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BREEDING PREFERANCE OF *AMBYSTOMA MACULATUM* IN VERNAL AND PERMANENT PONDS.

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ABSTRACT

In a survey of five vernal and five permanent ponds near Huntingdon, Pennsylvania, we found that more eggs of the salamander *Ambystoma maculatum* occurred in vernal ponds than in permanent ponds. A comparison of several biotic and abiotic factors (e.g., presence of predators, pH , temperature and other physical characteristics of the ponds), suggested that reduced predation is probably the most important factor causing *A. maculatum* to lay its eggs preferentially in vernal ponds. However, this hypothesis remains to be tested.

Keywords: Abundance, Ambystoma maculatum, *predator-prey relationships, vernal ponds, salamander*

INTRODUCTION

Near Huntingdon, Pennsylvania amphibians lay their eggs in two major types of ponds: relatively shallow vernal ponds that dry up during the summer months, and relatively deep permanent ponds that are present year-round. Because of their temporary character, vernal ponds typically have fewer aquatic predators than permanent ponds.

Aquatic predators can greatly affect an amphibian's life-history traits, including its evolutionary fitness (Figid and Semlitsch, 1990). Larval *Ambystoma talpoideum* and *A. maculatum* have reduced activity and growth rates when reared with fish (Figid and Semlitsch, 1990). Reduced activity makes amphibian larvae less conspicuous to visual hunters such as fish (Figid and Semlitsch, 1990).

In predator-poor vernal ponds desiccation is a major threat to salamanders. The need to cope with periodic drying imposes severe constraints on a species behavior, development and life history, and only those species that can overcome these constraints are successful in these habitats (Wellborn *et al.*, 1996).

Acidification of ponds is another problem for amphibians. Acid rain caused by air pollution or other definable point sources such as mining (Ireland, 1991) contribute to the acidity of many ponds and streams. Some amphibian species, such as *A. maculatum,* are relatively acid tolerant with high mortality below pH 4 and above pH 5 (Ireland, 1991). Acidification tends to be more severe in shallow vernal ponds than in deep permannet ponds, and thus pH may be a factor affecting the breeding preference of *A. maculatum* in these ponds.

The purpose of this study was to test whether eggs of the spotted salamander, *A. maculatum,* occur more frequently in vernal ponds than in permanent ponds, thus indicating a breeding preference for vernal ponds. We also compared various environmental factors that may affect salamander breeding preference (i.e., pH, temperature, presence of predators, and physical characteristics of the ponds), between vernal and permanent ponds.

It is important to determine the breeding preference of *A. maculatum* in order to help preserve the species. If spotted salamanders do, in fact, preferentially lay their eggs in vernal ponds, then special efforts should be made to preserve these often under-valued habitats.

METHODS AND MATERIALS

Water temperature was determined with mercury thermometers, and pH with a .Markson model 88 pH meter. The width and length of each pond were estimated using a Keson 100ft tape-measure, as shown in Fig. 1. The number of egg masses in each pond were counted as an index of breeding activity.

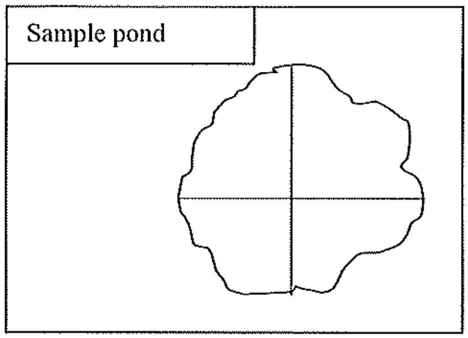

Figure 1. How width and length of a pond were measured to estimate pond size.

FIELD SITES

The permanent ponds all contained predators and or competitors. The predators included sunfish, dragonfly larva, and large tadpoles. The competitors included newts and other salamanders, emerging tadpoles, and small fish. These organisms could compete for the same food resources as the emerging salamanders.

Garner pond contained no egg masses however the pond did contain salamanders. The pond is 40 ft x 27 ft. Fields and low grasses surround the pond so it is exposed to direct sunlight. We observed fish, frogs, and other salamanders in the pond, which could act as predators and competitors.

Scott pond is 99 ft x 55 ft. This pond is located in an open field with low grasses around the rim. The substrate is composed of gravel intertwined with underwater mosses and silt. The silt is most likely the result of surface run-off from a nearby cultivated field. Fish were observed in the pond. There were no egg masses present.

Donelson pond is located near the edge of a field and has partial tree cover and is stream fed. The substrate was mainly composed of gravel and silt with some decaying leaf matter and a large dead fall in the center. The pond dimensions are an oblong 200 ft x 80 ft. There were fish and frogs observed in the pond as well as muskrats.

Detwiler pond 1 contained 14 salamander egg masses. The pond is spring fed with mature trees dominating its banks. The trees are birch, eastern hemlock, and oak. The pond substrate is composed of sand and decaying leaves. There were fish and frogs observed in the pond. The dimensions are 80 ft x 50 ft.

Detwiler pond 2 had numerous predators and competitors present, including fish, salamanders, frogs, and mallard ducks. The pond is surrounded by an oak-birch forest. The pond's substrate is composed of decaying leaf matter and dead fall. There were 8 egg masses in the pond.

Although the vernal ponds contained no predators, many of them contained potential competitors.

Vernal pond #1 was located near a house near Petersburg. Its dimensions were 74.8 ft x 41 ft. There were 2 egg masses in the pond, as well as several frog egg masses. The substrate was entirely composed of decaying leaf matter with a few sticks. Large oaks and smaller brush surrounded the pond.

Vernal pond #2 was shallow and had leaves on the bottom and grass rooted in the bottom and emerging out of the water. There were 213 egg masses, as well as numerous frog egg masses. The pond was in a clearing and very open with a temperature of 15° C. The pond was 114 ft x 41 ft. There were numerous newts in the pond, as well as frog eggs, which most likely compete for the same food resources.

Vernal pond #3 was small, 17 ft x 8.8 ft, and was under the cover of large trees and green brambles. There were 5 egg masses in the pond. The substrate was composed of deadfall and decaying leaf matter.

In vernal pond #4 mature trees and green brambles surrounded the area. The substrate was composed of deadfall and decaying plant and leaf matter with numerous submerged branches. There were 184 egg masses in the pond. There were no predators or competitors observed in the pond. Dimensions of the pond were 54.5 ft x 44.9 ft.

Vernal pond #5 contained 32 egg masses and was 32 ft x 20 ft. There were other salamanders observed in the pond, as well as frog eggs. The substrate was comprised of deadfall and decaying plant and leaf matter. Large oaks and maples surrounded the pond and a wire fence ran through it.

RESULTS

Table 1 shows the pH, temperature, and number of egg masses in each vernal and permanent pond. The number of egg masses was significantly higher in the vernal ponds than in the permanent ponds (Fig. 2; Table 2). Number of egg masses was unrelated to both pond pH and temperature (Figs. 3, 4).

Table 1. The number of egg masses, pH and temperature (°C) in each vernal and permanent pond.

Vernal or Permanent	Egg masses	pH	Temp (oC)
V	2	6.85	12
V	213	4.64	15
V	5	4.3	10
V	184	4.93	12
V	32	5.19	12
P	0	8.8	16
P	0	8.07	17
P	0	8.55	16
P	14	5.28	12
P	8	5.26	12

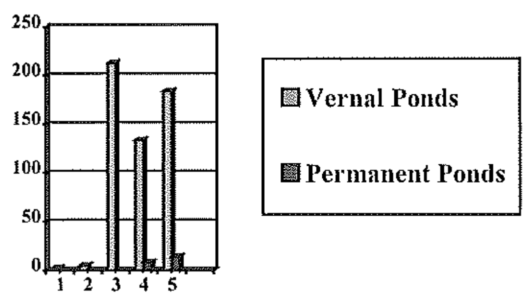

Figure 2. A bar chart showing the number of salamander egg masses in each vernal and permanent pond.

Table 2. Comparison of the frequency of egg masses in vernal vs. permanent ponds.

Chi-Square Test

Total number of egg masses in vernal vs. perm.

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Expected counts are printed below observed counts

            C5        C6     Total
    1      436        22       458
        332.50    125.50

    2      229       229       458
        332.50    125.50

Total      665       251       916

Chi-Sq = 32.217 + 85.357 +
         32.217 + 85.357 = 235.148
df = 1, P < 0.001
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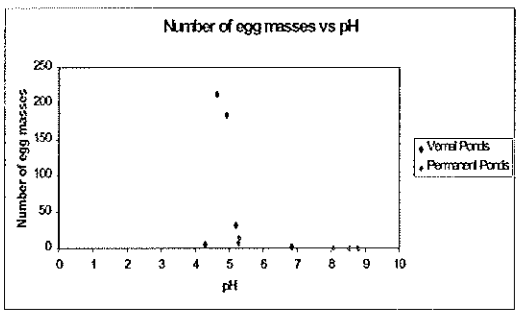

Figure 3. Number of egg masses in relation to pond pH.

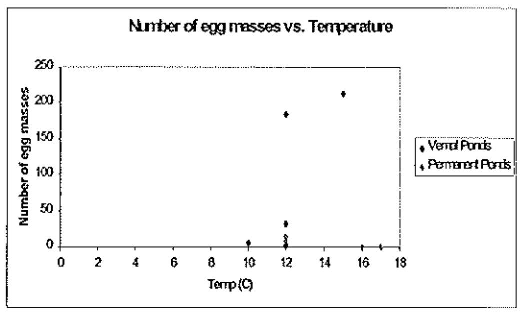

Figure 4. Number of egg masses in relation to pond temperature

DISCUSSION

As we predicted, the vernal ponds had more egg masses of the salamander *Ambystoma maculatum* than permanent ponds (Fig. 2; Table 2). All of the vernal ponds had egg masses, whereas only two permanent ponds had any egg masses at all (Table 1). This breeding preference for vernal ponds appeared to be unrelated to pH, temperature and pond size and depth because none of these factors was related to egg-mass numbers (Figs. 3, 4). However, it is interesting that all three permanent ponds that had no egg masses had the highest pH (all $\geq$ 8.0). Perhaps alkaline conditions inhibit egg laying by spotted salamanders.

We suggest that the breeding preference of *A. maculatum* for vernal ponds is due to their decreased level of predation. Terrestrial predators such as raccoons, herons and water snakes (Mitchell, 1997) may prey upon salamander eggs in both vernal and permanent ponds. However, permanent ponds are usually rich in fish predators whereas vernal ponds typically lack fish. Low fish predation in vernal ponds may favor salamander eggs in these habitats, despite the threat of desiccation.

Further research should examine the mortality rate of salamander eggs and larvae in both vernal and permanent ponds and attempt to identify the agents of mortality, including various abiotic and biotic factors not considered in this study.

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