Timing of Juvenile Amphibian Dispersal from Small Ponds in Southern Virginia

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Introduction

Small ponds provide important breeding sites for many amphibian species. Whereas some adult anurans may remain in or near ponds throughout the year, the dispersal of juveniles away from ponds after metamorphosis is typical (Martof 1953; Schroeder 1976). In a previous study using pitfall traps in forests on the campus of Ferrum College, Fredericksen et al. (2010) found that high relative humidity and rainfall initiated the dispersal of juvenile amphibians from ponds during the summer, but different amphibian species dispersed at different times. The peak dispersal for juvenile Green Frogs (*Lithobates clamitans*) occurred in July but the Red-Spotted Newt (*Notophthalmus viridescens*) had peak dispersal in September. The peak of juvenile dispersal for Bullfrogs (*Lithobates catesbeiana*) and Pickerel Frogs (*Lithobates palustris*) was less clear. These sampling plots, however, were located in forests more than 100 m from the presumed natal ponds and the timing of dispersal was uncertain since amphibians may have found refuge under leaf litter between dispersal from pond and capture in the forest pitfall arrays. Martof (1953) found the dispersal timing of green frogs was positively correlated with both precipitation and humidity, while Timm et al. (2007) found that the amount of precipitation was also important in the departure of juvenile amphibian species from breeding ponds. They also observed that the timing of juvenile dispersal varied among amphibian species.

The objective of our study was to determine the timing of juvenile dispersal of pond-breeding amphibians from small ponds in southwestern Virginia. Specifically, we wanted to determine the time of year and duration of juvenile dispersal for different species of frogs, toads and the Red-spotted Newt. We also investigated whether dispersal events were linked to rainfall events and if amphibians preferentially dispersed in certain directions from the pond.

Methods

This study was conducted on two different ponds on the campus of Ferrum College in Franklin County, Virginia over a three-year period (2011-2013). Chapman Pond is a small (0.5 ha) impoundment pond on the western side of campus. It is surrounded on three sides by forest and on one side by a grassy field. On each of two of the forested sides of this pond in 2011, we installed a 20 m segment of drift fence approximately 2 m from the edge of the pond, parallel with the shoreline. Woven plastic silt fence (75 cm tall) was supported by wooden stakes and the bottom of the fence attached to the ground with landscaping pins. Flush with the side of the fence, we buried three 10 liter plastic buckets in the ground to serve as pitfall traps on each side of the fence. Pitfall traps on the inside (pond side) of the fence were likely to capture juveniles dispersing from the pond, while traps on the outside of the fence (facing away from the pond)

would likely capture individuals trying to enter the pond. The buckets were installed in the middle and at the ends of the silt fence and holes were drilled to allow for water drainage. Bucket lids were supported over the buckets using stakes in order to provide shelter for captured amphibians. During periods when we were not sampling, lids were closed over the buckets. One stretch of fence was located on the west side of Chapman pond located along the border of a small Loblolly Pine (*Pinus taeda*) plantation. Another fence was located along a mature mixed hardwood forest on the east side of the pond. In 2013, we also installed an additional fence along the grassy field on the north side of the pond. At Chapman Pond, we trapped from June 5-October 31 in 2011, March 1- October 31 in 2012, and March 10-October 15 in 2013.

We also installed one 20-m drift fence with pitfall traps around a smaller (0.05 ha) cattle watering pond on the eastern side of campus that bordered a palustrine wetland. The other sides of the pond included cattle pasture and dense Alder (Alnus *sp*.) thickets. The water was much shallower and more turbid than Chapman Pond. This site was trapped only in 2011 and part of 2012 (until July 9) because of damage to the traps from cattle which had gained access to the side of the pond where the pitfall traps were placed.

The number, species, life stage, and side of fence of capture for each amphibian was recorded each day during the sampling period. The life stage of amphibians was based on approximate body size and categorized as juvenile (recent hatchling or metamorph), subadult (not likely to be a recent metamorph, but not normal adult body size), or adult. Captured animals were not marked and were released on the opposite side of the fence from where they were captured. Juveniles captured on the inside of the fence were released at least 3 m from the drift fence away from the pond in order to reduce the possibility of recapture.

In 2012, we collected rainfall data on a daily basis from June 7 – October 15 using a standard rain gauge in an open area approximately 1 km from each pond to test for a correlation between rainfall and the number of amphibian captures.

Results

Overall, the Red-spotted Newt was the most commonly captured species, followed by the Green Frog, Pickerel Frog, and Bullfrog (Table 1). The Green Frog was the most commonly captured species at the cattle pond. A large number of juvenile newts were captured leaving the ponds, especially Chapman Pond, but most newt captures were what we called “subadults”, individuals still in the terrestrial “eft” stage that were apparently returning to the pond to enter the adult stage. We did not capture any aquatic adult newts. Most frog captures were juveniles (new metamorphs). We did not capture any juvenile American Toads (*Anaxyrus americanus*) in either pond, despite capturing adults and observing mating toads each year at Chapman Pond.

Table 1. Captures of adult, subadult, and juvenile amphibians at Chapman Pond (2011-2013) and a small cattle pond (2011-2012) on the campus of Ferrum College in Franklin County Virginia.

Species	**Chapman Pond**			**Cattle Pond**		
	Adult	Subadult	Juvenile	Adult	Subadult	Juvenile
American Toad (*Anaxyrus americanus*)	29	0	0	20	1	0
Eastern Narrow-mouthed Toad (*Gastrophryne carolinensis*)	1	0	0	0	0	0
Bullfrog (*Lithobates catesbeianus*)	2	1	64	0	4	0
Green Frog (*Lithobates clamitans*)	8	3	181	7	2	41
Pickerel Frog (*Lithobates palustris*)	16	0	82	0	7	5
Wood Frog (*Lithobates sylvaticus*)	0	0	2	0	0	1
Red-spotted Newt (*Notophthalmus viridescens*)	0	505	256	0	11	3
Spring Peeper (*Pseudacris crucifer*)	4	0	0	0	0	0

Of all juveniles of the four most commonly captured species (Red-spotted Newt, Green Frog, Pickerel Frog, and Bullfrog), 90% were captured in traps on the inside fence, indicating that they were likely dispersing from the pond. For Red-spotted Newt subadults, 92% were captured in traps on the outside fence, indicating that they were trying to enter the pond. For adult frogs and toads, 70% were captured in traps on the outside fence. The majority of adult or subadult anurans captured were between March-May.

Green Frog juveniles dispersed earliest in the year, with Pickerel Frog juveniles dispersing soon afterwards (Figure 1, Table 2). In 2013, four juvenile Green Frogs and four Bullfrogs were captured following a warm rain on March 12. These individuals were undoubtedly juveniles that had overwintered in the pond and the capture dates were clearly disjunct from the main juvenile dispersal period for these species beginning in late May to mid-June. Juveniles of both Green Frogs and Pickerel Frogs dispersed predominantly in the latter half of June. Dispersal of Bullfrog juveniles was the latest of all species, consistently began in mid-July with the largest number of captures occurring from late July to early September. Juvenile Red-Spotted Newts began to disperse in late June to mid-July with peak capture timing later than Green Frogs and Pickerel Frogs, but earlier than that of Bullfrog juveniles (Figure 1). Juveniles of all four of the above-mentioned species continued to disperse at least into October when trapping ceased. Red-Spotted Newts that were presumably ending their terrestrial stage were captured in traps on the outer edge of the pond beginning late August or early September with peak captures occurring in late September.

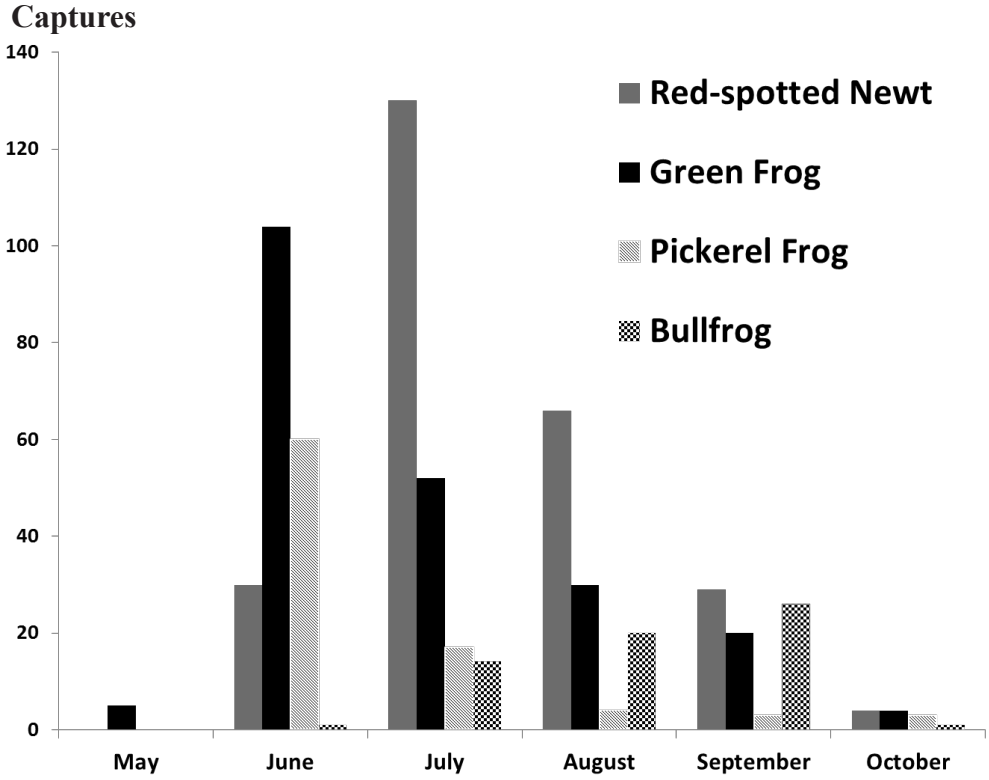
Table 2. Juvenile dispersal dates of selected amphibian species from ponds in southwestern Virginia 2011-2013.

Species	Earliest Dispersal*			Latest Dispersal			Median Dispersal			Highest captures		
	2011	2012	2013	2011	2012	2013	2011	2012	2013	2011	2012	2013
Red-spotted Newt	7/12	6/21	6/30	9/30	9/19	10/7	8/21	8/5	8/19	9/8	8/15	7/17
Green Frog	6/12	5/23	6/3	9/28	10/11	9/14	8/2	8/1	7/24	6/19	6/21	6/19
Bullfrog	7/13	7/15	7/10	9/28	10/2	10/7	8/20	8/23	8/24	9/6	9/2	7/28
Pickerel Frog	6/18	6/13	6/23			8/16	8/15	8/14	7/19	6/19	6/13	6/30

*- A few isolated dispersal events for Green Frog and Pickerel frog were recorded in March and April, 2013.

Species	Earliest Return			Latest Return			Median Return			Highest captures		
	2011	2012	2013	2011	2012	2013	2011	2012	2013	2011	2012	2013
Red-spotted Newt	9/8	9/5	8/28			10/8	9/29	9/25	9/17	9/30	9/19	9/22

Figure 1. Captures of dispersing juveniles by month (May-October) summed over the 2011-2013 sampling seasons for the four most common amphibian species in two ponds on the campus of Ferrum College.



During the three years of the study, dispersing juvenile Green Frogs, Bullfrogs, Pickerel Frogs, and Red-spotted Newts from Chapman Pond were captured on the mixed pine-hardwood forest 2-3 times more than the side with the mature Loblolly Pine plantation. Of the 503 Red-spotted Newts captured returning to the pond, 94% were captured in traps on the side facing the mixed-pine hardwood forest. In 2013, when an additional fence was installed along the side of the pond facing the grassy border, the side of the pond with the mixed pine-hardwood forest again had 2-3 times as many juvenile captures as the side with the Loblolly Pine border. The grassy side of the pond had 2-7 times fewer juvenile captures than the side with the Loblolly Pine plantation, except for the Bullfrog, which had two more captures on the grassy border compared to the pine plantation. No juvenile Red-spotted Newts were captured on the side with the grassy border.

There was a weak, but significant ($R^2 = 0.06$, $p = 0.03$) relationship between the number of amphibian captures and precipitation within the previous 24 hours of checking traps. The relationship was stronger ($R^2 = 0.47$, $p = 0.001$) between captures and precipitation within the previous 48 hours of checking traps.

Discussion

Four main species were captured at our study ponds, the Red-spotted Newt, Green Frog, Pickerel Frog, and Bullfrog. The high captures of these four species was due to the large number of juveniles dispersing from the pond. Only adult American Toads were captured. Spring peepers were captured only as adults in the early spring and included two pairs in amplexus. While spring peepers have been observed calling from the pond, no juveniles were captured. The lack of captures of this species could be at least partially related to its climbing ability which may have allowed it to escape from pitfall traps and climb the drift fence. A few juvenile Wood Frogs were captured, but this species typically breeds in vernal pools, not permanent water bodies such as those in our study. The Eastern Narrow-mouthed Toad was only captured once and is a recent new record for Franklin County (Fredericksen et al. 2007). Most captures were made around Chapman Pond, the larger of the two ponds. The cattle pond was small with turbid water and only trapped in 2010 and part of 2011. Most captures at the cattle pond were Green Frogs and Bullfrogs, both of which are generalist species (Hecnar and M'Closkey 1997; Beane et al. 2010) and seemingly tolerant of turbid water (personal observation).

Despite observations of breeding behavior in both ponds and frequent adult captures, it is interesting to note the lack of juvenile captures of American Toads. Toads prefer permanent breeding sites, such as ponds, provided that there are shallow areas, which is the case for our ponds (Klemens 1993). Petranka et al. (1994) noted that wood frog tadpoles are strong predators on toad eggs, but few wood frogs were captured in our study. Relyea et al. (2005) also noted strong predation pressure on American Toad tadpoles by Red-spotted Newts, which are abundant in Chapman Pond. We are not aware of any other studies, however, showing selective predation or parasitism of American Toad eggs or tadpoles compared to the other species that were frequently captured in this study. Berger et al. (1989) found American Toad tadpoles much more sensitive to agricultural runoff than ranid tadpoles. This sensitivity may explain the lack of reproductive success in the cattle pond, but not Chapman Pond, which has a lower sediment load because it is not impacted by cattle. In addition, metamorphic toads were observed near another pond on campus (Adams Lake), which is much more eutrophic than Chapman Pond.

Similar to other studies (Mazerolle 2001; Paton and Crouch 2002), we found a temporal segregation in the use of breeding ponds and differential dispersal among amphibian species in our study. Juvenile dispersal varied among species with some overlap, but usually with different peak dispersal periods. Green Frogs were the earliest to disperse, followed by Pickerel Frogs, Red-Spotted Newts, then Bullfrogs. Dispersal varied over a wide range of dates for all species. This result differed from Timm et al. (2007) who observed a clearly defined window for juvenile dispersal of amphibians from ponds in western Massachusetts, although it varied among species. Schroeder (1976) found that 97% of juvenile green frogs dispersed within 27 days from Mountain Lake, Virginia, which again differed from the prolonged dispersal of Green Frogs in our study. Green Frogs have a long breeding season and a relatively long tadpole stage (Oldham 1967; Pough and Kamel 1984). Tadpoles of both Green Frogs and Bullfrogs frequently overwinter in ponds, not emerging until the next spring (Beane et al. 2010). In our study, juvenile Green Frogs and Pickerel Frogs were captured leaving the pond as early as March and April, which is during the early breeding season for these species.

Juvenile dispersal was correlated with rainfall events. There was a better linkage with rainfall within the previous 48 hours compared to that within the previous 24 hours perhaps indicating that juvenile amphibians continued to disperse as long as moisture on the forest floor remains high. Relative humidity was not measured in this study, but we infer that higher humidity would follow recent rain events. Highest capture dates also coincided with mid-summer days when air and water temperatures were high. Other studies have similarly found juvenile amphibian dispersal from ponds, and amphibian movements in general, to be positively correlated with precipitation, humidity and temperature (Martof 1953; Healy 1975; Schoeder 1976; Pough and Kamel 1984; Timm et al. 2007; Roe and Grayson 2008). Semlitsch (2008) observed that nocturnal rainfall may be particularly important with respect to the timing of amphibian movements from ponds.

Juvenile movement away from ponds may be a mechanism for reducing overpopulation and increasing outbreeding within a metapopulation (Rothermel 2004; Cushman 2006), although risks of mortality from dispersal may confer higher fitness with philopatry to natal ponds (Semlitsch 2008). For some species, few frogs may return to ponds. For example, Schroeder (1976) found that only 6 of 468 marked juvenile Green Frogs returned to their natal pond within the next year. For other species, such as the Red-Spotted Newt, juveniles may leave the pond and enter their terrestrial stage, but may return to it when reaching the adult stage (Gill 1978). In this case, what we are calling dispersal for this species, is perhaps the first phase of migration (Semlitsch 2008), although we do not know if some of these newts are from other ponds.

Amphibian species appeared to have a preference for the direction of dispersal from the largest pond in our study, which had drift fences and pitfall traps placed on three sides with differing plant communities on each of the three sides. Most amphibians dispersed from the West side of the pond which was bordered by a mature mixed pine-hardwood forest. This was particularly true for Red-Spotted Newts, only a few of which dispersed from the South side of the pond bordered by a mature Loblolly Pine plantation and none dispersed from the North side of the pond that was bordered by tall grasses and sedges. In a study in Maine, deMaynadier and Hunter (1999) observed that juvenile amphibians appear to show a preference for dispersing in areas with dense overstory and understory cover, although Schroeder (1976) found that Green Frog dispersal was random from a pond in Mountain Lake, Virginia. Birchfield and Deters (2005) found that frogs tended to disperse through the habitat type that presented the least resistance to movement. In our study, the two forested sides of the pond probably presented less resistance to movement than the tall grass. The movement of Red-spotted Newts to Chapman Pond in the late summer and early fall occurred almost exclusively from the mature mixed hardwood-pine forest on the west side of the pond, perhaps because this forest provided a litter layer that provided more suitable cover and facilitated travel more than the sides with the pine plantation and grass-sedge vegetation. We also noticed that returning newts were more frequently captured immediately after the passage of cold fronts in late August through mid-September.

In summary, juveniles of pond amphibian species differed with respect to the timing of dispersal from ponds in southwestern Virginia over a three-year study, although the period of dispersal

overlapped among species and was more prolonged during the summer and fall compared to reports from other studies. The most common species of dispersing amphibians included the Green Frog, Pickerel Frog, Bullfrog, and Red-spotted Newt. American Toads were observing breeding in the ponds, but no dispersing juveniles were seen or captured. Amphibian dispersal was positively correlated with rainfall during the previous 24-48 hours and there was a preference for dispersal into mature mixed pine hardwood stands compared to a pine plantation or grass-sedge habitat. The arrival to the pond of Red-Spotted Newts that were transitioning from the terrestrial to aquatic phase of their life cycle was also recorded and peaked in late summer and early fall.

Literature Cited

Beane, J. C., A. L. Braswell, J. C. Mitchell, W.M. Palmer and J.R. Harrison III. 2010. Amphibians and Reptiles of the Carolinas and Virginia. University of North Carolina Press, Chapel Hill, NC. 274 pp.

Berger, L. 1989. Disappearance of amphibian larvae in the agricultural landscape. Ecology International Bulletin 17: 65-73.

Birchfield, G. L. and J. E. Deters. 2005. Movement paths of displaced Northern Green Frogs. Southeastern Naturalist 4: 63-76.

Cushman, S.A. 2006. Effects of habitat loss and fragmentation on amphibians: A review and prospectus. Biological Conservation 128: 231-240.

deMaynadier, P.G., and M.L. Hunter Jr. 1999. Forest canopy closure and juvenile emigration by pool-breeding amphibians in Maine . Journal of Wildlife Management 63: 441–450.

Fredericksen, T.S., J.D. Fiore, H.S. Shively, M.B. Webb, J.L. Scott, and R.L. Smith. 2010. Activity patterns of small terrestrial vertebrates and relationship to coarse woody debris in Virginia Piedmont forests. Banisteria 35: 53-60.

Fredericksen, T.S., M.B. Webb, and J.D. Kleopfer 2007. Eastern Narrow-mouthed Toad. Field notes. Catesbeiana 27:40.

Gill, D .E. 1978. The metapopulation ecology of the Red-Spotted Newt, *Notophthalmus viridescens* (Rafinesque). Ecological Monographs 48:145–166.

Healy, W. R. 1975. Breeding and postlarval migrations of the Red-spotted Newt, *Notophthalmus viridescens*, in Massachusetts. Ecology 56: 673-680.

Hecnar, S. J. and R. T. M'Closkey. 1997. Spatial scale and determination of species status of the Green Frog. Conservation Biology 11: 670-682.

Hurlbert S. H.1970. The post-larval migration of the Red-Spotted Newt *Notophthalmus viridescens* (Rafinesque). Copeia 1970:515-528.

Klemens, M. W. 1993. Amphibians and reptiles of Connecticut and adjacent regions. Bulletin Number 112. State Geological and Natural History Survey of Connecticut, Hartford.

Martof, B. S. 1953. Home range and movements of the green frog, *Rana clamitans*. Ecology 34: 529-543.

Mazerolle, M. J. 2001. Amphibian activity, movement patterns, and body size in fragmented peat bogs. Journal of Herpetology 35: 13-20.

Oldham, R. S. 1967. Orienting mechanisms of the Green Frog, *Rana clamitans*. Ecology 48: 477-491.

Paton P. W. C. and W.B. Crouch III. 2002. Using the phenology of pond-breeding amphibians to develop conservation strategies. Conservation Biology 16: 194-104.

Petranka, J. W., M.E. Hopey, B. T. Jennings,S. D. Baird S. D., and S. J. Boone. 1994. Breeding habitat segregation of Wood Frogs and American Toads: The role of interspecific tadpole predation and adult choice. Copeia 1994: 691-697.

Pough, F. H. and S. Kamel. 1984. Post-metamorphic change in activity metabolism of anurans in relation to life history. Oecologia 65: 138-144.

Relyea, R.A., N.M. Schoeppner, and J.T. Hoverman. 2005. Pesticides and amphibians: the importance of community context. Ecological Applications 15: 1125-1134.

Roe, A. W. and K. L. Grayson. 2008. Terrestrial movements and habitat use of juvenile and emigrating adult Eastern Red-Spotted Newts, *Notophthalmus viridescens*. Journal of Herpetology 42: 22-30.

Rothermel B. B., 2004. Migratory success of juveniles: a potential constraint on connectivity for pond breeding amphibians. Ecological Applications 14: 1535-1546

Schroeder, E. E. 1976. Dispersal and movement of newly transformed green frogs, *Rana clamitans.* American Midland Naturalist 95: 471-474.

Semlitsch, R. D. 1980. Differentiating migration and dispersal processes for pond-breeding amphibians. Journal of Wildlife Management 72: 260-267.

Timm, B. C., K. McGarigal, & B. W. Compton. 2007. Timing of large movement events of pond-breeding amphibians in western Massachusetts, USA. Biological Conservation 136: 442-454.