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THE LONG ISLAND NEWT: A CONTRIBUTION TO THE LIFE HISTORY OF *TRITURUS VIRIDESCENS*

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There are in existence three comprehensive monographs and a series of special papers treating with the life history of our common water newt, *Triturus viridescens*. The last monograph has appeared so recently (Pope, 1924) that it would be expected to represent a complete statement of our present knowledge concerning the life history of this familiar aquatic animal. Pope has summarized the subject in thirty-four conclusions. During the past five years, while carrying on field work in the New York City region, I have had various opportunities to study the life history of the newt. I find as a result of this work that I cannot accept seven of Pope's conclusions. The present paper represents a brief criticism of these seven points.

DISTRIBUTION

Newts seem to be restricted on Long Island to the moraine region, for they are not found in the numerous sandy ponds which dot the southern portion of the island. I have taken specimens at Queens (1921–3), Syosset (1922–3), and Middle Island (1924–5). Long Island specimens with a definite locality record in the American Museum come from Jamaica, Richmond Hill, and East Setauket. This aversion of newts for typical coastal plain ponds is very striking at Middle Island where they are abundant in Victor Edward's Pond on the moraine, but absent from Zigs Pond, Clear Pond, and several others just south of the Middle Island road near Manorville. All of the ponds have water lilies in them and many water weeds cover the bottom, but wherever such typical coastal plain plants as *Eriocaulon* are present, the newt is invariably absent. Certain ponds on the moraine support *Rana catesbeiana*, *Acris gryllus*, and *Hemidactylium*, but these forms, like the newts, are absent from the ponds just south of the moraine. *Rana clamitans* and *R. pipiens*, however, are found in both types of ponds. It would be interesting to determine the nature of the limiting factor for the first

group of Amphibia in the coastal plain ponds. From the predominance of sand and sand-loving plants, it is probable that these southern waters are more acid.

The newt is not abundant on Long Island, but it is perhaps fortunate that it occurs there at all, for there are so many mainland Amphibia absent from the island. *Plethodon glutinosus, Pseudotriton ruber,* and *Gyrinophilus porphyriticus* are lacking,although there would seem to be habitat suitable to them along the north shore. It also seems strange that *Hyla andersonii, Hyla (Pseudacris) triseriata,* and *Rana virgatipes* do not occur in the miles of pine barrens along the south shore.

Life Cycle

It has been generally believed since the classical work of Gage (1891) that all newts hatch from eggs laid by greenish parents. After a short larval life they metamorphose into brownish, rough-skinned adults which soon take on the brilliant orange tone characteristic of the red eft. After a terrestrial existence, estimated from one to four years, the red efts change into brownish forms and seek the water where they assume the colors of the typical greenish adult. Jordan (1893, p. 279), however, makes certain reservations: "I do not yet feel prepared to say that I regard the assumption of the terrestrial habit as a necessary stage in the development of every individual. It is quite possible that certain individuals attain maturity without ever leaving the water, although perhaps the great majority of newts pass their *Wanderjahre* on land."

Pope (1924, p. 325) rejects this reservation, and, after showing that the newts he measured seem to fall into certain modes, each presumably representing a year's growth, he concludes: "With this evidence, I feel confident in saying that all newts come out of the water at metamorphosis and that they reach an average length of 80 to 85 mm. before returning to the water."

The statistical evidence given by Pope is based upon comparatively few individuals (105 in one case, 284 in another). Further, there are only two lots of 50 and 55 individuals, respectively, in this series which afford valuable data in such a study as he made, for urodeles metamorphose at greatly different sizes according to the temperature of the habitat. Graphs to be convincing would have to be based on animals collected in a single locality.

There is a more direct method of attacking the question of the length of terrestrial life. This would be to study the rate of growth in individual specimens. Such a method, however, presents certain difficulties, for red efts do not feed well in captivity.

I have studied the question of life cycle in the Long Island newt by direct observation on the individuals in a single pond. For this, I selected Victor Edward's Pond in Middle Island. Newts were not very abundant here but they were more numerous than in any other pond I knew.

On May 30, fishing with a minnow seine in this pond yielded twenty-two specimens. Of these, seven were bright yellowish brown and one (No. 2) was distinctly reddish. All seven were small and, as shown in the following table, agree in size with the measurements of the red eft as given by Pope (1924). A dissection of these seven specimens showed that they were all sexually immature; the gonads being very small and translucent.

I returned to the pond July 9 and, with the help of Mr. Jay A. Weber, succeeded in collecting sixty-six individuals. Only five of these specimens were brownish, and these averaged darker than the specimens collected May 30. They also averaged smoother and distinctly larger. On dissection, all five proved to be immature females. No pigment spots, due to degenerating eggs of a past season, were present. Serial sections revealed typical oöcytes either devoid of yolk or showing the beginnings of yolk formation. No evidence of degenerating eggs was visible. These ovaries averaged larger than those of the immature newts collected May 30. Further, a few of the oöcytes in each ovary were larger than the others. It was apparent that in the growth of the ovaries, which had taken place since May, certain oöcytes had developed faster than the others, but none had reached maturity.

Sexually Immature Aquatic Newts Collected at Middle Island (Victor Edward's Pond) May 30, 1925

No.	Total Length	Snout to Posterior Corner of Vent
1	42.5	23
2	46	27
3	51	27.5
4	55	30.5
5	56	29.8
6	57	31
7	66.5	35
Average	53.4	29.1

Sexually Immature Aquatic Newts Collected at the Same Locality July 9, 1926

No.	Total Length	Snout to Posterior Corner of Vent
1	68.5	34
2	74	38.5
3	75	37
4	76	39
5	79	43
Average	74.5	38.1

From these data it is clear that some Long Island newts pass the early part of their life cycle as metamorphosed individuals (red eft stage) in the same ponds as the adults. Further, the immature metamorphosed newts undergo a rapid development in the water. It is, therefore, highly probable that they do not require more than one season as a metamorphosed individual to reach sexual maturity. This conclusion is based upon only twelve individuals and should be supplemented by other evidence. The present evidence, although brief, demonstrates fully, and for the first time, that some newts undergo the early part of their postmetamorphic life in the water. The inference is that all newts on Long Island similarly skip over the terrestrial stage in their life cycle.

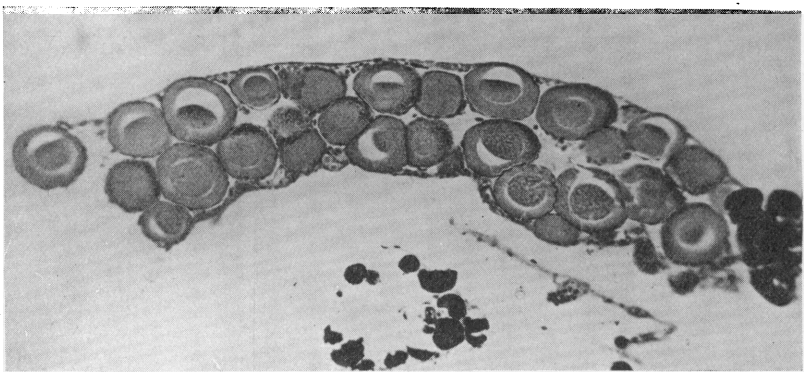

Fig. 1. Sagittal section of ovary of an aquatic metamorphosed immature newt taken on Long Island May 30. Compare these oöcytes with those in Fig. 2. × 46.

It is, nevertheless, strange that all of the twelve immature newts mentioned above are females, or at least show no evidence of spermatogenesis in their ovaries. Sections of the gonads of the specimens collected in May show the ovarian sacks to be filled uniformly with small oöcytes (Fig. 1). It is possible that the May specimens could be considered "undifferentiated" individuals which will later develop into males.

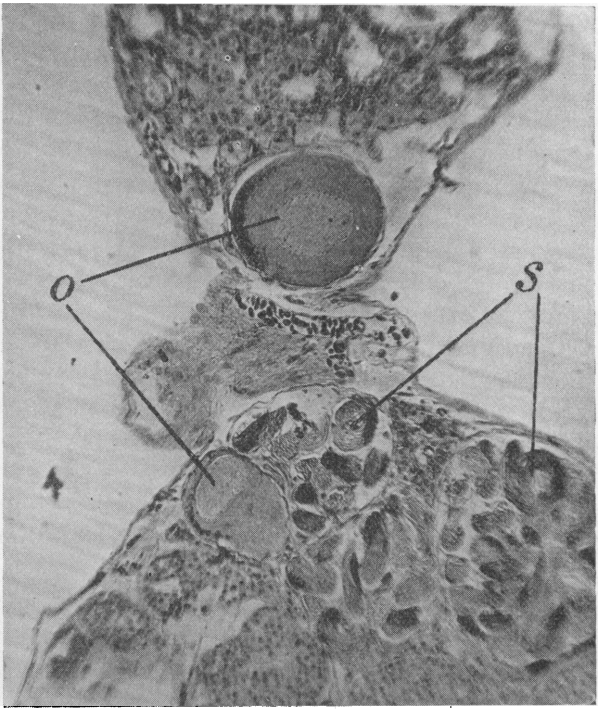

Fig. 2. Portion of the testis of a breeding male newt, Long Island, May 30. ×72.
O = oöcyte-like cells. The leader reaches to the nucleus. The black deposit in the surrounding cytoplasm is yolk. *S* = packets of sperm.

Although there is some evidence that these oöcyte-like cells in other forms may be hypertrophied spermatids,—most recent workers prefer to call them larval gonocytes (Champy, 1924; Beccari, 1925)—I have seen no evidence of a true spermatogenesis in any of the "red" specimens collected on Long Island. In short, the data given above demonstrates merely that some sexually immature newts may be aquatic. All such specimens which I have collected appear to be either females or undifferentiated individuals with the gonad uniformly filled with oöcyte-like cells.

In support of the hypothesis that the Long Island newt normally passes through an oöcyte-like stage in its spermatogenesis, it may be pointed out that several of the breeding males secured on Long Island still possess the oöcyte-like cells in their mature testes. (Fig. 2.) Swingle (1925) has shown how bullfrogs from different parts of the country, or even from the same region, may vary in their spermatogenesis. It is probable that the Long Island individuals differ from the New Jersey specimens in a similar respect.

The Red Land Stage

It is possible that the red land stage is omitted from the life cycle of other lowland newts, for, as Pope (1924) has pointed out, red efts are very rare in some regions. This point could be readily determined by the histological examination of the gonads of all brownish aquatic newts from such a region. There are, of course, numerous brownish newts in museums, but a record of the exact habitats in which these were found is usually lacking. It cannot be dogmatically stated that all brownish newts below a certain size are immatures. Color is no criterion of sexual maturity. For example, specimens Nos. 3 and 5 in my July series were identical in size and dorsal color with several breeding female newts which I collected in New Jersey. The ventral color of the Long Island specimens averaged slightly more orange.

It has not been sufficiently emphasized that the sexually mature water newt is able to change within a few hours from a brown to a greenish, or vice versa. It is these brownish individuals which are usually called "intermediates" between the terrestrial and aquatic forms. Rogers (1906) has accurately described the change as a temporary condition. On January 3, 1926, Mr. Jay A. Weber and I collected 302 newts in a single pond at Newfoundland, N. J. The edges of this pond were frozen and no terrestrial forms could have recently migrated into it. Of this series of specimens 89 were females and 213 males. Sixty-six specimens in the series were brownish, strikingly different from the other 236 specimens. All small female specimens were dissected and proved to be sexually mature females. Many were of the same size as the Long Island aquatic immatures. It was impossible to distinguish them from the latter by external examination (except for the more yellow venter).

All of the larger brownish newts were allowed to remain in aquaria over night. Many the next morning had changed to the greenish color, while others in the aquaria of green individuals had changed to brown. None of the Long Island browns which were kept for a few days, and in

one case ten months, showed any suggestion of becoming green. The older sexually immature aquatic newts can, therefore, be readily confused with the smaller sexually mature females, but only if the latter have assumed temporarily the brownish phase.

Pope (1924, p. 348) claims: "The skin of the land form is similar in structure to that of the adult, though noticeably rougher, while both are rough as compared with the larva."

This statement is not wholly correct. Sections reveal that the cells in the superficial layer of epidermis of the red land stage are spinose (Noble, 1925, Fig. 13), while in the adult they are smooth. If the red eft is dropped in water, a silvery coat of air bubbles clings to its skin much longer than in the case of an adult newt which has been retained on land until its skin dried and then similarly immersed. The difference seems to be due to these spinose cells which retain the air bubbles. The only other amphibian which I know to be similarly equipped with a coat of finely spinose cells is *Salamandrina terdigitata* (Noble, 1925, Fig. 14). This is also a small terrestrial salamandrid.

There are other differences equally important between the skin of the red land stage and that of the aquatic adult. Pigment granules are far less abundant in the epidermis of the former and the melanophores between derm and epidermis are few and far between. Xanthophores and leucophores must be represented in far different proportions in the two forms, although my sections having been run through the alcohols do not show the former clearly. In short, the integument of the red land stage differs both in texture and number of pigment cells from that of the adult.

Sections of the integument of several of the immature Long Island specimens listed above reveal the epidermis to be spinose (Fig. 3), although not as much so as in the red eft. The outer border of the cells of the superficial layer is irregularly extended into a jagged edge which averages lower than in the typical land form. It would seem that the spinose epidermis of the latter was a character of immaturity rather than a consequence of land life. It is possible that the terrestrial habit has exaggerated this spinosity. A study of the integument of the red eft immediately after metamorphosis might throw some light on this question.

The Long Island "red" newts differ from the red efts chiefly in color. The younger, or at least the smaller individuals, are redder than the older specimens from the same pond, but neither are as red as the red efts. Is this constant difference in color due merely to the different

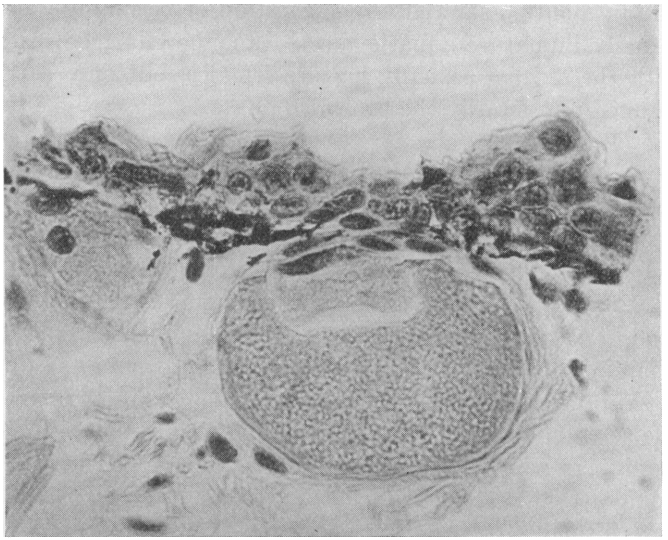

Fig. 3. Integument from the sides of the body of a Long Island aquatic red newt (metamorphosed immature), showing the irregular spinosity in the superficial layer of epidermal cells. A similar but more exaggerated spinosity occurs in the typical red eft. Section vertical to the surface. × 345.

environments acting during ontogeny on the different colonies? Pope has brought together considerable evidence to show that all red efts when subjected to moist aquatic conditions become more heavily pigmented and hence approach the Long Island "reds" in color. I have checked this conclusion by a single experiment. I placed a typical red eft from Connecticut, measuring 64.5 mm. in length, in an aquarium. A record was made of its color when immersed, on November 21. This specimen shed its skin December 10, only 19 days after being placed in the vessel. Its new skin was distinctly suffused with brown.

The distinctive integument of the land form cannot be influenced by the gonads, for red efts have been found sexually immature and others mature. Further, none of the six breeding newts which I castrated showed any tendency to increase the yellow pigment in their integument. They lost the secondary sexual characters in from twenty-one to twenty-five days, and although several lived four months in captivity, they showed no tendency to revert to the reddish form. Further, I have found no difference in dorsal coloration between the immature Long Island specimens mentioned above and breeding New Jersey females which had temporarily assumed the brownish coloration.

These data seem to narrow the possible factors controlling the distinctive coloration of the land form down to a single one: namely, the absence of excessive moisture. It would seem that any recently metamorphosed newt striving to take up an abode on land would necessarily have to change into a brownish skinned individual if it was forced to abandon its original intention and seek shelter in the water. Whether a recently metamorphosed newt will develop the bright vermilion colors of the red eft or the drab tones of the Long Island "red" is determined, according to this hypothesis, during each ontogeny by the environment.

There has been much discussion as to the length of the terrestrial stage. Pope (1924, p. 329) concludes that it lasts three years, for the newts enter the water "when they are three and a half years old and have reached the length of about 80 mm." I have collected aquatic newts in New Jersey measuring from 63.5 to 104 mm. in total length (32.5 to 49 mm. head and body). As the extremes were sexually mature female newts, it is natural to assume that the mainland newts vary enormously in size at the time they reach sexual maturity and return to the water. Further, the evidence given above would show that the red aquatic newts on Long Island remained only a single season in the water before reaching sexual maturity. In view of such direct evidence that newts return to the water at different sizes, Pope's statistics based largely on individuals without definite habitat notes cannot be accepted. There is, in short, no definite proof that newts remain more than one year as metamorphosed individuals without reaching sexual maturity.

I have taken aquatic newts in New Jersey smaller than any recorded by Pope (1924). Thus, two specimens which I collected at Millburn, N. J., April 9, 1926, measured in total length 63 and 68 mm., respectively (35 and 37 mm. from snout to posterior corners of vent). Both were reddish in color. On dissection they proved to be females with a few mature eggs in a very unevenly developed ovary. I have never found any aquatic newts in New Jersey with immature gonads. It would seem that in the hilly parts of New Jersey the red efts do not return to the water until the gonads are mature.

The differences in spermatogenesis in the different "races" of frogs have been attributed by one school of workers to genetic differences, by another, to environmental factors. It may well be asked: does the Long Island newt represent a distinct race in the sense of the systematist? I have not been able to find any constant differences in color or proportions between New Jersey and Long Island specimens. Nevertheless, Long Island specimens are peculiar in the large number of individuals

which retain gill rudiments after metamorphosis. For example, of sixty-six adult newts collected at Victor Edward's Pond, July 9, 1925, twelve had rudimentary gills varying from 1 to 2.5 mm. in length. The other fifty-four had no trace of the stubs. I have taken adult newts with gill stubs on various other occasions on Long Island, but never in New Jersey.

The Long Island newts average larger than the New Jersey specimens. One hundred and five adults from Newfoundland, N. J., averaged 84.75 mm. (max. 104, min. 63.5) in total length and 43.37 mm. (max. 49, min. 32.5) in head and body length. Contrasting to this, 57 adults from Victor Edward's Pond, Long Island, averaged 91.61 mm. (max. 120, min. 79) in total length and 46.25 mm. (max. 60, min. 38) in head and body length. Most of the very large specimens from Long Island retain rudiments of the gills.

The only evidence for considering the Long Island newt an incipient race rests in the tendency toward the retention of gills, of oöcyte-like cells in the testis, in the average larger size, and in the different life cycle. Whether these are genetic or environmentally produced differences can only be determined by experiment.

Adaptability of the Newt

The question therefore remains: would a New Jersey newt skip the red eft stage if transplanted to Long Island, or the Long Island newt develop one in the hilly parts of New Jersey? Newts are adaptable in certain other respects and it is not improbable that they are adaptable in their life cycle.

Newts are certainly more adaptable in their hibernating than Pope would have us believe. He concludes (1924, p. 349): "There seems to be little or no period of hibernation for the adult." It is true that where permanent ponds, rich in plant life occur, the newts may not hibernate. I have caught active newts in a pond at Northampton, Massachusetts, November 26, 1921, and in Greenwich, Connecticut, on November 20, 1921. Again, I secured a large series of newts through the ice at Newfoundland, N. J., January 3, 1926. But on Long Island many of the ponds inhabited by newts either dry up entirely or become very low in fall. Hence, the majority of the Long Island newts must hibernate on land. Although I have never unearthed a series of hibernating newts on Long Island in midwinter, I have caught various specimens apparently beginning their hibernation. At Queens, L. I., on November 6, 1921, I collected four adult newts in the last remnant of a pond that was drying up. Another adult was found under a log at the edge of a lake which had

dried up. The creature was dormant and did not move when disturbed. At Syossett, L. I., November 8, of the same year, I caught a few newst in the ponds and several under logs near the water. The latter were lethargic, their eyes were closed and they did not move when handled. All the logs under which newts were found would be under water when the ponds rose in the spring. It is probable that these newts were actually hibernating.

Conclusions

(1).—The newt does not tolerate typical coastal plain ponds. Its distribution on Long Island is limited to the region of the terminal moraine.

(2).—The Long Island newts do not go through the terrestrial red eft stage, but pass one spring and summer as dark reddish or yellowish forms in the water before reaching sexual maturity.

(3).—The Long Island newts show a tendency toward the retention of gill rudiments and of oöcyte-like cells in the mature testis. They also average larger than New Jersey newts.

(4).—The delicate spinosity of the epidermis of the red eft is a character of immaturity and is found to occur, but developed to a less degree, in aquatic metamorphosed immatures.

(5).—The newt may pass the winter on land or in the water according to the local environmental conditions.

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