SOME MORPHOLOGICAL AND BEHAVIORAL CHARACTERISTICS OF AN INTERGRADE POPULATION OF THE GREEN FROG, *Rana clamitans*, IN SOUTHERN ILLINOIS

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ABSTRACT. — A sample of 475 green frogs, representing an intergrade population of *R. c. clamitans* x *R. c. melanota*, was collected in southwestern Illinois. Variations were found in this population as compared with findings reported for green frogs in the northern portion of the range. These differences include: (1) shorter body length at metamorphosis, (2) smaller length at maturation, (3) shorter maximum length, (4) longer breeding period, and (5) longer period of annual activity. Supporting data are offered for biannual metamorphosis. Additional morphological aspects and seasonal behavior of the green frog are reported.

The green frog, *Rana clamitans*, is an anuran whose distribution encompasses almost all of the eastern United States. Although this frog has attracted the interest of many investigators, Smith (1950, p. 103) states that nothing is known of the life history of the green frog for populations in the central and southern portions of its range. *R. c. melanota* has been the subject of significant ecological studies in New York and Michigan such as those of Hamilton (1948), Martof (1953a, 1953b, 1956a, 1956b), Munz (1920), Ryan (1953), Wright (1914), and Wright and Wright (1942); however, little work has been done on the southern subspecies, *R. c. clamitans*.

Frogs of the present study were collected from the Pine Hills area of southern Illinois, and as Rossman (1960, p. 214) has described, represent an intergrade population of *R. c. clamitans* x *R. c. melanota*. This population exhibits some divergent behavioral and morphological characteristics from those reported for more northern animals. The following data are of particular worth from a comparative standpoint, being of further value when greater attention is given to the natural history of the green frog in its southern-most range.

MATERIALS AND METHODS

A total of 475 green frogs were collected in weekly samples from the Pine Hills region of Union County, Illinois from March 1963 to February 1964. Most animals were taken from or near LaRue Swamp. A thorough floristic description of the area is given by Ashby and Kelting (1963) and Mohlenbrock (1959).

Frogs were hunted where their numbers seemed greatest. No selection was made as to size of frog collected, but there was an attempt to obtain 20 juveniles and 20 adults per month. After capture the frogs were taken to the laboratory and frozen in plastic bags for future processing. Upon thawing each frog was placed dorsum down on a millimeter rule with gentle pressure applied so the cranium and vertebral column were aligned and straight. The snout-vent length was measured from the snout to the tip of a pointer whose shaft was pressing the posterior edge of the ischium. Length was recorded to the nearest millimeter. Determination of the tympanic diameter was made along the longitudinal axis between the outer perimeter of the left tympanic ring; the resulting value was recorded

to the nearest half millimeter. Other seasonal data were gathered from the sample, including stomach contents (Jenssen and Klimstra, 1966), organ weights, and an endoparasite examination.

Results and Discussion

Metamorphosis

The size of transforming green frogs from southwestern Illinois appears smaller than those found further north. Snout-vent lengths of 15 juvenile frogs from Pine Hills which still possessed tail stumps ranged from 23 to 33 mm with a mean length of 27.2 mm; this value agrees well with the 26.1 mm average obtained from 34 transforming frogs from adjacent Jackson County. Some of the latter specimens were utilized in a dietary study of larval and transforming green frogs (Jenssen, 1967).

From Ann Arbor, Michigan, Martof (1956a, p. 106) reports the snout-vent lengths of newly transformed frogs, those possessing tail stumps, as ranging from 28.4 to 36.3 mm with a mean of 32.6 mm. Data collected in Ithaca, New York by Munz (1920, p. 41) showed a range of 29 to 36 mm for 15 transforming green frogs (tail stumps 2 to 15 mm long) and a mean of 32.5 mm; this is almost identical with Martof's observations. Both investigators report significantly larger snout-vent lengths than those measurements taken of frogs in southwestern Illinois.

Traditionally, the green frog tadpole was thought to overwinter before completing its larval development. However, the recent works of Martof (1956a, 1956b) in Michigan, Richmond (1964) in Pennsylvania, and Ting (1951) have produced strong evidence that development from egg to frog can occur within the same season. A similar conclusion is drawn for the Pine Hills population.

Evidence for a biannual metamorphosis is indicated in Figure 1. The length frequencies for the fall-

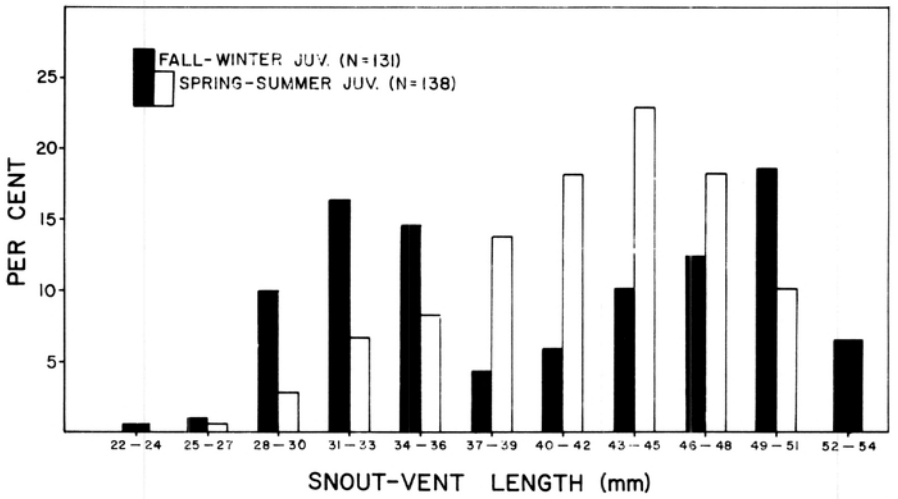

Figure 1. — The percent frequency of occurrence of snout-vent lengths of juvenile green frogs collected Mar.-Aug., 1963 (Spring-Summer) and Sept., 1963—Feb., 1964 (Fall-Winter), LaRue Swamp, Pine Hills, Union County, Illinois.

winter juveniles illustrate a distinct bimodal distribution. The first peak includes approximately 30% of the sample within snout-vent lengths of 31 to 36 mm. In all probability these frogs represent the late summer transformation. Many of the larger animals are products of the acknowledged early summer metamorphosis.

Furthermore, collections and observations of small juveniles with tail remnants were made only during May 24 through June 29 and August 28 through September 5. Field notes record the largest numbers of newly transformed frogs were seen on June 12 and September 1. The period of late summer transformation is probably greater than the dates given as no trips to the study area were made between September 5 and September 23. In comparison with the Illinois dates, Martof (1956a, p. 105) found metamorphosis near Ann Arbor to occur during June 5 through July 12 and August 3 through September 28.

Juveniles

The snout-vent lengths of juveniles ranged from 23 to 54 mm. There was no consistent body length which delimited juveniles from adults (Figs. 1 and 2). Besides the natural hereditary variations involved in maturation, sex of the frog and season had a large influence on the size at which adulthood was reached.

The largest non-adults were females. Of the juvenile frogs having body lengths between 49 and 54 mm, 30 were females as opposed to 16 males. No juvenile males were found in the 52-54 mm class. Martof (1956a, p. 113) reports males maturing before females, but could find no significant difference in growth rate for juvenile males and females. He concluded it took longer for gametic development in females than males.

The largest juveniles were found in the fall-winter samples. Subadults passing through the breeding season without attaining sexual maturity would possess adult lengths by fall. There is little confusion in classifying males as there are obvious secondary sexual characteristics which appear at puberty, such as enlarging tympanums. However, the author knows of no adequate means of ascertaining the age category of a female frog when it is between 49 and 55 mm long without consideration of the season and an internal examination.

Adults

Referring to Illinois green frogs, Smith (1961, p. 97) states that adult females are said to be larger than adult males, but the size difference was not obvious from the series of frogs available. Although Ryan (1953, p. 77) reports a greater size for adult females in his New York study, Martof (1956a, p. 113) could find no difference in mean lengths of the sexes taken from 344 adult males and 307 adult females from Michigan.

The length frequencies of 206 Pine Hills adult frogs are presented in Figure 2. A distinct sexual difference in length is obvious. It is felt that a representative sample of large males was obtained since during the three month breeding season

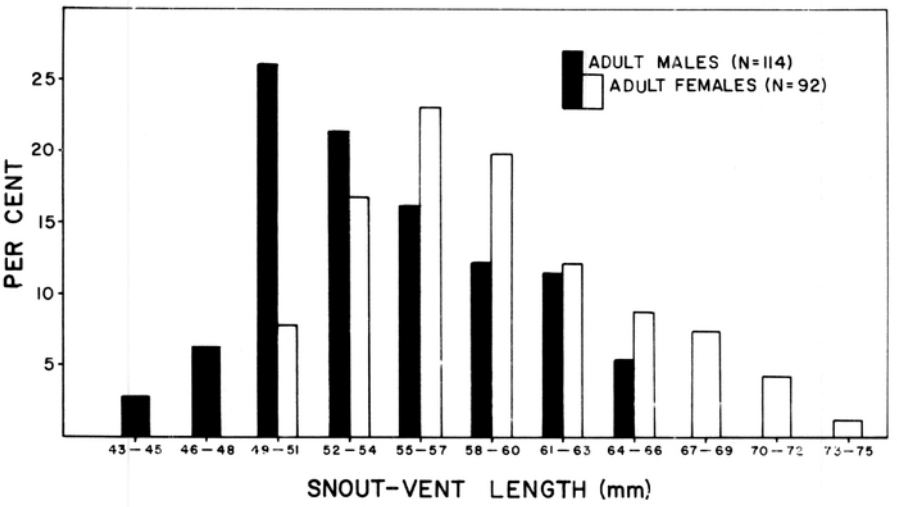

FIGURE 2. — The percent frequency of occurrence of snout-vent lengths of adult green frogs collected Mar., 1963—Feb., 1964, LaRue Swamp, Pine Hills, Union County, Illinois.

the calling led the collector to the adult males. Still the largest male (66mm) is considerably smaller than the largest female (75mm). Adult male and female mean snout-vent lengths are 54.6 mm and 59.0 mm, respectively. The smaller adults were collected in late spring and summer, the periods when subadults come into sexual maturity.

In comparing the above values with lengths recorded by other workers, Martof (1956a, p. 112) found adult males in Michigan matured at 60-65 mm, had a mean length of 79.8 mm, and reached a maximum size of 103 mm. The adult females matured at 65-75 mm, had a mean length of 80.3 mm, and reached 105 mm in size. Wright and Wright (1942, p. 192) state green frogs in the south (presumably *R. c. clamitans*) are smaller than northern frogs. They give adult male snout-vent lengths as ranging from 52 to 72 mm and the adult females 58 to 75 mm; these values agree closely with lengths found in the Pine Hills population, though some of the latter frogs exhibit maturation at a smaller size.

Martof (1956a) presents a reliable field technique for recognizing adult males. By dividing the snout-vent length by the diameter of the tympanum, one derives the sex index. Martof (1956a, p. 115) found that if the index was less than 10, the frog from which the measurements were taken was an adult male. Individuals with an index of 10 or greater were classified as either juveniles or adult females.

This sex index was applied to the intergrade population of Pine Hills and was found to be accurate. How-

ever, in these frogs the dividing point for adult males was 9 or less with juveniles and adult females being greater than 9 (Fig. 3). The only overlap occurred in the 9.0-9.4 class; here existed a number of subadult males approaching maturity while some of the remaining frogs were just acquiring adulthood as evidenced by enlarging gonads and thumbs.

It is not too surprising that a comparison of the sex index of Michigan frogs with that of the Illinois frogs should reveal a difference since there are other morphological variations between the two populations. The disparity in the allometric relationship of the body length to tympanum size found between the frogs of the two states may possibly be related to the smaller snout-vent length of the southern subspecies. In computing the sex index, it can be seen that a decreased body size divided by a constant tympanic diameter results in a smaller index value.

The sex index is of particular use when working in the field with *R. c. clamitans,* as many adult males of this subspecies do not have a yellow throat and the enlarged thumb is a character of subjective evaluation. The snout-vent/tympanum index, however, can be applied precisely throughout the year.

Seasonal Activity

In November juvenile frogs remained common along the swamp shoreline long after adults disappeared. Juveniles were collected in the swamp proper up to November 26. In contrast, the last adults were taken from the swamp on November 9. Near Ann Arbor, Michigan all frogs were hibernating between October 29 and November 13 (Martof, 1956b, p. 225). Throughout the winter many Pine Hills juvenile frogs

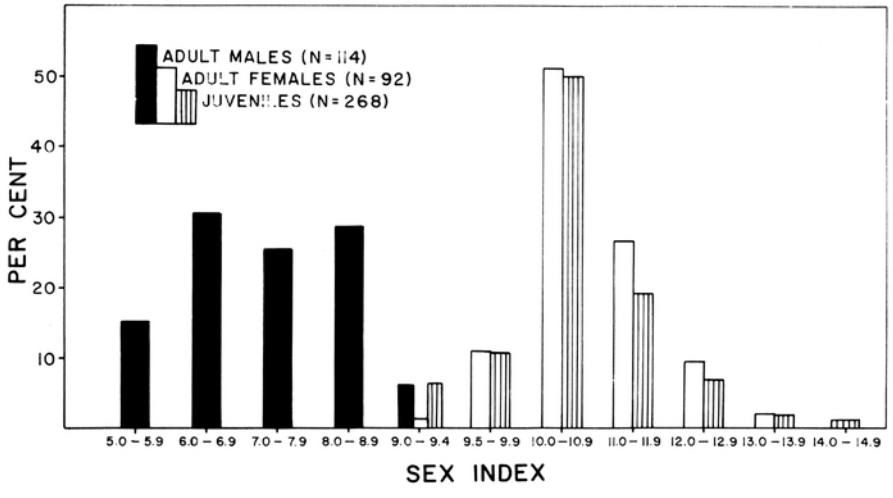

FIGURE 3. — The percent frequency of occurrence of the sex index ratio (snout-vent length/tympanic diameter) of green frogs collected Mar., 1963—Feb., 1964, LaRue Swamp, Pine Hills, Union County, Illinois.

remained active in the small spring-fed streams which run into the swamp from the base of the adjacent limestone bluffs. These frogs were frequently captured away from any apparent hibernaculum. Presumably, the young frogs were foraging as evidenced by a smaller percentage of empty stomachs among juvenile frogs than the adults during much of the winter (Jenssen and Klimstra, 1966, p. 171).

Adults also overwintered in the streams, but were seldom judged to be active as most were found confined within small chambers beneath rocks, mud banks, and leaf debris. Many adults were discovered under the snow in the cavities of rock piles where seepage water from the bluffs trickled through their hibernacula; these microhabitats were never found frozen even though the nearby swamp was covered with 3 to 4 inches of ice. On one occasion a gathering of 5 large green frogs was seen through the swamp ice. A culvert carried spring water into the area and the animals were probably responding to the increased water temperature.

Other investigators have reported overwintering behavior of the green frog. During a warm rain on December 18 in New York, Sanwals (1916) observed an active adult near a pond. Martof (1956b, p. 225) uncovered hibernating frogs during early spring buried in the bottom mud of a stream. A detailed description of the climatic factors and microhabitat of a hibernaculum in Michigan is given by Bohnsack (1951). And Pope (1947) has found green frogs to be active about springs in the Chicago area during mild winter temperatures.

Frogs from Pine Hills began emerging from hibernation during the second week in March. After a series of rains around March 22, frogs were prevalent especially in the flooded woodland along the swamp. As in November when juveniles were the last to go into hibernation, it appeared the juveniles were the first to emerge as they were abundant while adults were at first scarce. Northern green frogs appear approximately two weeks later than those in southern Illinois. Near Ithaca, New York, Ryan (1953, p. 76) placed emergence during the last week of March or the first week of April. Martof (1956b, p. 224) also found Ann Arbor frogs appeared during the last week of March. However, emergence can be as deferred as late April in southern Wisconsin (Breckenridge, 1944, p. 79).

The onset of the breeding period is heralded by the first calls of the males. In the present study calling was first heard on April 20; it continued until August 29, with no calls heard from September 1 on. Peak choruses were estimated as occurring between June 3 and August 18. The breeding period as reported by other authors is relatively consistent over the green frog's range, yet there is a trend for a shorter breeding period with an increase in latitude (Table 1). Because there can be some disagreement concerning what constitutes the breeding period (ie. calling period versus the period of

egg laying), Table 1 lists the authors' specific designations.

Summary

A total of 475 green frogs were collected in weekly samples throughout a year, March 1963 — February 1964, in southwestern Illinois. The collections represented an intergrade population of *R. c. clamitans* x *R. c. melanota*. Some variations were found in this population as compared with findings reported for green frogs in other portions of their range.

1. The mean snout-vent length of newly transformed frogs from southwestern Illinois was smaller (26.5 mm) than the mean lengths reported for northern green frogs (32.6 mm).

2. Field observations and seasonal body length frequencies indicate a biannual transformation, one in early summer and the second in late summer-early fall.

3. Females were the largest juvenile frogs taken during most months, suggesting that males may mature at a slightly earlier age.

4. Seasonal snout-vent length frequencies showed the largest juvenile frogs were captured in the fall and winter; many were of adult proportions.

5. Frogs of the Pine Hills adult population are smaller than northern green frogs. Males ranged between 44 and 66 mm with a mean of 54.6 mm. Females showed a greater size than males, ranging between 49 and 75 mm with a mean of 59.0 mm.

6. To aid the field investigator's ability to distinguish between a precociously matured male and a large subadult, Martof's sex index (snout-vent length/tympanum diameter) was applied and found accurate. Adult males possessed an index value of less than 9 while for adult females and juveniles it was greater than 9; however, the corresponding value for Michigan frogs was 10.

7. Green frogs in southwestern Illinois have a longer yearly activity period than frogs of Wisconsin, Michigan, and New York. Hibernation at Pine Hills began in early November for adults and late November for juveniles and lasted til early March. Spring-fed streams in the collecting area permitted some frogs to forage intermittently throughout the winter.

8. Calling was first heard at Pine Hills on April 20 and lasted til

Table 1.—The breeding period of the green frog, *Rana clamitans*, as reported across its range.

Locality	Dates of Calling	Dates of Breeding Season	Authority
New York		Late May—2nd Wk. August.	Ryan (1953)
New York		Late May—Mid August	Wright (1942)
Michigan	May 5—Mid August.	Late May—Mid August	Martof (1956a)
Illinois	May—September		Smith (1961)
Georgia	April 28—September 5		Wright (1932)
Florida		April 11—August 15	Carr (1940)

August 29. Peak choruses seemed to occur between June 3 and August 18. The calling period at Pine Hills is longer than in the northern portion of the green frog's range and shorter than in the southern part.

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