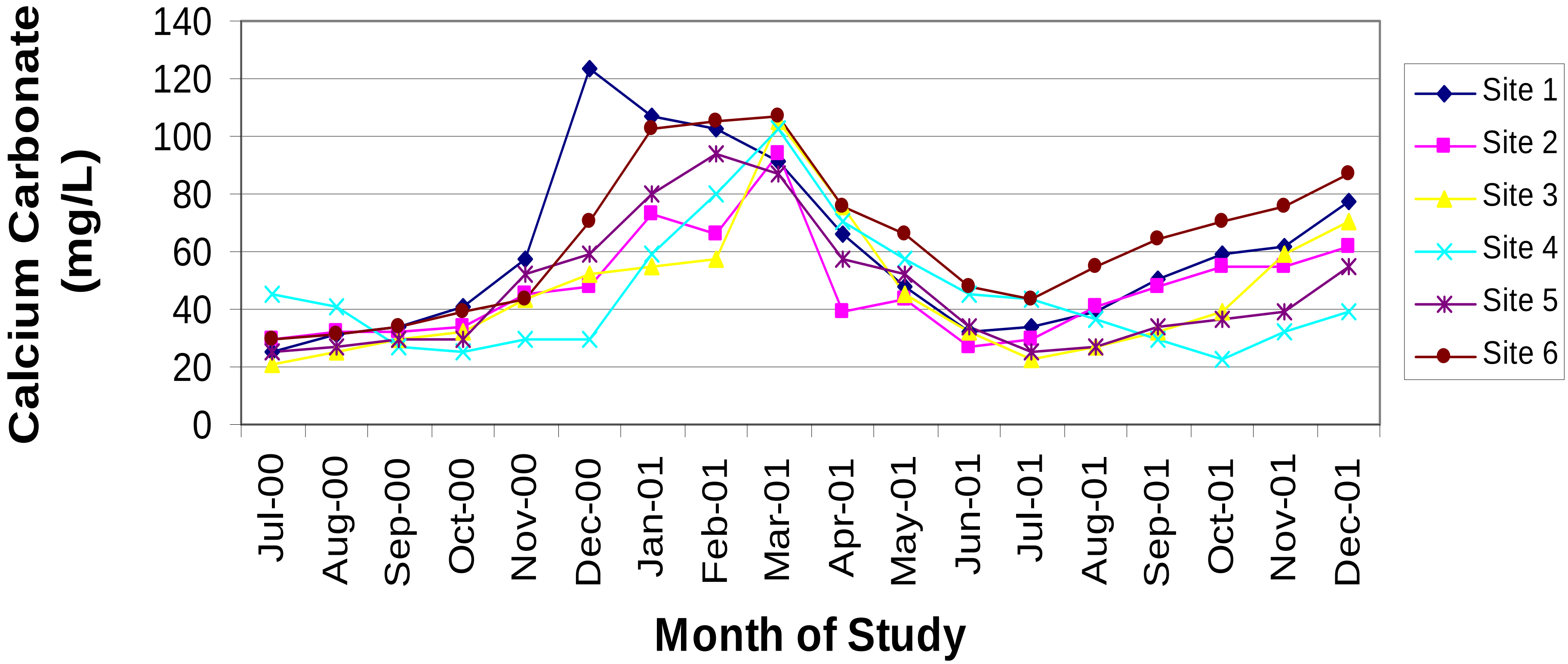


FIGURE 5.1 TOTAL ACIDITY OF WATER FROM STUDY SITES IN WEST VIRGINIA AND OHIO.

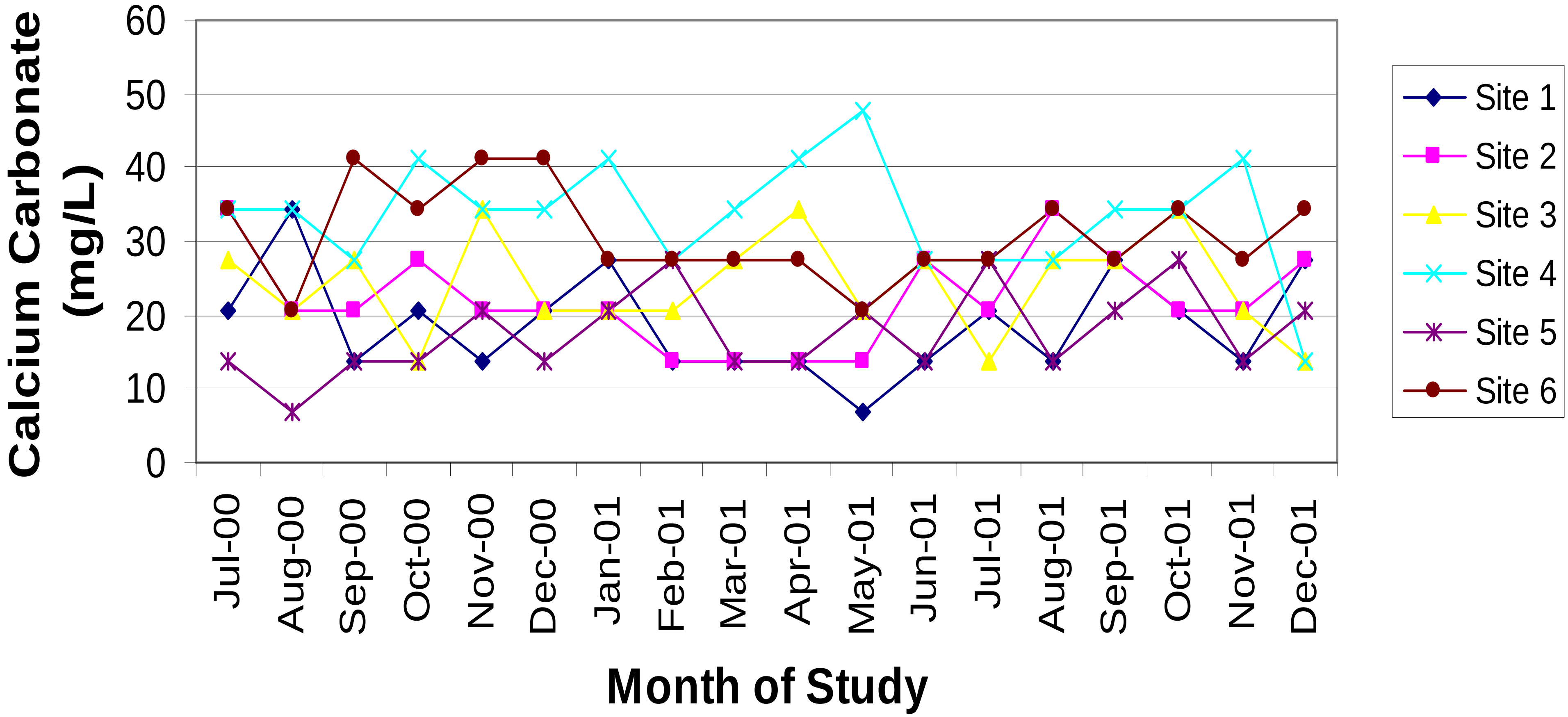


FIGURE 5.2 ALKALINITY OF WATER COLLECTED FROM STUDY SITES IN WEST VIRGINIA AND OHIO.

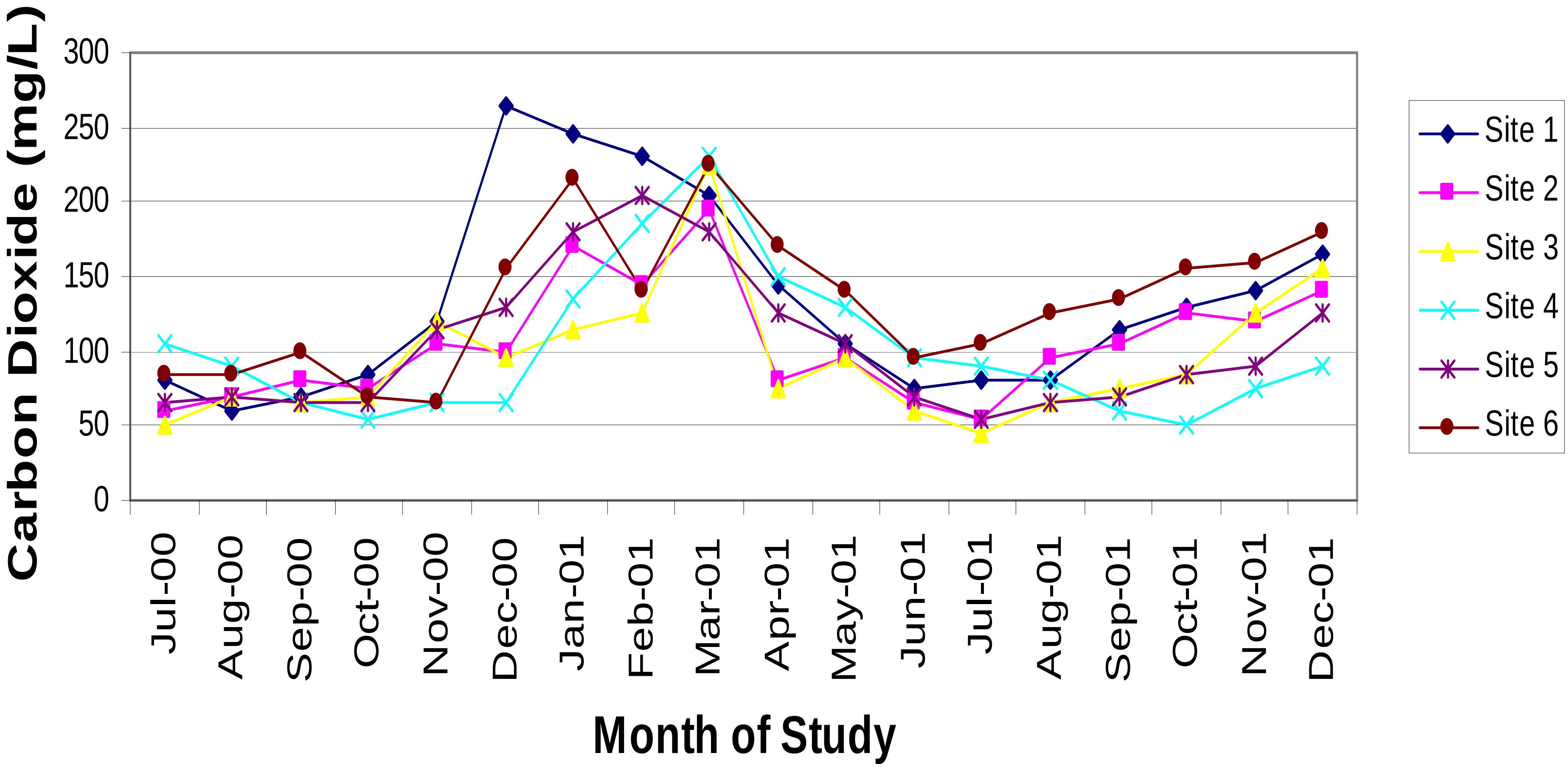


FIGURE 5.3 CARBON DIOXIDE LEVELS OF WATER FROM STUDY SITES IN WEST VIRGINIA AND OHIO.

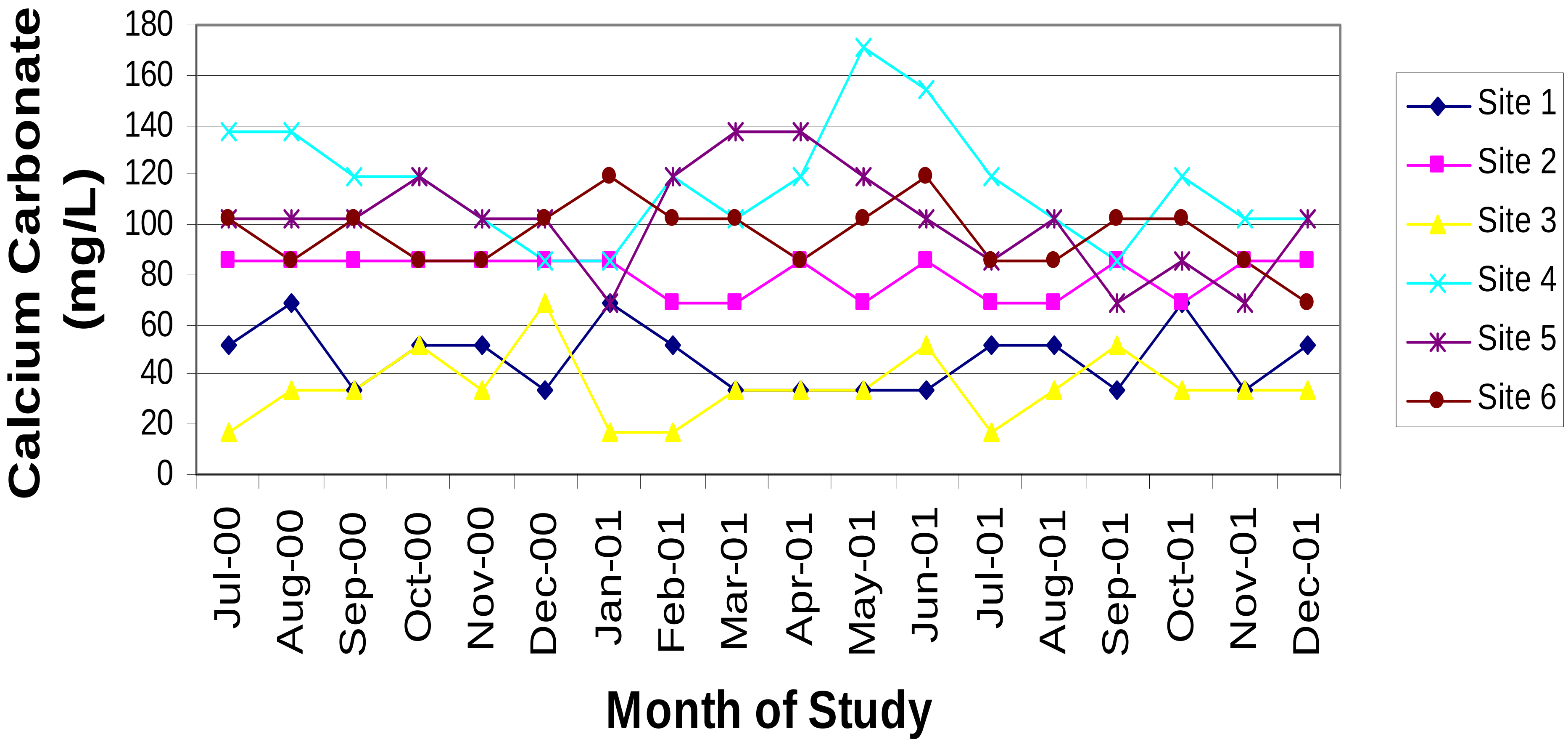


FIGURE 5.4 TOTAL HARDNESS OF WATER COLLECTED FROM STUDY SITES IN WEST VIRGINIA AND OHIO.

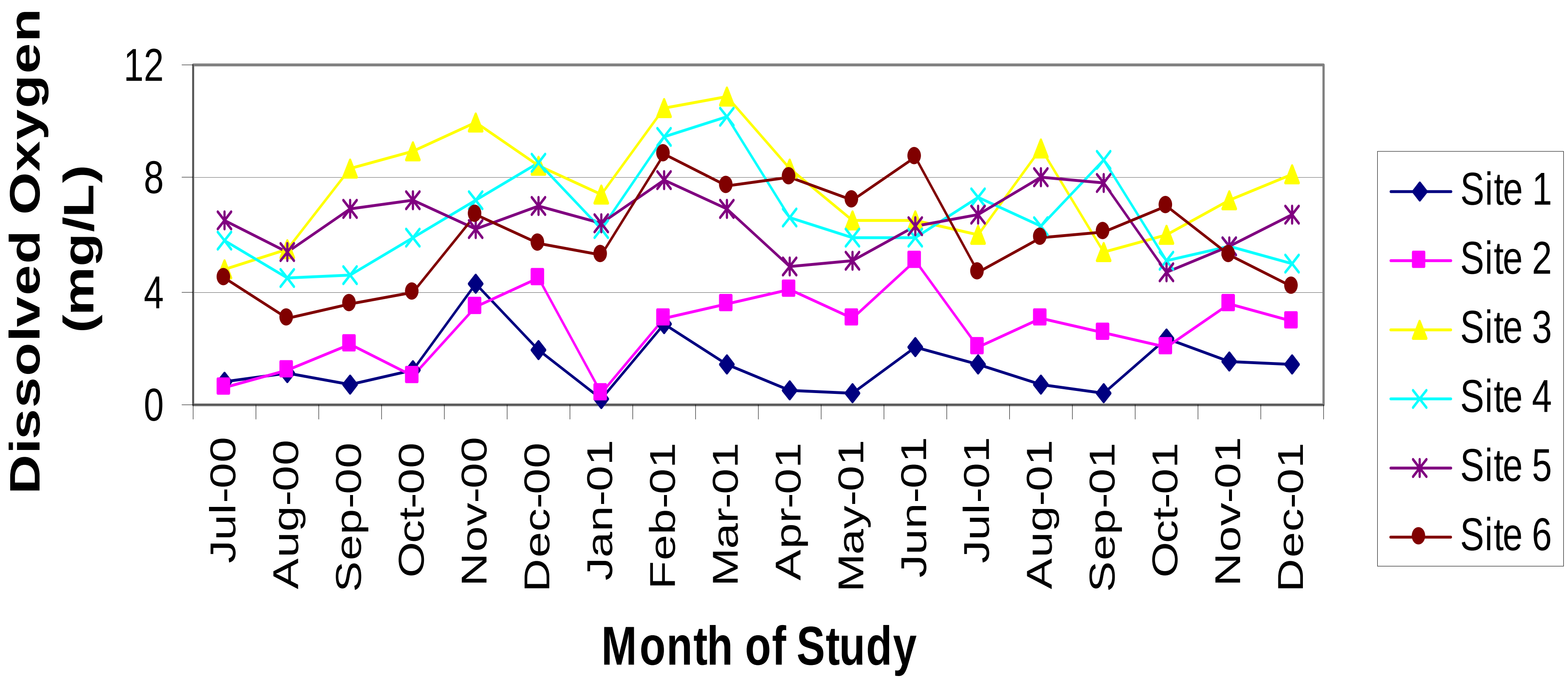


FIGURE 5.5 DISSOLVED OXYGEN LEVELS IN WATER OF STUDY SITES IN WEST VIRGINIA AND OHIO.

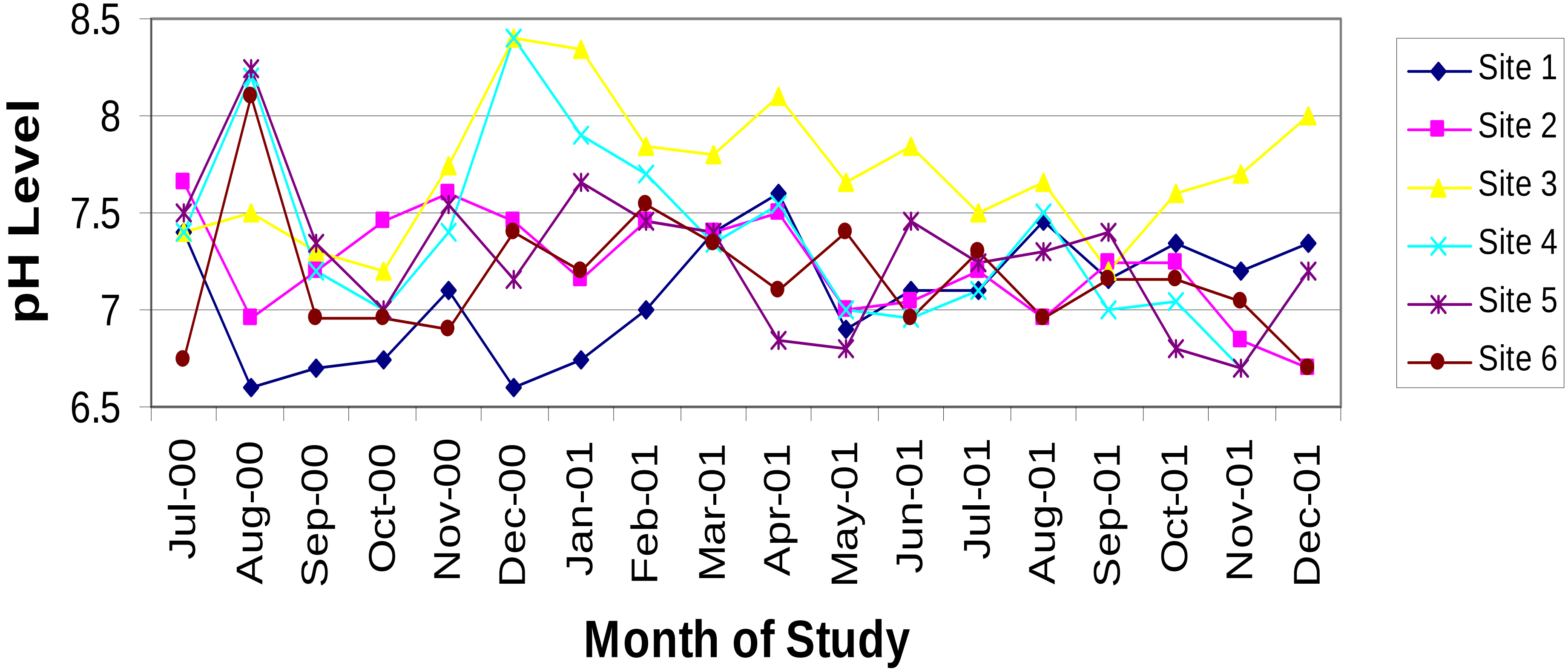


FIGURE 5.6 PH LEVELS OF WATER OF STUDY SITES IN WEST VIRGINIA AND OHIO.

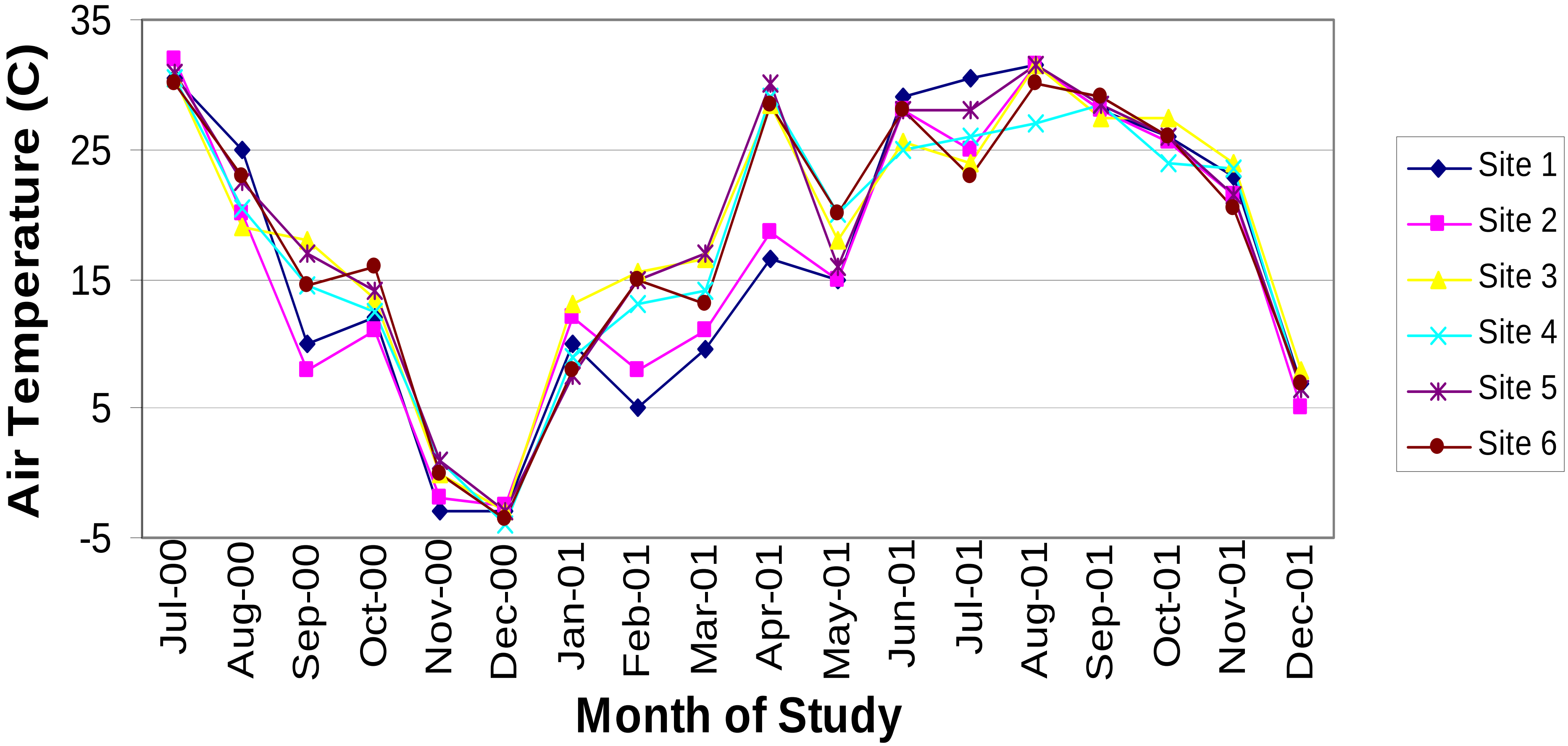


FIGURE 5.7 AIR TEMPERATURES OF STUDY SITES IN WEST VIRGINIA AND OHIO.

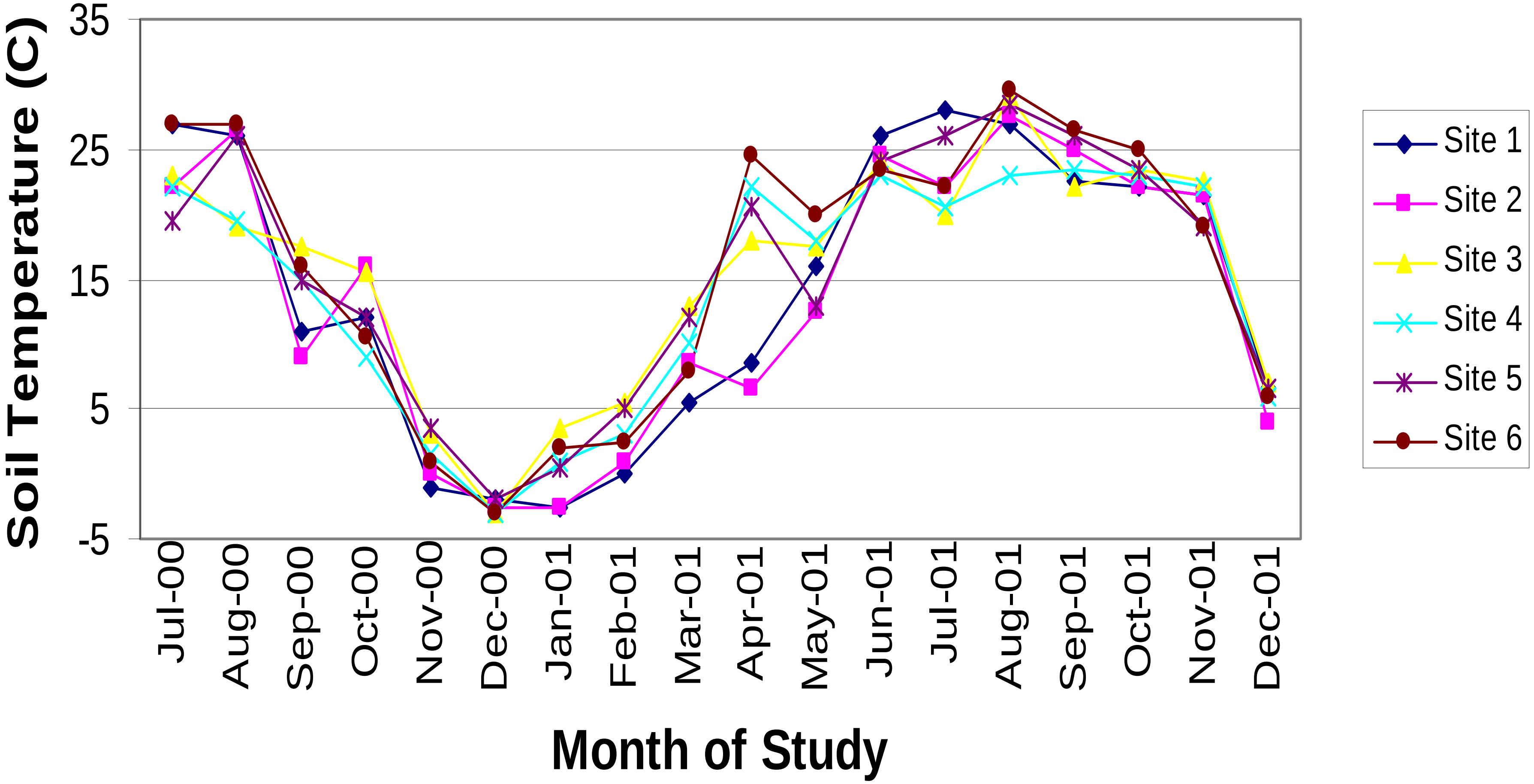


FIGURE 5.8 SOIL TEMPERATURES OF STUDY SITES IN WEST VIRGINIA AN D OHIO.

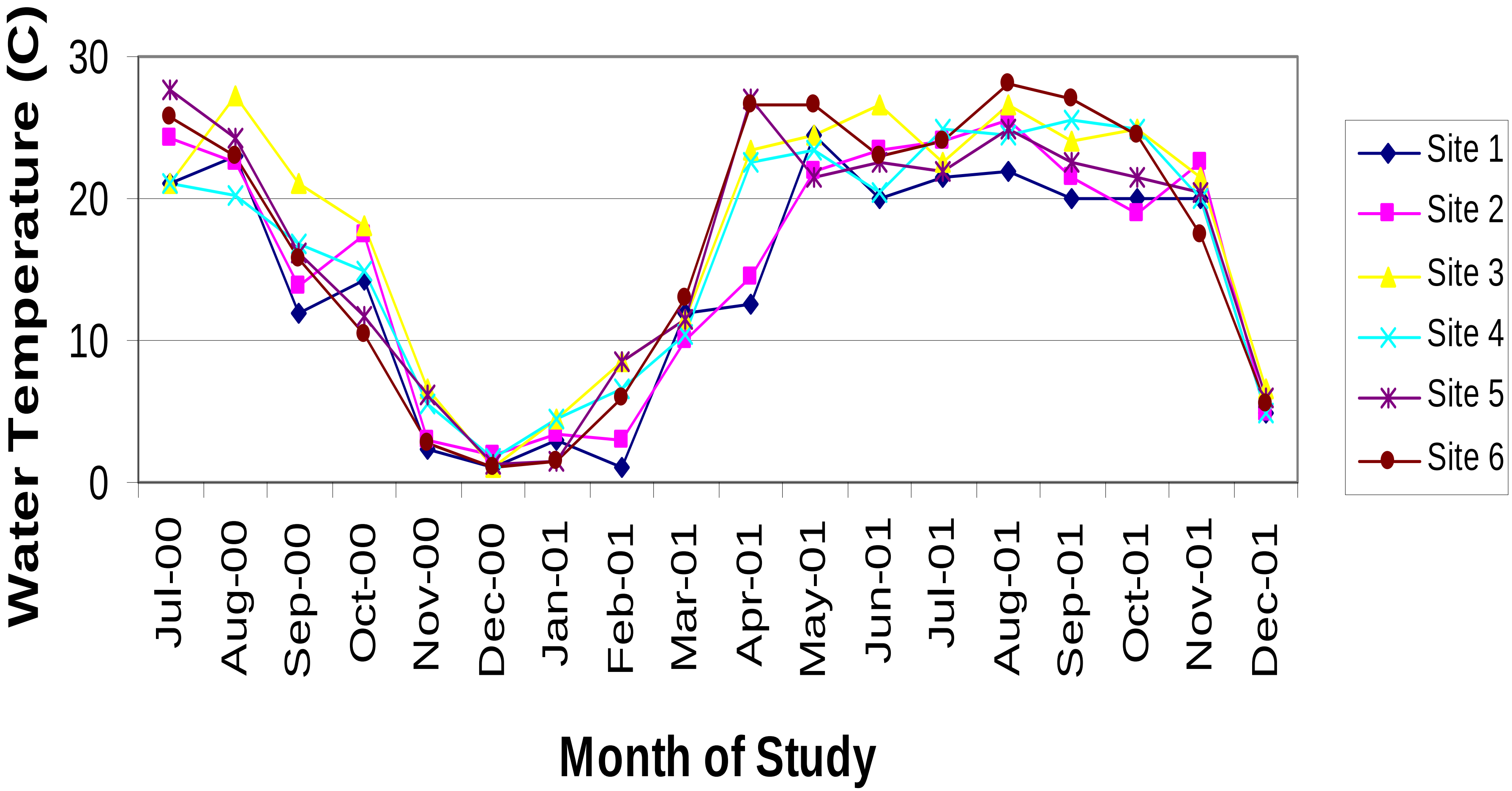


FIGURE 5.9 WATER TEMPERATURES OF STUDY SITES IN WEST VIRGINIA AND OHIO.

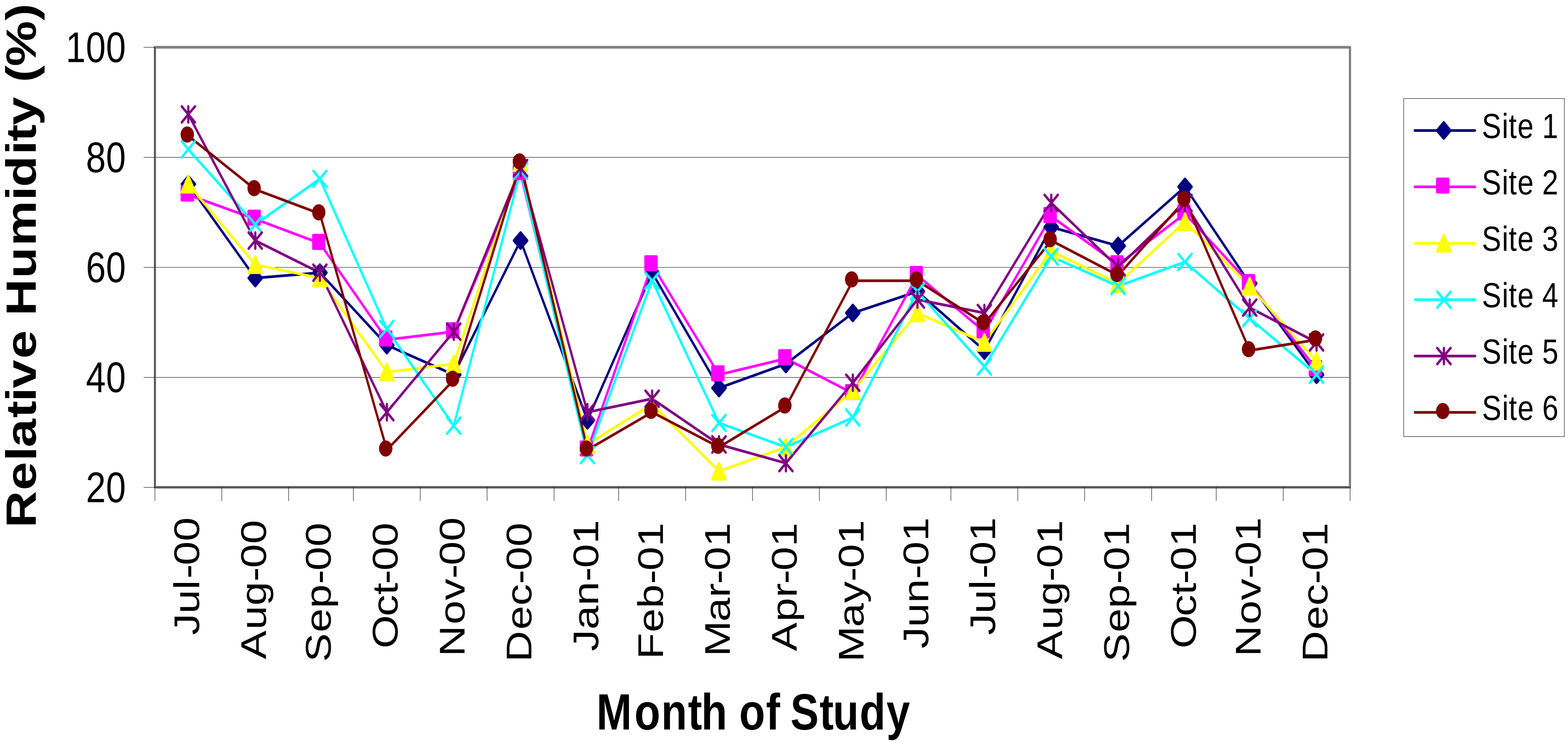


FIGURE 5.10 RELATIVE HUMIDITY LEVELS OF STUDY SITES IN WEST VIRGINIA AND OHIO.

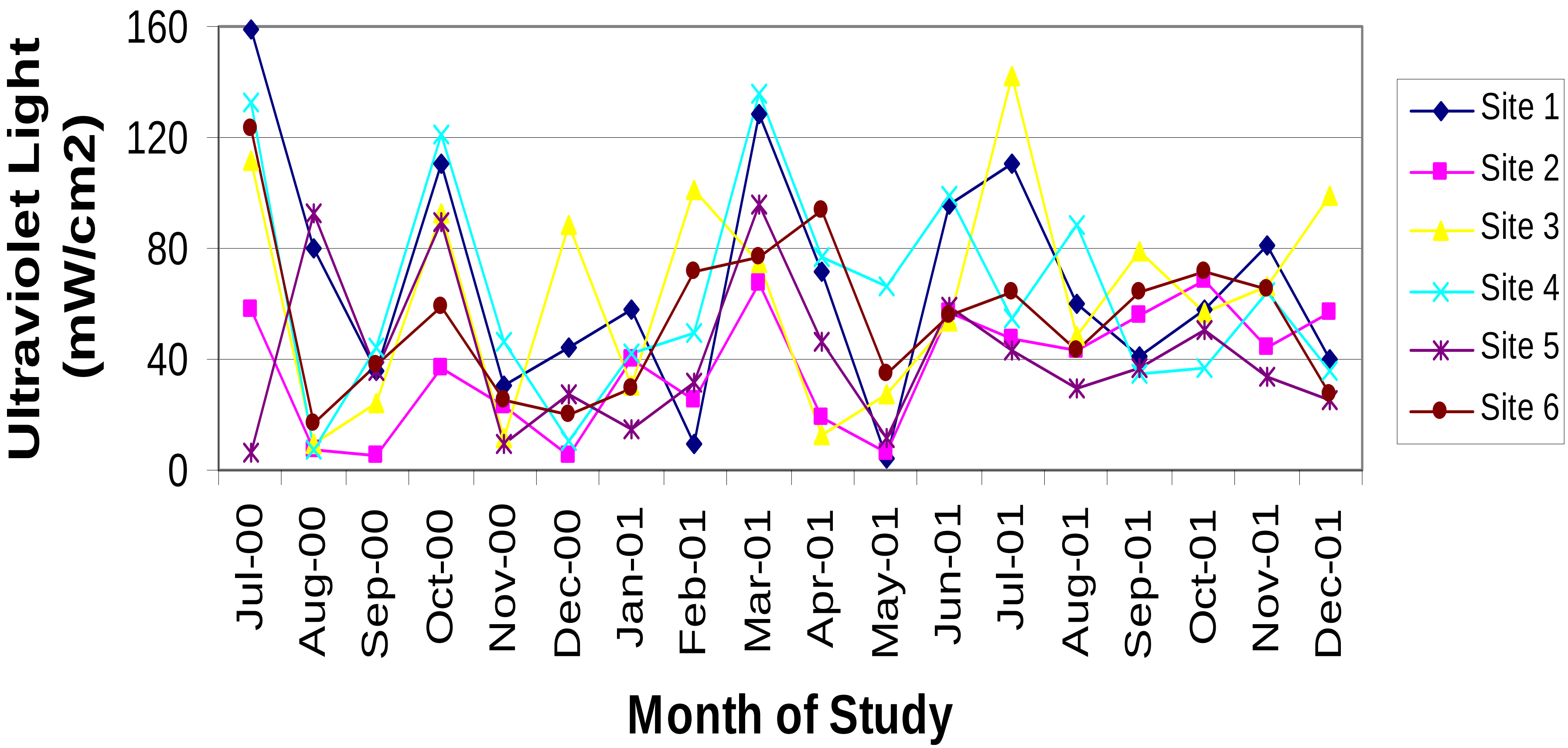


FIGURE 5.11 ULTRAVIOLET LIGHT PENETRATION LEVELS OF STUDY SITES IN WEST VIRGINIA AND OHIO.

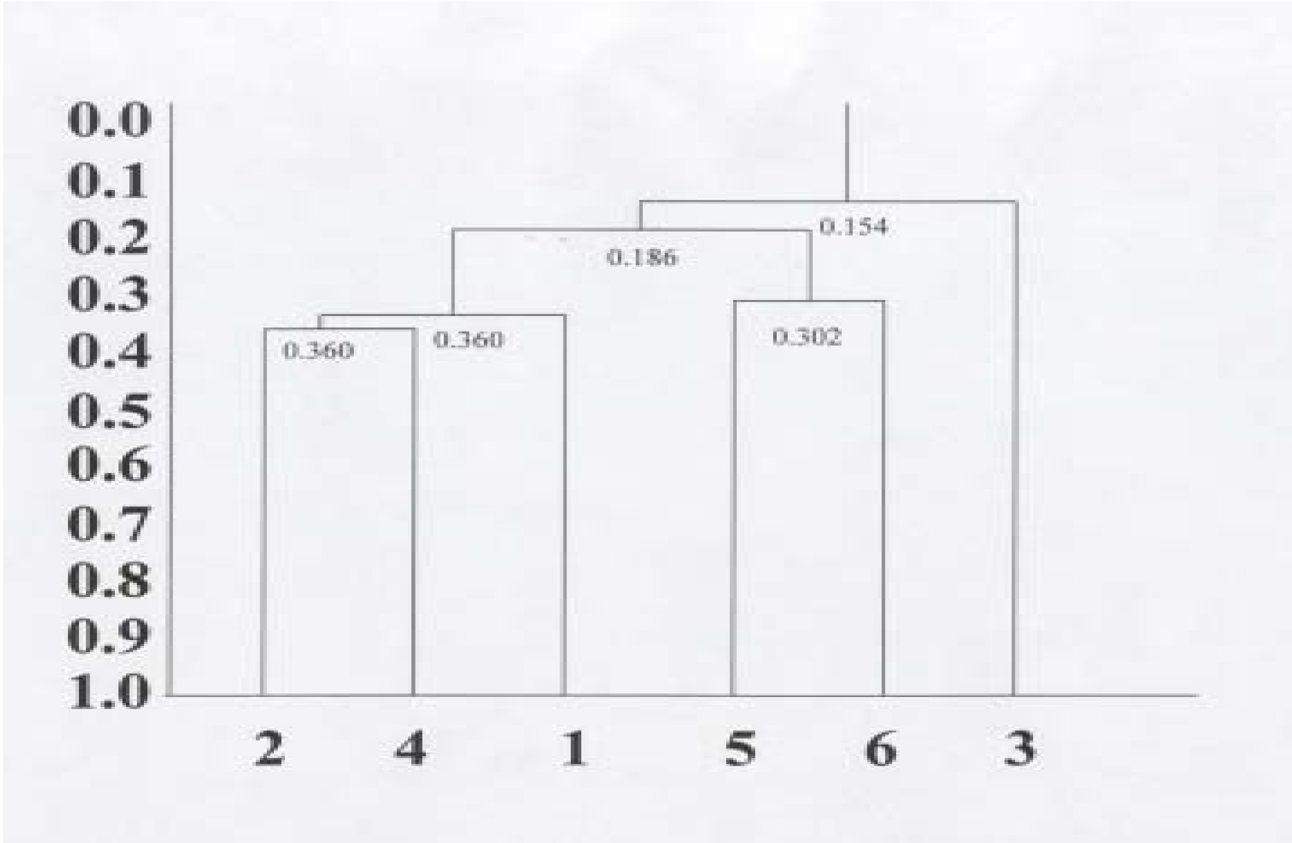


FIGURE 5.12 DENDOGRAM OF VEGETATION COLLECTED FROM ALL STUDY SITES.

Curriculum Vitae

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EDUCATION

- Hurricane High School, Hurricane, West Virginia 25526: June 1993

- West Virginia State College, Institute, West Virginia 25112: August 1995 to May 1996
  Undeclared major for 2 semesters
  25 semester hours

- Universidad Antonio de Nebrija, Madrid, Spain: June 1998
  One month foreign language studies
  6 semester hours

- Marshall University
  Huntington, West Virginia 25755
  Bachelor of Biological Sciences: May 2000

- Marshall University
  Huntington, West Virginia 25755
  Master of Science: expected May 2002
  27 semester hours completed as of 12/01

WORK EXPERIENCE

- **Graduate assistant**
  3/2000 to present
  Semester work: $6,000 per year stipend plus tuition waiver: 20 hours per week
  Optional summer work: $6.25/hour and $35 daily per diem, 40 hours per week
  Marshall University 400 Hal Greer Blvd Huntington, WV 25755
  Supervisor: Thomas K. Pauley (304) 696-2376

Below is a list of eight projects I have worked on under Dr. Thomas K. Pauley

1. Master of Science Research
   Thesis: The natural history and possible extirpation of Blanchard's cricket frog, *Acris crepitans blanchardi*, in West Virginia
   Duties:
   -Searched the counties of WV where the frog was historically found
   -Visited 6 study sites on a monthly basis to take and analyze water

samples
-Collected and identified benthic insects and vegetation from the sites
-Trapped and identified turtles, fish, and mammals at each site
-Collected natural history data on an *A. c. blanchardi* population in Ohio
-Tagged frogs with elastomer injections for mark and recapture studies

Accomplishments:
-Determined, to the best of my knowledge, *A. c. blanchardi* has been extirpated
from the state of West Virginia
-Gathered information on growth of the larval period of *A. c. blanchardi* that is not known to exist in the literature

2. Risk assessment for amphibians and reptiles in the northeastern United States

Duties:
-Searched the literature to find information on life history, demographic traits, habitat use, and movement for 8 salamanders of the family *Plethodontidae* for Robin Jung of NEPARC (Northeastern Partnership for Amphibians and Reptiles)

Accomplishment:
-This work will benefit the proposed conservation of many amphibians in the northeastern United States

3. North American Amphibian Monitoring Program (NAAMP). Regional Coordinator for West Virginia

Duties:
-Recruited and trained volunteers to conduct frog and toad surveys
-Created and distributed volunteer packets
-Supervised 15 volunteers in 2001 and will do so for 28 in 2002
-Entered (and later analyzed) data returned by volunteers into database on internet
-Conducted surveys myself when volunteers could not be recruited for a route

Accomplishments:
-Recruited volunteers for 35 of the 39 routes of West Virginia during my first year
as Regional Coordinator (54% increase from the previous year)
-Reported 6 county record frogs and toads based on data reported by volunteers

4. Reconnaissance and Establishment of Long-term Monitoring Sites of Vertebrates in the Gauley National River

Duties:
-Worked with a team to conduct surveys which would create an inventory of the reptiles and amphibians within park boundaries
-Drove 4 wheel drive vehicle to access remote areas of the park
-Conducted stream surveys during daytime and nighttime for salamanders

of the genus *Desmognathus*
-Conducted terrestrial surveys during daytime and nighttime for woodland salamanders
-Sampled road puddles and ditches for amphibians and identified adults and larvae
-Captured, sexed, aged, and measured amphibians and reptiles including venomous snakes
-Used GPS unit to determine site locations and reach destination points
-Used equipment to gather environmental data at each study site established
-Determined aspect, elevation, canopy cover, shrub layer, herbaceous layer, and potential species at each new site
-Trapped for aquatic turtles in the Gauley River. Handled large and small specimens
-Worked in adverse weather conditions and hiking was routinely required
-Operated small water craft on River to recover turtle traps or travel
Accomplishment:
-My team and I located 27 species of reptiles and amphibians during the first year of the study

5. Non-target Impacts from Regional Insecticide Applications and Gypsy Moth Defoliation

Duties:
-Conducted day stream searches for larvae of *Desmognathus, Gyrinophylus,* and *Eurycea* by using tea strainers and larval refugia bags
-Conducted day terrestrial searches for *Plethodon* species which included employment of cover boards established transects
-Conducted night searches for stream salamanders established transects
-Conducted night searches for *Plethodon* salamanders in established transects
-Measured, weighed, aged, and sexed all salamanders captured
-Collected environmental data by using pH meters, thermometers, densiometers, and various other equipment
-Collected salamanders and, in the laboratory, dissected them to determine reproductive state and completed tail fat analysis
-Collected leaf and soil samples and analyzed them in the lab
-Entered data into Microsoft Excel and participated in generating reports
-Worked in adverse weather conditions and hiking was routinely required
Accomplishment:
-The first year I participated in the study 408 of the 900 desired salamanders to be collected for dissection were captured. (At least 15% increase from all previous years)

6. Atlas of Reptiles and Amphibians in West Virginia

Duties:
-Collected voucher specimens of amphibian and reptile county records for the West Virginia Biological Survey Museum housed at Marshall University
-Fixed, preserved, and cataloged each specimen at time of entry into museum
Accomplishment:
-To date I have collected more than 2 dozen county records for the West Virginia Biological Survey

7. West Virginia Biological Survey of Amphibians and Reptiles
Duties:
-Identified, numerically tagged, and cataloged amphibian and reptile specimens housed in the West Virginia Biological Survey Museum at Marshall University
-Transferred hand written data from museum catalog into Microsoft Access database
Accomplishment:
-My efforts in the museum have contributed the excellent organization of West Virginia Biological Survey collection and familiarized me with identification of preserved specimens

8. Teaching Assistant
Duties:
-Taught Herpetology laboratory (BSC 406/506) for undergraduate and graduate students at Marshall University, Huntington, West Virginia during fall 2000 and 2001
-Assisted in teaching Ornithology laboratory (BSC 408/508) for undergraduate and graduate students at Marshall University, Huntington, West Virginia during spring 2002
Accomplishment:
-Contributed to teaching more than fifty students at Marshall University the proper identification of the reptiles and amphibians of West Virginia
-Contributed to teaching more than twenty five students at Marshall University the proper identification of the birds of West Virginia and their calls

- Field Assistant
  6/99 to present
  $250 to $500 per summer
  5 hours per week average
  Ohio Biological Survey
  1315 Kinnear Road
  Columbus, OH 43212
  Supervisor: Jeffrey G. Davis (513)868-3154

Ohio Frog and Toad Atlas

Duties:

-Collect voucher specimens of township record anurans in the four southernmost counties of Ohio

-Recorded GPS location of each specimen collected

-Fixed, preserved, and cataloged each specimen before shipment to Mr. Davis

Accomplishment:

-To date I have collected over 75 township records for the Ohio Biological Survey.

- **Volunteer**
  4/99 to present
  1 night per month (February through May)
  Wayne National Forest (USDA)
  Ironton Ranger District
  6518 State Route 93
  Pedro, OH 45659
  Supervisor: Kathy Flegel (740)534-6531

Ohio Biological Survey

Duties:

-Conduct surveys for calling frog and toad species in southern Ohio

-Record sky conditions, time, air temperature, species calling, and relative number of calling species at each site onto datasheet

-Used tape recorder to record calling frogs and toads

Accomplishment:

-Blanchard's cricket frog has been found at four of the twenty sites I established in Ohio. The frog had not been recorded in the area within the previous twenty years.

- Clerk GS-0303-02
  4/1/98 to 3/25/99
  $8.28 per hour
  16 to 40 hours a week (depending on school schedule)
  US Army Corps of Engineers
  Winfield Locks and Dams
  RFD1 Box 530
  Red House, WV 25168
  Supervisor: Terry R. Whitley (304) 586-2501

Duties:

-Performed routine clerical work including receiving telephone calls, greeting visitors to facility, and taking messages for staff

-Prepared numerous routine reports as necessary to support the mission of the organization

-Updated manuals on policies, directives and memoranda

-Recorded and filed information, correspondence and reports according to regulations in accordance with MARKS filing system

Accomplishment:

-Organized the file cabinet containing blank file forms. I created folders and labeled them making it very easy to located and pull files in the cabinet. This saved administrative personnel time from searching for blank forms, and they were able to spend their time in more productive ways.

OTHER QUALIFIACTIONS

- Job related skills

  12 semester hours of Spanish
  Computer skills: Microsoft Word, Excel, and PowerPoint. Internet user.
  Type 60 WPM
  Experienced with use of hand and power tools

- Job related awards

  West Virginia Nongame Wildlife and Natural Heritage Program ($3840 grant for thesis work) 2/01
  Ohio Biological Survey Small Grants Program ($500 grant for thesis work) 9/00
  Graduate Assistantship at Marshall University under Dr. Thomas K. Pauley 3/00

- Job related special accomplishments

Publications

Dickson, Nancy J. Egg size and larval development of Blanchard's cricket frog, *Acris crepitans blanchardi*, in southern Ohio. Joint annual meetings of the Herpetologist's League and the Society for the Study of Amphibians and Reptiles 3 – 8 July (Abstract, in press).

Dickson, Nancy J. and Thomas K. Pauley. 2002. The natural history of Blanchard's cricket frog, *Acris crepita*

Dickson, Nancy J., Keith A. Johnson, and Thomas K. Pauley. 2001. A one-year comparison of Historical Blanchard's cricket frog sites in western West Virginia to Current sites in southeastern Ohio. Joint annual meetings of the Herpetologist's League and the Society for the Study of Amphibians and Reptiles 27 – 31 July: 65 (Abstract).

Dickson, Nancy J., Keith A. Johnson, and Thomas K. Pauley. 2001. A comparison of historical Blanchard's cricket frog sites in western West Virginia to current sites in southeastern Ohio. Southeastern Biology 48(2): 95 (Abstract).

Felix, Zachary, Jessica Wooten, Nancy J. Dickson, Robert Fiorentino, Ariana Breisch, Mizuki Takahashi, and Thomas K. Pauley. 2001. Non-target impacts on terrestrial and aquatic salamanders from insecticide applications and gypsy moth defoliation. Southeastern Biology 48(2): 92 (Abstract).

Memberships
Society for the Study of Amphibians and Reptiles since 2000
Herpetologist's League since 2002
American Society of Ichthyologists and Herpetologists since 2002
West Virginia Chapter of the Wildlife Society since 2002
International Society for the History and Bibliography of Herpetology since 2002

Public speaking
I have completed Seminar I and have already fulfilled my requirements this semester for Seminar II at Marshall University. This includes 1 hour and 10 minutes of public speaking for which I have received the highest allowed grade in both classes.

Occasionally it is required by my work at Marshall University that I speak to organizations or at annual meetings. I have presented to the annual Ohio Biological Survey meeting in 2001, the Huntington, West Virginia Audubon Society, and the WVU Chapter of the Wilderness Club.

REFERENCES

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