

The largest Eastern Newts, *Notophthalmus viridescens* (Rafinesque, 1820), are found at high elevation in North Carolina

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Geographic variation in body size of amphibians has long been known to herpetologists (Morrison and Hero, 2003). Much of this variation has been attributed to latitudinal and elevational differences among populations (Morrison and Hero, 2003). Interestingly, data on body size variation is lacking for many widespread species. This is especially true of extreme differences in body size (e.g., gigantism) (Bonett et al, 2009).

The Eastern Newt, *Notophthalmus viridescens* (Rafinesque, 1820), has a wide distribution, ranging across most of the eastern United States of America to as far west as eastern Texas and north to Minnesota and southeastern Canada. There are currently four recognised subspecies: *N. v. viridescens*, and *N. v. dorsalis*, *N. v. piaropicola* and *N. v. louisianensis*. In a previous literature review on salamanders from the United States and Canada (Petranka, 1998), snout-vent length (SVL) of *N. viridescens* aquatic adults was reported as 31–54 mm, with little variation between males and females.

From primary literature, *Notophthalmus viridescens* reported from Newfoundland, NJ, USA populations possessed a mean SVL of 43.37 mm (sex ratio not provided; range of 32.5–49 mm) and *N. viridescens* from Victor Edward's Pond in Long island, NY, USA were slightly larger with a mean SVL of 46.25 mm (sex ratio not provided; range of 38–60 mm) (Noble, 1926). *N. viridescens* populations from Highlands, NC, USA were reported to have a mean SVL of 45.11 mm and a range of 40–51 mm (sexes pooled; $n = 176$) (Chadwick,

1944). The maximum size of *N. viridescens* from the entire state of Illinois was reported as 45.2 mm (sex unknown) (Smith, 1961). Adult males ranged from 40–46 mm SVL from Edmonson County, KY ($n = 8$) and 40–46 mm SVL from females captured in Union County, IL ($n = 10$) (Brandon and Bremer, 1966). From a sample of 42 adults from Kansas (we assume from multiple counties), a mean SVL of 39 mm for males ($n = 24$, but this was not specifically stated; range of 32–46 mm) and 46 mm for females ($n = 18$; range of 38–50 mm) was reported (Ashton, 1977). North Carolina lowland populations ranged from 24–44 mm for males and 20–42 mm for females, but no SVLs were explicitly reported for individuals (Harris et al, 1988). While conducting mating behaviour studies there was no difference in SVL between courting males (mean = 47.9 mm) and interfering males (mean = 48.2 mm) in a sample of *N. viridescens* from Giles County, VA (Massey, 1990). In a study conducted in the Mastigouche Reserve, Quebec, Canada where they sampled 5 lakes totalling 173 *N. viridescens* (Caetano and LeClair, 1996), the authors reported mean SVL ranges of males between 41.2–45.9 mm across lakes ($n = 106$). Females were slightly larger with mean SVL ranges between 42.2–45.9 mm ($n = 67$). Takahashi et al (2010) surveyed *Notophthalmus v. viridescens* in the Piedmont of NC, the intermediate morphotype between *N. v. viridescens* and *N. v. dorsalis* (fall line between the Piedmont and Coastal Plain of NC), and *N. v. dorsalis* (Coastal Plain of NC), and summarised SVL data in a graph where female and male SVL were pooled. The maximum SVL was ~47 mm for *N. v. viridescens* ($n = 20$ male, 8 females), ~43 mm for the intermediate morphotype, and ~35 mm for *N. v. dorsalis*.

We collected *N. viridescens* from a series of high elevation (~1443 m) ponds in Ashe County, NC at the Pond Mountain Gamelands (permit #19-SC01312 and 20-2SC01312) for a comparative study on the reproductive cycles of *N. viridescens* across their range and, based on previous literature, we hypothesised

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that the *N. viridescens* collected from this site are the largest recorded adult *N. viridescens*. Collections for the reproductive cycle part of the project took place from March 2019 to February 2020. Additional measurements of individuals in this population were made during field work in 2024. In total the SVLs of 78 adult males and 34 adult females were measured at the field site. The mean SVL of males was 50.31 mm (standard deviation = 3.56) with a maximum size of 58.4 mm and minimum of 41.7 mm (Fig. 1). For females, the mean SVL was 50.53 mm (standard deviation = 3.17) with a maximum size of 56.0 mm and minimum of 43.4 mm (Fig. 1). Combined, the mean SVL was 50.37 mm (standard deviation = 3.43). To our knowledge, this makes our mean SVL the largest reported from a population of *N. viridescens*. The largest individual ever reported appears to be Noble's (1926) *N. viridescens* of 60 mm SVL (sex was not provided) and, at present, we consider this the largest *N. viridescens* specimen ever reported.

Unfortunately, in some of the most data intense published studies on *N. viridescens*, only total length (TL) was reported. SVL was measured for a study on breeding migrations of *N. viridescens* from Thompsons County, NY, but only TL was reported in the histograms and table comparing populations from different sites (mean TL of males ranged from 84.7 mm to 105.1 mm and mean total length of females ranged from 83.8 mm to 101.2 mm) (Hurlbert, 1969). Petranks (1998) suggests that the tail can make up ~50% of the TL of *N. viridescens*, so Hurlbert's (1969) data could be interpreted as ~42 mm to ~52.5 mm mean SVL for males and ~41.5 to ~50.5 mm mean SVL for females, with a maximum size of ~56 mm for both sexes. Thus, it is possible that the *N. viridescens* from Beef Farm I ($n = 87$ for males and 12 for females) and Corn Farm ($n = 127$ for males and 17 for females) of Hurlbert's (1969) NY collection rival the mean SVL of our sampled population. Unfortunately, we will never know, as Chadwick (1944) described tail length as ~2.4% longer than trunk length, with a high amount of variability. Similarly, studies from South Hadley, MA and NY have provided numerous TL measurements from extensive collection, but means reported were well under 100 mm for both males and females (Adams, 1940; Bishop, 1941). This was also the case for the TLs reported from Clear Lake, NY, Wilmington, NC, and the southeastern USA (Bishop, 1944).

Acknowledgments. We thank our institutions of employment for support of our research endeavours.

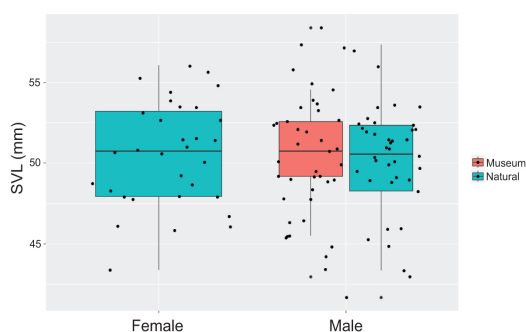


Figure 1. Box plot of *Notophthalmus viridescens* by sex from high elevation ponds in North Carolina. “Museum” represents males from a reproductive study using the same population that were preserved and vouchered in the collection of JM Davenport, and measured after fixation. “Natural” represents males and females from field measurements. Jittered points are measurements of each individual.

References

- Adams, D.E. (1940): Sexual conditions in *Triturus viridescens* III. The reproductive cycle of the adult aquatic form of both sexes. *American Journal of Anatomy* **66**: 235–275.
- Ashton, R.E. (1977): The central newt, *Notophthalmus viridescens louisianensis* (Wolterstorff) in Kansas. *Transactions of the Kansas Academy of Sciences* **79**: 15–19.
- Bishop, S.C. (1941): Salamanders of New York Albany, NY, New York State Museum Bulletin.
- Bishop, S.C. (1944): A Handbook of Salamanders. The Salamanders of the United States, of Canada, and of Lower California Ithaca, NY, Comstock Publishing Company.
- Bonett, R.M., Chippindale, P.T., Moler, P.E., Van Devender, R.W., Wake, D.B. (2009): Evolution of gigantism in Amphiumid Salamanders. *PLoS ONE* **4**: e5615.
- Brandon, R.A., Bremer, D.J. (1966): Neotenic newts, *Notophthalmus viridescens louisianensis*, in southern Illinois. *Herpetologica* **22**: 213–217.
- Caetano, M.H., LeClair, R., Jr. (1996): Growth and population structure of red-spotted newts (*Notophthalmus viridescens*) in permanent lakes of the Laurentian Shield, Quebec. *Copeia* **1996**: 866–874.
- Chadwick, C.S. (1944): Observations on the life cycle of the common newt in western North Carolina. *American Midland Naturalist* **32**: 491–494.
- Harris, R.N., Alford, R.A., Wilbur, H.M. (1988): Density and phenology of *Notophthalmus viridescens dorsalis* in a natural pond. *Herpetologica* **44**: 234–242.
- Hurlbert, S.H. (1969): The breeding migrations and interhabitat Wandering of the Vermilion-Spotted Newt *Notophthalmus viridescens* (Rafinesque). *Ecological Monographs* **39**: 465–488.
- Massey, A. (1990): Notes on the reproductive ecology of red-spotted newts (*Notophthalmus viridescens*). *Journal of Herpetology* **24**: 106–107.

- Morrison, C., Hero, J.-M. (2003): Geographic variation in life-history characteristics of amphibians: a review. *Journal of Animal Ecology* **72**: 270–279.
- Noble, G.K. (1926): The Long Island newt: a contribution to the life history of *Triturus viridescens*. *American Museum Novitates* **228**: 1–11.
- Petranka, J.W. (1998): *Salamanders of the United States and Canada* Washington, D.C., Smithsonian Press.
- Smith, P.W. (1961): *The Amphibians and Reptiles of Illinois*. Urbana, Illinois.
- Takahashi, M.K., Takahashi, Y.Y., Parris, M.J. (2010): On the role of sexual selection in ecological divergence: a test of body-size assortative mating in the eastern newt *Notophthalmus viridescens*. *Biological Journal of the Linnean Society* **101**: 884–897.