Developmental Mortality of *Ambystoma tigrinum* (Amphibia: Urodela) in Northern Indiana

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Introduction

The only comprehensive study of developmental mortality in the eastern tiger salamander, *Ambystoma t. tigrinum* (Green) was by Anderson *et. al.* (1) in New Jersey. They determined that an average of 3.3% of the total number of eggs deposited survived to metamorphosis and that increased mortality occurred during gastrulation, hatching and metamorphosis. Mortality was greater in small than large masses. Low temperatures, predation and possibly pH significantly effected developmental mortality (1). The present paper provides the first data on developmental mortality in a midwest population of *A. t. triginum.*

Materials and Methods

The study pond , in northern St. Joseph County, Indiana, was described by Sever and Dineen (2). Briefly, the pond at maximum size is .25 ha and 60 cm deep, is filled by melting winter snows and rainfall, and usually holds water until July. It is in an open grassy field, but there are some trees around the border and considerable emergent vegetation in the shallow areas. During the spring of 1976, the pH was 6.8-7.0. *A. trigrinum* was the only salamander breeding in the pond, but the anurans *Pseudacris triseriata* and *Bufo americanus* were present. Sever and Dineen (2) estimated 1500-2000 *A. tigrinum* in the breeding population.

Prior to appearance of adult salamanders in February, 1977, 10 quadrats, each 2 m^2, were randomly established within the pond. Water depth was 26-33 cm in seven and 37-46 cm in three. Emergent vegetation was more abundant in the shallower quadrats, but all contained sumberged branches and vegetation. After egg masses were deposited, the branch of vegetation to which they were attached was tagged and numbered. Eggs were studied from deposition to neurulation. The total number of dead eggs, living eggs, and the developmental stages of the living eggs were recorded every two days. Due to clarity of the water and large egg size, the eggs were easily examined with minimal handling.

Precipitation data were obtained from the U.S. Weather Bureau, South Bend, Indiana, Air, soil and water temperatures were recorded during the afternoon of each visit to the pond. A .01 probability level was used to determine statistical significance.

Results

The first eggs were noted on 11 March and the last new masses on 11 April. Between 11-16 March, 72% of the masses were deposited, and the remainder between 29 March-11 April. These periods corresponded to times of high precipitation, mean ambient air temperatures greater than 10°C (except 4°C on 5 April) and water temperatures greater than 8°C (except 6°C and 5°C on 1 and 5 April, respectively). On any given day, there was no significant vertical temperature gradient in the pond.

A total of 861 eggs were present in 50 masses unevenly distributed among the 10 quadrats. The seven shallow water quadrats had 1-14 masses, the three deep ones 1-4 masses. The number of eggs per mass was 3-41 ($\bar{x}$ = 17.2, SD = 5.49). The variance in number of eggs per mass was highly significant among quadrats (F = 489.0).

Of the 50 egg masses, 34.6% disappeared before hatching. Significant increases in the number of clusters that disappeared were seen on 19 March and 5 April, days of low temperatures ($\bar{x}$ = 6°C on 19 March) following periods of optimal temperatures and intense egg-laying activity. These masses were assumed to have 100% mortality because most were in early gastrula prior to disappearing. Some mortality but less than 100% occurred in 59.4% of the masses and six percent of the clusters had no mortality to neurula.

One way analyses of variance among quadrats were highly significant for mean mortality between cleavage and gastrula (F = 450.2), gastrula and neurula (F = 308.2) and cummulative percent mortality from cleavage to neurula (F = 1605.4). Such results indicate that further testing is required to identify individual differences among quadrats. However, the quadrats were artificial units, and variance of mortality within the pond may be such that these quadrats are not the appropriate units for comparison.

Mean mortality between developmental stages based on grouped data from all quadrats is shown in Table I. The mean percent mortality was greater between cleavage and gastrula ($\bar{x}$ = 51.1%) than between gastrula and neurula ($\bar{x}$ = 36.0%). The mean cumulative percent mortality from cleavage to neurula was 74.3%.

TABLE I *Mean percent mortalities and their standard deviations (SD) between developmental stages of **Ambystoma tigrinum**. Means are based on combined data on individual egg masses (N) from all quadrats.*

Developmental stages	N	Mean %	SD
Cleavage-gastrula	50	51.1	29.6
Gastrula-neurula	37	36.0	18.3
Cleavage-neurula	50	74.3	16.4

Clutch sizes were arbitrarily grouped into nests of 1-10 eggs (18% of the total), 11-20 eggs (50%) and 21 eggs or more (32%). By inspection, there were no significant differences among these categories in cummulative percent mortality from cleavage to neurula.

The earliest deposited egg masses developed to hatching by 29 March. The remaining masses hatched between 11-16 April. Predation on egg masses was not observed.

Discussion

There is considerable variation in clutch size and mortality among egg masses throughout the pond. There are fewer clutches laid in deeper water, but variation in size and mortality of these clutches is similar to those laid in shallower water. The lower number of clutches in deeper water is probably the result of fewer suitable objects for clutch attachment.

The appearance of new egg masses throughout the period of this study supports Sever and Dineen's (2) findings that female *A. tigrinum* in this population oviposit asynchronously.

Many of the masses disappeared on 19 March and 5 April, days of lowered temperature following intense breeding activity. Anderson *et al.* (1) also reported that low temperatures increased developmental mortality in *A. tigrinum*.

Contrary to the findings of Anderson *et al.* (1), we found higher mortality between cleavage and gastrula than between gastrula and neurula. Also, we found no correlation between clutch size and mortality while Anderson *et al.* (1) reported higher mortality in smaller clutches. The majority of the masses observed by Anderson *et al.* (1) were larger than the masses observed in this study.

These differences may indicate distinct adaptations between Indiana and New Jersey populations resulting from different environmental influences. On the other hand, both our study and that of Anderson *et al.* (1) report on only one breeding season, and egg mortality at a given stage within a population may vary from year to year depending on environmental factors.

Literature Cited

1. ANDERSON, J. D., D. D. HASSINGER, and G. H. DALRYMPLE. 1971. Natural mortality of eggs and larvae of *Ambystoma t. tigrinum*. Ecology 59:1107-1112.
2. SEVER, D. M. and C. F. DINEEN. 1978. Reproductive ecology of the tiger salamander. *Ambystoma tigrinum*, in northern Indiana. Proc. Ind. Acad. Sci. 87:189-203.