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Reviewed work(s):
Source: *Copeia*, Vol. 1967, No. 1 (Mar. 20, 1967), pp. 214-218
Published by: American Society of Ichthyologists and Herpetologists (ASIH)
Stable URL: http://www.jstor.org/stable/1442196
Accessed: 13/01/2012 15:32

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Food Habits of the Green Frog, *Rana clamitans*, Before and During Metamorphosis

Thomas A. Jenssen

One hundred forty-four *Rana clamitans* tadpoles were collected during April and May 1963 and September 1963 through March 1964 in southern Illinois. The larvae of the April and May collections were approaching or passing through metamorphosis; they exhibited no alteration of diet, even during the initial stages of metamorphosis. However, the tadpoles did fast from approximately the time the forelimbs broke through the body walls until their tails were about absorbed. Water samples were taken with each of the September through March collections. The kinds and numbers of organisms ingested by the tadpoles were proportionally reflected in the water samples; this correlation was statistically significant. It was concluded that green frog larvae are fortuitous and indiscriminate feeders with no apparent food preferences. Premetamorphic tadpoles appear to feed continuously, even in winter.

Introduction

The green frog, *Rana clamitans*, is a common anuran of the eastern United States. It has been the object of many life history investigations, including several dietary studies of the adult stage (Hamilton, 1948; Whitaker, 1961; Jenssen and Klimstra, 1966). However, the larval stage has been largely neglected. References to the diet of the larval green frog are for the most part very general. Hay (1892) reported that green frog tadpoles are vegetarians. Similar statements were made by Dickerson (1906) and Noble (1931). Pope (1947) stated that *R. clamitans* tadpoles feed on diatoms, algae, and minute quantities of small animal forms. The objectives of this paper are to present in more specific terms the food habits of the green frog tadpole, the relationship between available organisms and ingested food items, and the effect of metamorphosis upon the tadpole diet.

Methods and Materials

One hundred forty-four tadpoles were collected during April and May 1963 and from September 1963 through March 1964. Three bodies of water were utilized during the study. The first collection site was an impoundment on the Small Fruit Farm of Southern Illinois University located southwest of Carbondale, Illinois; this pond furnished the several April and May samples which were studied to observe the effects of metamorphosis upon the larval diet.

The second site was a small lake on the Jackson County Country Club property situated northwest of Carbondale. Tadpoles were taken from this location from September to December 1963 and in March 1964. Because ice formed on the lake in late December, a small stream adjacent to Larue Swamp in the Pine Hills area of Union County, Illinois was utilized as the third collection site during January and February 1964. Water samples were taken concomitantly with tadpole collections from September through March to determine whether tadpoles were selective feeders.

Tadpoles were netted near the shoreline in less than 3 ft of water and immediately placed in 10% formalin to stop digestion and preserve food items. In the months when water samples were taken, each collection of tadpoles was restricted to a reasonably small area of water. The water samples were then obtained from an undisturbed portion of the collection area.

Water samples were obtained separately from the surface, middle depth, and bottom of the collection site in 500 ml flasks. Each water sample was divided among 8 centrifuge tubes and spun for 3 min at 1000 rpm. The condensed materials were taken from the centrifuge tubes and placed in a watch glass with 10 ml of distilled water; from this concentrated mixture 2 drops were placed on a slide and examined under a compound microscope. Frequencies of all identifiable plants and animals were recorded. Because of the extreme difficulty of identifying

TABLE 1. THE PERCENTAGE COMPOSITION OF ORGANISMS FOUND IN 119 GREEN FROG (*Rana clamitans*) TADPOLES (TAD) AND WATER SAMPLES (HOH) COLLECTED SEPT. 1963–MARCH 1964, IN SOUTHERN ILLINOIS.

Organisms	Sept		Oct		Nov		Dec		Jan		Feb		March	
	TAD	HOH	TAD	HOH	TAD	HOH	TAD	HOH	TAD	HOH	TAD	HOH	TAD	HOH
Chlorophyceae	30.4	31.1	17.5	26.3	49.5	48.2	79.6	67.2	0.7	1.1	0.7	0.1	16.9	12.5
Chlamydomonas	—	0.1	—	—	—	—	—	—	—	—	—	—	—	—
Sphaerocystis	3.2	4.8	0.1	2.1	—	0.7	—	—	—	—	—	—	—	0.4
Palmodictyon	—	—	—	—	—	—	—	—	—	—	—	—	0.1	—
Ulothrix	0.1	0.2	—	—	—	0.1	—	—	0.1	0.4	0.6	—	9.9	3.6
Cylindrocapsa	—	0.6	trace	—	0.1	0.2	—	—	—	—	—	—	0.3	—
Coleochaete	—	—	trace	0.5	trace	—	—	—	—	—	—	—	—	—
Oedogonium	2.9	1.5	0.2	0.2	0.3	0.6	0.1	0.3	0.5	0.7	0.1	—	—	—
Cladophora	0.1	—	0.3	0.5	0.1	—	—	0.9	—	—	—	—	—	—
Rhizoclonium	2.8	2.8	4.2	4.1	2.3	4.0	0.5	0.5	—	—	—	—	—	—
Pithophora	0.1	1.0	0.1	—	—	—	0.2	0.4	—	—	—	—	—	—
Dictyosphaerium	0.1	0.1	0.1	0.1	5.3	1.7	15.4	4.6	—	—	—	—	0.4	—
Schoederia	0.1	—	2.5	1.1	11.6	10.1	10.7	13.9	—	—	—	—	—	—
Hydrodictyon	trace	0.4	0.7	0.6	0.4	1.4	—	0.7	—	—	—	—	—	—
Coelastrum	—	—	0.3	2.1	0.1	1.2	—	—	—	—	—	—	—	—
Eremosphaera	0.3	0.4	0.2	0.4	0.1	—	—	—	—	—	—	—	—	—
Oocystis	trace	—	0.1	—	trace	1.1	—	—	—	—	—	—	trace	0.2
Chodatella	—	—	1.0	3.4	0.1	1.2	trace	0.1	—	—	—	—	—	—
Ankistrodesmus	—	—	0.1	—	14.8	10.2	39.1	34.8	0.1	—	—	—	3.4	4.9
Selenastrum	2.8	1.8	0.5	0.2	1.0	0.9	1.7	0.4	—	—	—	—	0.2	0.8
Kirchneriella	1.7	1.7	2.0	1.3	6.0	4.6	9.9	5.1	—	—	—	—	2.2	2.6
Scenedesmus	6.5	5.1	2.1	2.6	5.4	5.9	1.7	4.9	—	—	—	—	0.4	—
Crucigenia	7.9	6.1	1.9	5.3	1.1	1.5	0.1	—	—	—	—	—	—	—
Mougeotia	—	—	0.1	—	trace	—	trace	—	—	—	—	—	—	—
Spirogyra	0.2	0.7	0.1	0.7	0.5	1.9	0.1	0.5	—	—	—	—	—	—
Sirogonium	trace	—	0.4	—	—	—	—	—	—	—	—	—	—	—
Closterium	0.1	1.1	0.1	0.4	0.1	0.6	trace	—	—	—	trace	—	trace	—
Cosmerium	1.2	2.0	0.3	0.4	0.1	0.2	0.1	0.1	—	—	trace	0.1	trace	—
Staurastrum	0.3	0.7	0.1	0.3	0.1	0.1	trace	—	—	—	—	—	—	—
Euglenophyceae	0.3	1.0	0.4	1.7	1.4	2.2	1.1	1.1	trace	—	—	—	0.5	2.3
Trachelomonas	0.3	1.0	0.4	1.7	1.4	2.2	1.1	1.1	trace	—	—	—	0.5	2.3
Bacillariophyceae	13.6	13.4	26.2	24.1	11.2	10.5	12.1	18.3	97.7	97.5	97.2	97.5	82.0	80.3
Dinophyceae	—	—	0.2	0.9	—	0.1	—	—	—	—	—	—	—	—
Ceratium	—	—	0.2	0.9	—	0.1	—	—	—	—	—	—	—	—
Myxophyceae	49.2	52.5	54.6	42.4	36.8	34.2	6.3	12.5	1.3	1.1	1.3	2.2	0.4	3.6
Anacystis	31.0	33.3	37.8	33.8	20.7	23.7	1.2	5.0	—	—	trace	—	—	—
Agmenellum	0.4	1.1	5.8	1.1	4.6	1.9	2.3	4.7	—	—	—	—	0.1	—
Gomphosphaeria	6.0	8.0	7.8	5.8	9.7	4.7	1.7	0.8	—	—	trace	—	—	—
Spirulina	4.5	2.5	0.1	0.2	—	0.1	—	0.1	0.1	—	—	—	0.1	—
Oscillatoria	6.7	7.2	3.0	1.5	1.7	3.8	1.1	1.9	1.2	1.1	1.3	2.2	0.2	3.6
Anabaena	0.6	0.4	0.1	—	0.1	—	—	—	—	—	—	—	—	—
Non-algal forms	6.4	2.0	1.0	4.5	1.0	4.8	0.8	0.9	0.2	0.3	0.7	0.2	0.1	1.3
Phycomycetes	—	—	0.1	—	—	—	—	—	—	—	—	—	—	—
Rhizopoda	2.3	0.8	0.4	1.1	0.5	0.8	0.7	0.2	0.2	0.1	0.5	0.1	0.1	0.6
Ciliophora	0.1	—	—	2.8	—	3.1	—	0.2	—	—	trace	0.1	—	—
Gastrotrichia	0.1	—	trace	—	—	—	—	—	—	—	—	—	—	—
Rotifera	1.4	0.3	0.2	0.3	0.1	0.3	—	—	trace	0.1	0.1	—	—	—
Cladocera	1.0	—	0.1	0.1	0.2	—	—	0.2	trace	—	trace	—	—	—
Ostracoda	1.3	0.9	0.1	0.1	0.2	0.5	0.1	0.3	—	—	0.1	—	trace	—
Copepoda	trace	—	—	0.1	—	0.1	—	—	—	0.1	trace	—	—	0.6
Nematoda	0.2	—	0.1	—	—	—	—	—	—	—	trace	—	—	0.1

diatoms, they were listed simply as Bacillariophyceae. Like the diatoms, entomostracans were also grossly classified. The remaining algal forms were identified to genus. Filamentous algae were counted as units.

The first 10 mm of intestine just posterior to the stomach were removed and the contents examined. The stomach was not incorporated in the examination because the internal volume of this organ varied considerably. Since the stomach, or manicotto, is not considered to have a gastric function in the larval stage (Griffiths, 1961), it presumably would not have a digestive effect on food items. The contents of the 10 mm length of intestine were emptied into 1 ml of distilled water; 2 drops of this mixture were examined and data handled in the same manner as the water samples.

Identification of organisms found in the tadpoles and water samples was facilitated by the works of Edmondson (1959), Prescott (1951), Smith (1950), and Tiffany and Britton (1952). Classification of the algae followed Smith (1950) with the exception of the blue-green algae; here the revision of the coccoid Myxophyceae by Drouet and Daily (1956) was substituted.

Results and Discussion

Similar to the conclusion drawn by Savage (1951, 1962) for *Rana temporaria*, data from the present study suggest that larval *R. clamitans* are continuous feeders. Except for a few digestive tracts from larvae in the late stages of metamorphosis, every one of the 144 alimentary canals examined, including those of winter samples, was completely filled with ingested material.

Sand, decomposed higher plants, and other debris made up a moderate portion of the intestinal bulk. The remaining intestinal contents were composed of algae, various entomostracans, and fungi. By far, algae were the most abundant of ingested living organisms. Diatoms were consistently found in large numbers; during the winter months this group was extremely prevalent as other organisms became scarce (Table 1). Microcrustaceans, though present in most tadpoles, constituted only a small numerical portion of living material ingested.

From the monthly comparisons presented in Table 1, it is evident that the tadpoles had ingested the same kinds of organisms and in approximately the same relative proportions as existed in the water. Regression analyses demonstrated a near perfect correlation between organisms found in the larval digestive tracts and organisms encountered in corresponding water samples (Table 2). The above data strongly suggest that the tadpoles had no apparent food preferences, and engulfed whatever entomostracans and algal forms were present.

Such a conclusion is also supported by the type of feeding mechanism found in anuran larvae. May it be planktonic or suspended animals and plants, bacteria, detritus, or material removed from a larger organic mass by abrasion of the teeth, nutritive material is involuntarily extracted by filtration from the water used for respiration (Savage, 1962; Reeder, 1964). Therefore, feeding is a continuous activity. Since the green frog tadpoles were found to have ingested mud as well as blue-green algae peculiar to the water's surface, it may be surmised that their feeding behavior is nondiscriminate. However, the extent to which any of the ingested materials actually contributed to the tadpoles' nourishment was not investigated.

Working with *R. clamitans* in Virginia, Farlowe (1928) found the intestinal contents of tadpoles served as a good indicator of the floristic composition of the environmental water. However, Farlowe made no quantitative comparison of ingested items with organisms in her water samples. In India, Kamat (1962) found a similar situation. He reported that tadpoles (species not mentioned) contained the same algal forms as were present in pond water with three notable exceptions: *Pithophora*, *Cladophora*, and *Chara* were plentiful in the environment, but absent in the tadpole intestines. Green frogs of the present study ingested members of every genus of filamentous algae found in the water samples, including *Pithophora* and *Cladophora*.

Tadpoles of the April and May collections were used to observe the effects of metamorphosis on the larval diet. Following the developmental stages described for *Rana pipiens* by Taylor and Kollros (1946), the collected tadpoles were grouped according to the following stages: (1) VI–XVII, (2) XVIII–XIX, and (3) XX–XXII. The average snout–vent length of each group was 25 mm.

There was no evident difference in the diet between the first two groups of larvae. However, tadpoles of the second group possessed shortened digestive tracts. When the length of intestine was related to snout–vent length, the resulting ratios averaged 16.3 for the first group as compared with 11.6 for the second. Additional alterations of the gastro-intestinal tract were noted in the latter group. In several specimens the manicottos tapered posteriorly, the intestines were slightly reduced in diameter, and rudimentary large intestines were evident.

The last group of tadpoles (stages XX–XXII) displayed the dramatic transition from tadpole to frog. Among the many external morphological changes were the appearance of the forelimbs and a frog-like mouth. Internally, the stomach, small intestine, and large intestine were differentiated. One specimen possessed a green stained duodenum indicating possible bile production. The ratio of intestine length to snout–vent length was much smaller than previous stages, averaging 3.2.

Even though there was much differentiation of the digestive system in this last group of tadpoles, the digestive tracts appeared nonfunctional. Lumens of the intestines were small, tighty compressed slits. The stomachs contained nothing but sloughed cells and seemed closed in the pyloric region. No ingested material was found in this group. Therefore, it is concluded the tadpoles fast during this period of gross anatomical differentiation. The external appearance of forelimbs is an indicator of the onset of the fasting period.

Abstinence continued in the transforming green frog until the tail was about absorbed. Seven millimeters was the longest tail length found for a frog which had commenced an adult diet. Munz (1920), who investigated the food habits of several species of anurans during the period of metamorphosis, recorded a maximum tail length of 5 mm for green frogs which had begun ingesting insects.

TABLE 2. "r" VALUES OF REGRESSION ANALYSES COMPARING ORGANISMS IN TADPOLE (*Rana clamitans*) INTESTINES WITH ORGANISMS FOUND IN CONCOMITANT WATER SAMPLES.

Date Collected	Sampled Tadpoles	"r" Values ($P < 0.001$)	Degrees of Freedom[1] ($N-1$)
29 Sept 1963	20	0.972	37
29 Oct 1963	15	0.956	42
14 Nov 1963	20	0.908	34
5 Dec 1963	12	0.900	27
7 Jan 1964	20	0.910	10
10 Feb 1964	20	0.934	14
29 March 1964	12	0.968	21

[1] N = kinds of food; trace items excluded.

ACKNOWLEDGMENTS

Grateful appreciation is given to Dr. W. D. Klimstra, under whose supervision this research was conducted. This study is a contribution of Project No. 10, Cooperative Wildlife Research Laboratory, Southern Illinois University, and represents a portion of the work submitted in partial fulfillment of the requirements for the Master's Degree in Zoology.

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