

Overwintering by tadpoles of the Green Frog, *Lithobates clamitans melanota* (Rafinesque, 1820), in Western Pennsylvania

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Abstract. Monthly distributions of tadpole body sizes from two ponds in western Pennsylvania were used to determine larval duration and transformation size of the Green Frog (*Lithobates clamitans melanota*) from a northern site, located along the latitude approximately midway in the geographic range of the species. Both populations, sampled in different years transformed in the spring and early summer of the following year at body sizes of 30-31 mm, which were typical of populations in the central portion of its geographic range.

Keywords. Overwintering, tadpole behaviour, *Lithobates clamitans*, USA.

Introduction

The Green Frog, *Lithobates clamitans melanota* (Rafinesque 1820) is one of two recognized subspecies of the eastern North American Bronze Frog, *L. clamitans* (Latreille, 1801). Occurring throughout much of the eastern United States and southeastern Canada, this taxon intergrades with the Bronze Frog, *L. c. clamitans* (Latreille, 1801), along the fall line in Georgia and Alabama (Conant and Collins, 1998; Pauley and Lannoo, 2005).

Besides differences in color pattern (Mecham, 1954), body size differences are apparent between the two taxa, with the northern subspecies being larger in adult (Wright and Wright, 1949; Mecham, 1954; Meshaka et al., 2009a,b, Meshaka, Bradshaw-Wilson, and Pauley, 2010; Meshaka, Marshall, and Heinicke, 2011) and metamorphosing size compared to the Bronze Frog (Wright and Wright 1949; Meshaka et al., 2009a,b, 2010, 2011). Breeding seasons follow a north-south gradient, with the shortest seasons in the north (Pauley and Lannoo, 2005; Meshaka et al., 2009a,b, Meshaka, Bradshaw-Wilson, and Pauley, 2010; Meshaka, Marshall, and Heinicke, 2011). Metamorphoslings are likewise produced over a longer season in the south (Meshaka et al. 2009a,b, Meshaka, Marshall, and Heinicke, 2011). To that end, the larval period in this species varies geographically, with tadpoles of many northern populations overwintering the following

year (Pauley and Lannoo, 2005). For Pennsylvania populations, Hulse, McCoy, and Censky (2001) noted a 70-365 day transformation period depending on the date the eggs were laid. The rate at which tadpoles grow and the relationship between growth rate and transformation size are unknown for Pennsylvania populations. Monthly collections of tadpoles from two nearby ponds in western Pennsylvania provided the data necessary to address this life history trait.

Materials and Methods

Two ponds comprised the study sites at Powdermill Nature Reserve, an 856.2 ha field station located in the Ligonier Valley of the Allegheny Mountains in Westmoreland County of western Pennsylvania. PNR consists of mixed forests, fields, ponds and streams, and serves as a field station for the Carnegie Museum amenable for long-term study of natural systems and their components. The location of the station is within the geographic distributions of many amphibian species (Hulse, McCoy, and Censky, 2001; Conant and Collins, 2002).

Alder Pond is an 1198 m² nearly permanent pond. Built in the late 1960s, Alder Pond is approximately 1 m in depth with a silt bottom. It is covered throughout with emergent vegetation and is unshaded. In addition to Green Frogs, centrarchid fish, Northern Water Snakes (*Nerodia sipedon*), Pickerel Frogs (*Lithobates palustris*), Spring Peepers (*Pseudacris crucifer*), Spotted Newts (*Notophthalmus viridescens*), Bullfrogs (*Lithobates catesbeianus*), Painted Turtles (*Chrysemys picta*), and Common snapping Turtles (*Chelydra serpentina*) were found in the pond. Common Garter Snakes (*Thamnophis sirtalis*) have been observed along the edge of the pond. Aquatic samples were collected during April-October 2009 and in March 2010.

Ravens Roost Rear Pond (RRRP) is a 453 m² nearly permanent pond. Build in the late 1970s, RRRP is approximately 1.5 m in depth with a soft substrate bottom. It is covered with emergent aquatic macrophytes only in some sections of the littoral zone and

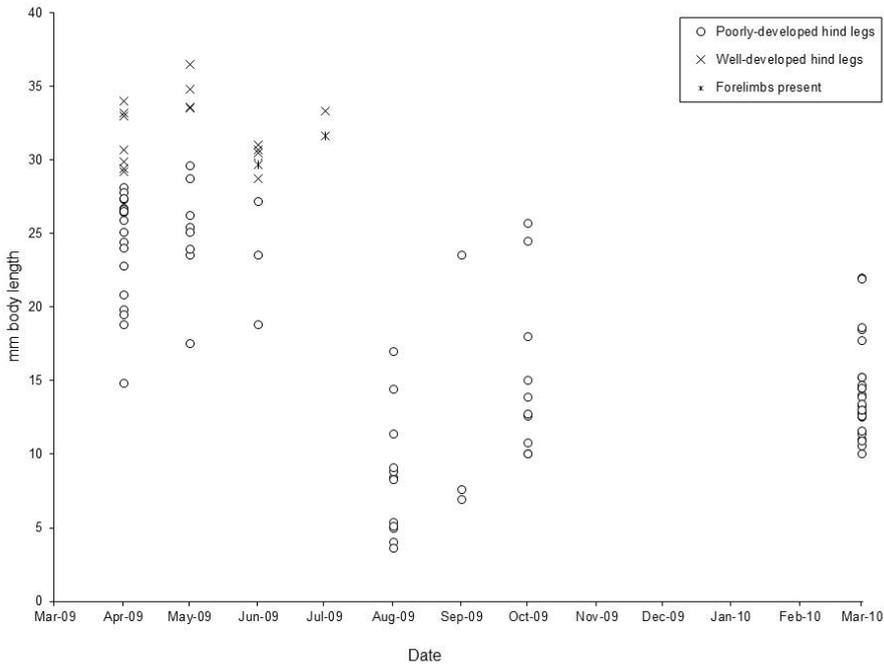


Figure 1. Monthly distribution of body sizes of 100 tadpole and metamorphosing Green Frogs (*Lithobates clamitans melanota*) from Alder Pond, Powdermill Nature Reserve, Rector, Westmoreland County, Pennsylvania, during April-October 2009 and in March 2010.

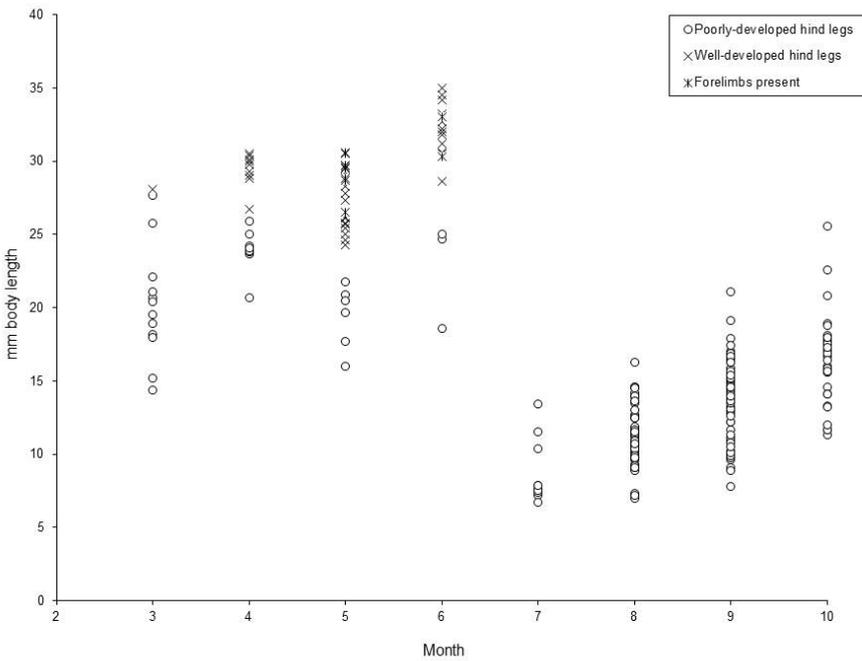


Figure 2. Monthly distribution of body sizes of 241 tadpole and metamorphosing Green Frogs (*Lithobates clamitans melanota*) from Ravens Roost Rear Pond, Powdermill Nature Reserve, Rector, Westmoreland County, Pennsylvania, during March-October 2010.

it is heavily shaded in a mixed deciduous forest. The pond is fishless; however, Eastern Newts, Spring Peepers, and Wood Frogs (*Lithobates sylvaticus*) were found in the pond. Aquatic samples were collected during March-October 2010.

Aquatic samples were taken with a dipnet in the littoral zone of each pond. Samples were preserved in formalin and stored in the Section of Zoology and Botany at the State Museum of Pennsylvania, Harrisburg, Pennsylvania. Tadpoles were scored as per Gosner (1960). For practical purposes, tadpoles were divided in categories of having poorly-developed hind legs (less than Gosner stage 37) or well-developed hind legs (Gosner stage of at least 37). Metamorphoslings were distinguished from tadpoles by the presence of forelimbs (Gosner stage 42) and distinguished from juveniles by the presence of a tail. Body lengths of all size-classes and developmental stages of tadpoles were measured in mm snout-vent length (mm SVL). Statistical analysis was conducted with the use of Excel. Means were followed by ± 2 standard deviations, and significance was recognized at $P < 0.05$.

Results and Discussion

Tadpoles of the two structurally different ponds did not transform until the following year as determined by the monthly distribution of body sizes (Fig. 1 & 2). Frogs at Alder Pond transformed the following June and July at a mean body size of 30.7 mm (std. dev. = 1.3; range = 29.7-31.6; n = 2). Tadpoles with well-developed rear legs averaged 31.9 mm (std. dev. = 2.3; range = 28.7-36.5; n = 17). Frogs at RRRP transformed the following May and June at a mean body size of 29.7 mm (std. dev. = 1.6; range = 26.5-33.0; n = 11). Tadpoles with well-developed rear legs averaged 29.1 mm (std. dev. = 2.8; range = 24.3-35.0; n = 39).

Metamorphosing body sizes at PNR were similar to that of populations from Indiana (Minton, 2001) (range = 28-36 mm), New England (Klemens, 1993) (mean = 30.1 mm; range = 27-34), central New York (Wright, 1931) (range = 28-38 mm), southeastern Michigan (Martof, 1956 (mean = 32.6 mm; range = 28.4-36.3), and neighboring West Virginia (Meshaka, Bradshaw-Wilson, and Pauley, 2010) (mean = 29.4 mm; range = 18.4-34.5).

Comparatively, metamorphosing body sizes at PNR were larger than those of most southern populations: Texas (Meshaka, Marshall, and Heinicke, 2011) (mean = 22.1 mm; range = 18.6-27.2), southeastern Georgia (Wright, 1931) (mean = 23.3 mm; range = 20-28), Florida (WEM, unpubl. data) (mean = 24.1 mm; range = 19.1-29.6), southern Louisiana (Meshaka et al., 2009b) (mean = 28.3 mm; range = 19.6-47.0). From these limited comparisons, it appears that although geography may play some role in metamorphosing body size, particularly at geographic extremes, causal

factors responsible for this trait are too complicated to be explained by geography alone.

The longer breeding season and warmer water temperatures in the south provide the time necessary for tadpoles to transform over several months in the same season as they were born. In that regard, in some southern locations larval periods were determined to range 2-3 months (Meshaka et al., 2009a,b), with transformation known to occur without overwintering (Collins, Collins, and Taggart, 2010) or generally so (Meshaka et al., 2009a,b). In other southern sites, same-season transformation was a likely inference in light of extended or nearly continuous production of metamorphoslings (Meshaka, Marshall, and Heinicke, 2011).

Not surprisingly then, a shorter breeding and growing season, as in northern populations, can only be overcome by overwintering. Experimentally, it was determined that progeny of early breeders could transform in the same season (Ting, 1951), and in a Michigan field study Martof (1956) demonstrated the date on which the eggs were laid determined whether or not the tadpole would transform the same season that it was born or the next. In West Virginia, the monthly distribution of metamorphosing body sizes (Meshaka, Bradshaw-Wilson, and Pauley, 2011) was indicative of overwintering, but same-season metamorphosis could not be ruled out. In the mid-Atlantic area such as the western Pennsylvania sties of this study, it might then be expected that overwintering is the typical, even if not exclusive, larval response to a cool climate and intermediate breeding season. In turn, this response can lend itself to the production of larger metamorphoslings.

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