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## IDENTIFICATION AND DISTRIBUTION OF *HYLA VERSICOLOR* AND *HYLA CHRYSOSCELIS* IN WISCONSIN

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**ABSTRACT:** *Hyla chrysozelis* is absent in much of the northern half of Wisconsin, whereas *Hyla versicolor* is much more widespread in the state. Pulse rates of mating calls of both species were significantly and positively correlated with esophageal or calling-site temperatures. The regressions of pulse rate on temperature for the two species were significantly different ( $P < .001$ ). There was no overlap of pulse rates for the two species at any temperature measured in Wisconsin (14.8–29.0/s for *H. versicolor*; 41.4–71.4/s for *H. chrysozelis*). Calling *H. versicolor* ♂♂ are significantly larger and tend to be darker than *H. chrysozelis* ♂♂. Mean size of *H. versicolor* ♂♂ was 42.6 mm (SD = 2.02); *H. chrysozelis* ♂♂ were 35.2 mm (SD = 3.69).

JOHNSON (1966) recognized that *H. versicolor* included a sibling species, *H. chrysozelis*, and that the only means of identification in the field is by mating call. The calls of both species consist of a series of pulses (Fig. 1), and *H. versicolor* has the slower pulse repetition rate. Zweifel (1970) found that pulse rate alone is not sufficient for identification when the two species are not found together. He showed that pulse rates for the two species from Delaware, New Jersey, and Virginia were the same

when calls of *H. versicolor* at the highest temperatures were compared to calls of *H. chrysozelis* at the lowest temperatures. The species can also be separated by cytological evidence (Bogart and Wasserman, 1972; J. P. Bogart, *personal communication*). *Hyla versicolor* is tetraploid and *H. chrysozelis* is diploid.

Throughout the literature *H. versicolor* and *H. chrysozelis* are reported to be largely allopatric. Parapatric populations were reported by Noble and Hassler (1936),

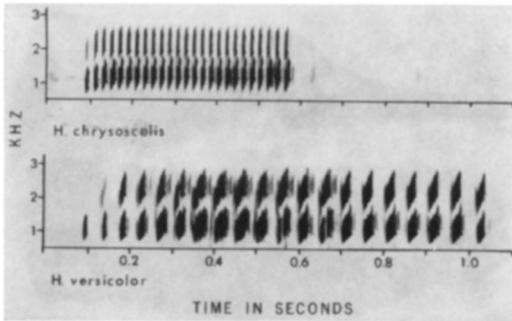


FIG. 1.—Sonograms of the mating calls of *Hyla chrysoscelis* (24.4°C) and *H. versicolor* (20.1°C) (wide band filter 300 Hz).

Hoffman and Kleinpeter (1948), Blair (1958), Johnson (1966), Ralin (1968), Zweifel (1970), and Gerhardt (1974). Blair (1958) reported one locality in Wisconsin where the two species were found together. This is the only report of *H. chrysoscelis* from Wisconsin prior to this study. Because the two species are difficult to differentiate except by call and karyotype, and because it was only recently that *H. chrysoscelis* was resurrected from synonymy of *H. versicolor* the general distributions of these frogs are poorly known. Even less is known about their areas of sympatry. The purpose of this paper is to present information on the distributions of these two species in Wisconsin. Data on the effect of temperature on pulse rate in Wisconsin are also reported.

#### METHODS

Frogs were observed at night at 92 localities from April through July during the years 1971–1974. Sound recordings were made with a Uher® 4000R recorder, at a tape speed of 7½ in/s, and a Uher® M516 microphone. A Schultheis thermometer was used to measure esophageal temperature. Air and water temperatures were also taken as close as possible to the frog's calling site. Either water or air temperature was used for site temperature depending upon frog location. Water temperature was used

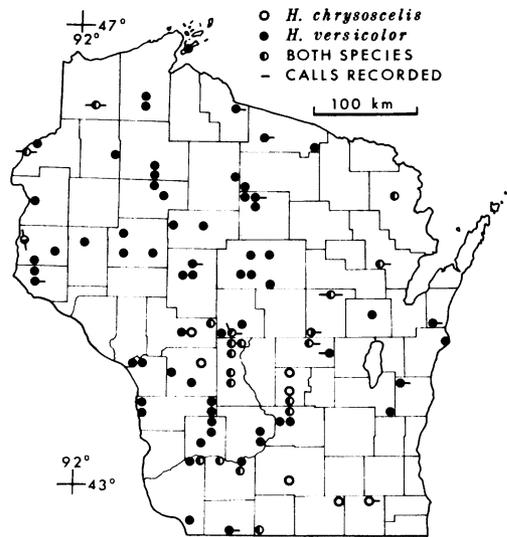


FIG. 2.—Distribution of *Hyla versicolor* and *H. chrysoscelis* in Wisconsin. At sympatric localities a flag from the open half of the circle indicates an individual of *H. chrysoscelis* was recorded. A flag from the solid half indicates an individual of *H. versicolor* was recorded.

for site temperature when frogs were calling on the water surface.

Recordings were copied using a Uher® 4000S recorder at a speed of 7½ in/s and analyzed with a Kay Electric Sound Spectrograph™ (7030A) with a band filter (300Hz). One call from each of 31 frogs from 23 localities was analyzed. The relationship of temperature to pulse rate was determined by least squares regression analysis. Regressions were compared by analysis of covariance. Populations other than those analyzed by sonogram were identified by ear.

Snout-vent length (SVL) was measured on 26 male *H. versicolor* from nine localities and 25 male *H. chrysoscelis* from seven localities. Measured frogs were selected from preserved material by appearance that suggested they could be most accurately measured. Each frog was measured three times using dial calipers to .1 mm and the mean was used in the analysis. A total of 295 *H. versicolor* and 117 *H. chrysoscelis* were collected for this study.

TABLE 1.—Linear regression equations, correlation coefficients ( $r$ ), and coefficients of determination ( $r^2$ ) for pulse rate ( $Y$ ) and temperature ( $X$ ), esophageal and calling site.

Species and temperature type	Regression equation	$r$	$r^2$	Significance level	$N$
<i>H. chrysoscelis</i>					
esophageal temperature	$Y = 2.59 X - 2.90$	.75	.56	.005	12
calling site temperature	$Y = 2.36 X + 5.43$	.72	.52	.01	12
<i>H. versicolor</i>					
esophageal temperature	$Y = 1.30 X - 4.95$	.71	.50	.001	18
calling site temperature	$Y = 1.00 X + 2.78$	.69	.48	.001	19

These frogs were deposited in the University of Wisconsin-Madison Zoological Museum and the Milwaukee Public Museum. Tapes were deposited at the University of Wisconsin-Madison Zoological Museum.

### RESULTS

*Hyla chrysoscelis* was not found in north-central Wisconsin and is most common in the southern half of the state. *Hyla versicolor* was found throughout Wisconsin except in the southeastern corner (Fig. 2).

Mating call pulse rates were significantly correlated with temperature, esophageal or calling-site, in both species (Table 1). Regressions of pulse rate on esophageal temperature were significantly different ( $P < .001$ ) between species; in fact, there was no overlap in observed pulse rate (Fig. 3). This was also true for the regression of pulse rate on calling site temperature.

Calling *H. versicolor* were either a gray-brown dorsal ground color with dark markings or a light green dorsal ground color with darker green markings. These markings were usually surrounded with an entire or broken black line. Less than 2% of the male *H. versicolor* found calling were green with darker green dorsal markings without black borders. Calling *H. chrysoscelis* usually had a green dorsum with no markings. They often had darker green dorsal markings that ranged from slightly darker than ground color to much darker. Less than 17% had a black broken line around their dorsal markings. Less than 4% had entire black outlines around their dorsal mark-

ings. No calling *H. chrysoscelis* had a dorsum of brown or gray. Both species showed all colorations in the laboratory.

Twenty-five calling *H. chrysoscelis* from nine localities ranged from 27.4 mm to 42.0 mm SVL ( $\bar{x} = 35.2$ ,  $SD = 3.69$ ), whereas 26 male *H. versicolor* from seven localities

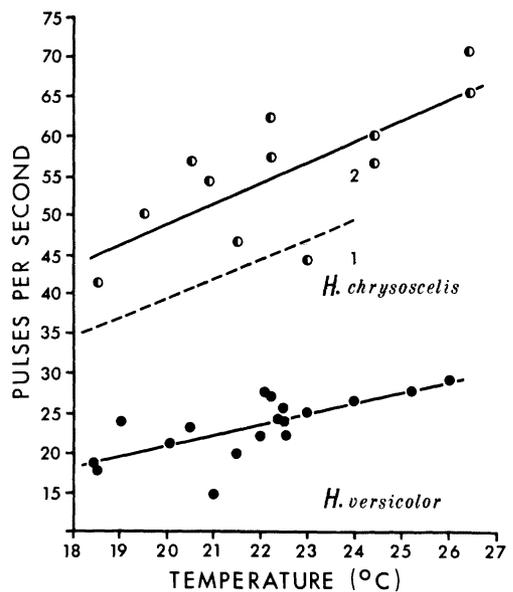


FIG. 3.—Relationship of pulse rate of mating call to esophageal temperature in *Hyla versicolor* and *H. chrysoscelis*; refer to Table 1 for explanation of regression lines. The dashed line refers to Zweifel's (1970) northeastern *H. chrysoscelis*. Point 1 is the mean pulse rate of eastern *H. chrysoscelis* corrected to 24°C reported by Gerhardt (1974) from Georgia and South Carolina. Point 2 is his western *H. chrysoscelis* value from Texas.

ranged from 38.9 mm to 46.3 mm SVL ( $\bar{x}$  = 42.6, SD = 2.02). Calling *H. chrysosecelis* were significantly smaller than *H. versicolor* ( $P < .001$ ). Our measurements show that 84% of the *H. chrysosecelis* were smaller than any *H. versicolor* and that 65% of the *H. versicolor* were larger than any *H. chrysosecelis*.

#### DISCUSSION

Wisconsin *H. versicolor* and *H. chrysosecelis* can be distinguished in the field by their different and nonoverlapping pulse rates. Zweifel (1970) was not always able to distinguish between the species in the northeast because of overlap in their pulse rates. We were unable to record *H. chrysosecelis* at esophageal temperatures as low as some of those recorded by Zweifel (1970). Similar overlap may occur in Wisconsin frogs only if *H. chrysosecelis* calls at much lower esophageal temperatures than those recorded by us.

The range of pulse rates for *H. versicolor* in Wisconsin, within the same temperature range, is similar to that found by Zweifel (1970) in the northeast. However, the range of pulse rates for Wisconsin *H. chrysosecelis* (41.4–62.2/s) is higher than Zweifel's (34–50/s) at a temperature range of 18–24°C (see Fig. 3 for comparison of regression lines). Gerhardt (1974) also reported geographic variation in *H. chrysosecelis*, Texas populations having faster pulse rates than those from Georgia and South Carolina (see Fig. 3 for comparison).

Ralin (1968) found that *H. versicolor* and *H. chrysosecelis* at one locality near Bastrop, Texas, were significantly different in average size, but the extensive overlap in SVL range precluded the use of size for species identification. In his study only 3% of the *H. chrysosecelis* were smaller than the smallest of *H. versicolor* and only 1% of the *H. versicolor* were larger than the largest *H. chrysosecelis*. This contrasts with our measurements from throughout Wisconsin which show that 74% of these frogs can be identified by SVL alone. Male coloration can also be used in identification.

However, the color differences described above apply only to calling males and are not absolute. Since calls give absolute identification, coloration is of little additional value in identification.

Temperature is known to be an important factor affecting pulse rate in these frogs. Ralin (1968) reported no significant regression of pulse rate on body length. It is often difficult to capture frogs and accurately record their temperatures. Small frogs can readily change temperature when handled and site temperature may not correlate well with frog temperature (e.g., Ralin, 1968; Pace, 1974).

The two scatter diagrams for pulse rate versus (a) esophageal temperature (Fig. 3) and (b) calling site temperature (not pictured) are different. However, either esophageal temperature or calling site temperature could have been used to show that pulse rates of the two species did not overlap in Wisconsin. Slightly more variance in pulse rate was explained when using esophageal temperature as the independent variable. Undoubtedly, accurate measurement of esophageal temperature is the better estimate of frog body temperature.

Both species were calling at the same body of water at 21 localities in Wisconsin. This represents the most extensive sympatry reported thus far. *Hyla chrysosecelis* is most common in the southern half of Wisconsin, and it was found alone at only seven localities. This species appears to be absent from the north-central part of Wisconsin and its distribution in general corresponds to past prairie, oak savanna, and pine savanna (Curtis, 1959). This agrees with Blair's (1958) report that *H. chrysosecelis* is a grassland species in the western part of its range. *Hyla versicolor* has a broad range in Wisconsin and its apparent absence from the southeastern corner of the state may reflect insufficient collecting or urban disturbance.

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## REPRODUCTION IN FRESHWATER AND TERRESTRIAL TURTLES OF NORTH FLORIDA

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**ABSTRACT:** Reproductive data for the freshwater and terrestrial turtle species found in north Florida is presented. Reproductive strategies range from production of a single, small clutch annually (as in *Terrapene carolina*) to continuous production of large clutches throughout the year (as in *Chrysemys floridana*). Turtle size is positively correlated with both clutch size and estimated annual fecundity. Unstandardized egg volume is positively correlated with turtle size and clutch size. Relative egg volume (standardized to turtle size) is negatively correlated with clutch size. The relationship of habitat to reproductive strategy is discussed.

As interest in reptilian reproductive and demographic strategies increases, the need for basic information on reproductive cycles becomes apparent. Except for a few commonly studied turtle species (*Chrysemys picta*: Moll, 1973, and Cagle, 1950; *Chrysemys scripta*: Moll and Legler, 1971; and *Sternotherus odoratus*: Tinkle, 1961), trends in chelonian life-history phenomena have

been neglected, primarily because of the lack of substantial reproductive information. Even in those well-studied species, data are often lacking from large portions of the species' range.

The following is an attempt to add the knowledge of reproductive biology for all freshwater and terrestrial species of turtles in a single geographic area, and to briefly