The Problem of Toxicity in *Rana palustris*

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The person most responsible for the claims of toxicity in the pickerel or marsh frog, *Rana palustris,* is Albert Hazan Wright. In publishing alone (7, 8) and with his wife Anna Allen Wright (9, 10), he constantly refers to toxicity in *R. palustris.* The Wrights observed the following: (1) dogs and snakes demonstrating great discomfort after grasping pickerel frogs with their mouths; (2) amphibians confined with *R. palustris* dying before their container was carried from the collecting area to the laboratory.

These claims were amplified by the following: (1) Walker (6) mentioned that pickerel frogs were rejected as food by garter snakes (genus *Thamnophis*). He attributed this effect to the acrid skin secretions of *R. palustris.* (2) Conant (2) noted that few snakes will eat the marsh frog. He claimed that the distasteful secretions of skin glands were responsible. (3) Pope (4) speculated that toxicity confers upon *R. palustris* an immunity to predation which allows it to survive in snake infested areas where other frogs would perish. (4) Cockran (1) warns about placing other frogs in the same vivarium as *R. palustris,* due to its supposed toxicity.

Despite this evidence, Pope (4) and Smith (5) thought there was need for additional proof before the claim of toxicity could be accepted. In addition, Manion and Cory (3) contradicted most of the previous evidence. They found that a year-old snake of genus *Thamnophis,* when presented with live *R. palustris,* on successive days "eagerly seized and swallowed *R. palustris.*" It was also noted by Manion and Cory that the record of *R. palustris* being present in Livingston County, Michigan, indicates that the frog was found in the stomach of a garter snake.

The following quote from the dissertation of Manion and Cory (3) demonstrates that *R. palustris* is not toxic to other amphibia.

> "On two occasions individuals of this species (*R. palustris*) were closely confined with other frogs. . . . In one case, 2 individuals with 1 *R. clamitans* in a two-quart jar; in the other case, 8 *R. palustris* with 3 young *R. catesbeiana,* 4 *R. clamitans* and 2 *R. pipiens* in a 17 x 9 x 9 inch aquarium. In both cases, *R. palustris* was first to succumb under crowded conditions. All 10 individuals of this species died before any of the others, with the exception of the *R. clamitans* in the 2-quart jar, and even in this case the 2 *R. palustris* died first."

The following experiments were designed to test the question of toxicity in *R. palustris.* The non-toxicity demonstrated by Manion and Cory with 10 *R. palustris* associated with 10 other amphibia, was confirmed using over 100 adult *R. palustris,* 2 dozen other amphibia and more than 250 larvae.

The experimental animals were kept in a 4 gallon aquaria. One end of each aquarium was raised 30 degrees, and approximately 1¼ liters of tap water was included. A paper towel placed over the area of the aquarium floor not covered by water became saturated through capillary action, and enabled the animals to climb out of the water. The larvae remained in the water which was shared by the adults. Control larvae were kept in 8″ diameter finger bowls in an amount of water equal to that in the aquaria.

TABLE I

Association of *R. palustris* Adults with Adults of *R. pipiens* and *Notophthalmus viridescens*

Group	Species	Number of Adults	Mortality in 30 Days
I	*R. palustris*	97	26%
	R. pipiens	15	20%
II	*N. viridescens*	9	0%
	R. palustris	56	4%
III	*N. viridescens*	6	0%

Table I shows three groups. The first group includes single adult *R. pipiens* maintained for at least a month in the same tank with as many as twenty Michigan, Massachusetts or Wisconsin *R. palustris.* Eighty percent of the *R. pipiens* survived, a six percent higher survival than the *R. palustris* with which they were associated. This result would have been impossible if *R. palustris* was toxic to *R. pipiens.*

In the second group, single *Notophthalmus (= Triturus) viridescens* were kept with some of the same *R. palustris.* Over a period of more than thirty days' exposure all salamanders survived, as did their controls, group three.

TABLE II

Survival of *R. pipiens* Larvae Associated with *R. pipiens* and *R. palustris* Adults

Species of Adults	Number of Adults	Number of Larvae	Initial Larval Length	Larval Mortality After First Day	Larval Mortality After 120 Days
R. palustris	39	67	11-20 mm.	3%	15%
R. pipiens	26	56	11-20 mm.	2%	2%
Control	0	43	14-20 mm.	0%	51%

A test for toxic effect on ranid larvae was devised (Table II). *Rana pipiens* larvae were raised under three varying conditions: (1) with *R. pipiens* adults (non-toxic), (2) with *R. palustris* adults (said to be toxic), (3) in finger bowls (as an experimental control). In the last two columns, Table II lists the number of larvae which were found dead and could possibly be considered as toxicity victims. Larvae which were cannibalized or crushed by the adults were not included in this total, since it is not likely that they could have been poisoned.

In order to be killed in either of these fashions, the larvae would have to be swimming in the shallow water near the basking area of the adults. Larvae killed by poison or congenital defects would sink to the bottom of the slanted floor. If they had been poisoned their lack of activity could not incite a feeding reaction in the adults, thus they must have been alive and in reach. Therefore those larvae eaten or crushed were not considered as being poisoned.

Should there have been a strong toxin secreted by the *R. palustris* adults, many larvae would have been found after the first day of contact with the marsh frogs. Such was not the case. Through the course of the next 120 days very few larvae were ever found dead, let alone in a condition which could be interpreted as a toxic effect. The total larval mortality, including deaths through cannibalism and injury, is

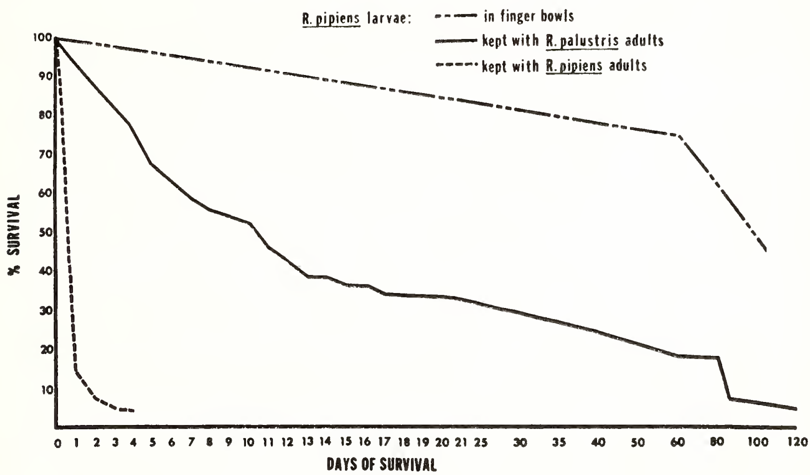

Figure 1

represented in Figure I. In case of *R. pipiens* larvae associated with *R. pipiens* adults, there is an immediate reduction in the number of survivors. Yet *R. pipiens* adults are not known to be toxic and could hardly be thought to poison their own species. The rapid decline of the larvae can only be attributed to injuries they received from the bulky adults.

Those *R. pipiens* larvae associated with *R. palustris* adults were far from being decimated. There was no initial dip in the survival curve which would indicate a strong toxic effect. Sixty percent of the larvae survived for at least a week. Close to thirty-five percent were alive after 20 days. Between fifteen and five percents lasted from 80 to 120 days in an environment which was supposedly toxic. Any decline in the experimental as compared with the control survival rates can be explained by the effect of (1) some degree of jostling, which was not as great as in the case of the more bulky *R. pipiens* adults; (2) cannibalism on the part of the *R. palustris* adults. (Photographic evidence of cannibalism was presented at the October meetings.)

TABLE III

Survival of Tadpoles Associated with Adult *R. palustris*

Species of Larvae	Number of Larvae	Number of Adults	Larval Mortality After	
			First Day	17 Days
R. pipiens (11 mm.)	60	31	0%	12%
R. pipiens (14-25 mm.)	43	52	0%	5%
R. palustris (16-25 mm.)	40	52	0%	3%

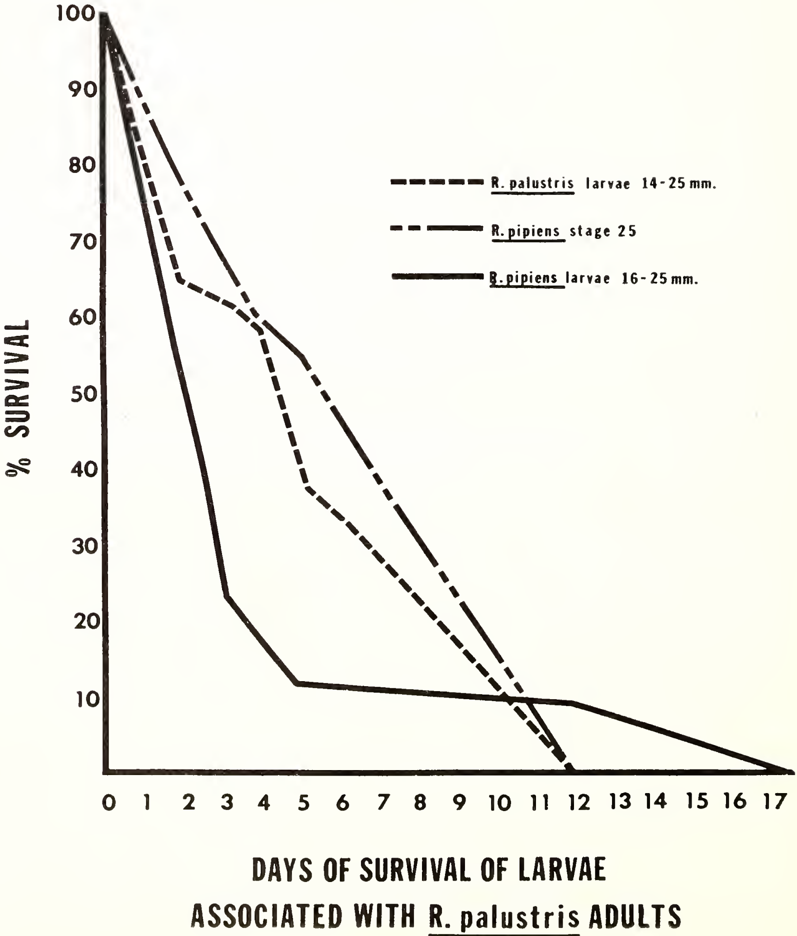

Figure 2

When compensation is made for cannibalism and injury the survival curves of adult associated larvae approach that of the control, making the claim of toxicity less tenable.

Another comparative experiment is represented in Table III and Figure II. Two types of larvae were associated with *R. palustris* adults: those of *R. pipiens* which should have been poisoned, and those of *R. palustris* which should not. In Table III it is again noted that throughout the experiment, few larvae were ever found dead. Initial contact with the adults produced no suspected toxicity victims. After 17 days, less than 9% of the total *R. pipiens* larvae could be remotely considered as poison victims. Examination of the total survival of the two *R. pipiens* age groups and one *R. palustris* larval group, shows that the decline of the *R. palustris* larvae fell well within the variation between the two leopard frog survival curves. Had there been a difference in the survival rates based on susceptibility to toxin, there would have been a greater divergence of the *R. palustris* curve from the other two. It seems that the decline throughout all these experiments could be attributed to cannibalism and crushing, which applied to each larval species to the same extent.

A subsequent experiment investigated the extent to which cannibalism and physical injury, increased the mortality rate of adult associated larvae. Small numbers of *R. pipiens* larvae of the same size range, age and health were divided into three groups. One was placed in the tank water with adult *R. palustris*. The second group was placed in 250-300 ml. Erlenmyer flasks, sealed with highly porous cheese cloth. The flasks were then placed into the tank allowing free exchange of water between tank and flask. The third group was kept in finger bowls completely isolated from the adults. The number of larvae totally exposed to adults was reduced through physical injury or cannibalism, whereas those flask-enclosed larvae survived at a rate which approached that of the controls.

After experiments in which *R. palustris* were associated with other amphibia in different phases of their life cycles, there was no demonstrable toxicity on larval and adult amphibia of other species. These results do not support the theory of pickerel frog toxicity.

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