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The photograph of a plains leopard frog (*Rana blairi*) from Spring Lake, Tazewell County, Illinois, used on the cover was taken by Dr. Douglas W. Whitman.

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# Distribution, Habitat, and Zoogeography of the Plains Leopard Frog (*Rana blairi*) in Illinois

Lauren E. Brown and Michael A. Morris

The early study of leopard frogs (*Rana pipiens* complex) in Illinois and elsewhere was hampered by several factors. Most important were (1) overlapping and confusing morphological and color pattern variation among the different species, (2) availability of a number of specific names coupled with a complex nomenclatural history (Brown et al. 1977), and (3) lack of knowledge about the nature of reproductive isolation and cryptic speciation in frogs. Consequently, little of significance was published on leopard frogs in Illinois until the appearance of *The Amphibians and Reptiles of Illinois* (Smith 1961). Smith recognized two leopard frog taxa in Illinois: *Rana pipiens pipiens* in the northern one-third of the state and *Rana pipiens sphenocephala* in the southern one-third of the state. A wide zone of intergradation was thought to occur across the center of Illinois. Subsequent research (Brown and Brown 1972) revealed different "call types" in Illinois that were considered to represent distinct species. Other research (summarized by Brown 1973) supported this suggestion, and three sibling species are now recognized as occurring in Illinois (northern leopard frog, *Rana pipiens* Schreber 1782; southern leopard frog, *Rana sphenocephala* Cope 1886; and plains leopard frog, *Rana blairi* Mechem et al. 1973).

A number of publications (Axtell 1976; Axtell and Haskell 1977; Brown and Brown 1972; Brown and Funk 1977; Mechem et al. 1973; Pace 1974; Vogt 1981) presented distributional information on *Rana blairi* in Illinois but comprehensive coverage has been lacking. The objectives of this paper are (1) to present the results of an in-depth investigation of the distribution of *R. blairi* in Illinois, (2) to provide information on the present and probable past habitats occupied by the species in the state, and (3) to discuss the zoogeography of the species.

## Materials and Methods

Distributional records for *Rana blairi* were obtained through examination of preserved specimens and fieldwork. The collections of the following 17 museums, academic institutions, and private individuals were searched for specimens: Chicago Academy of Sciences, Eastern Illinois University, Edward O. Moll collection, Field Museum of Natural History, Illinois Natural History Survey, Illinois State Museum, Illinois State University, Lauren E. Brown collection, Michael A. Morris collection, National Museum of Natural History—Smithsonian Institution, Principia College, Southern Illinois University at Carbondale, Southern Illinois University at Edwardsville, University of Illinois Museum of Natural History, University of Kansas Museum of Natural History, University of Michigan Museum of Zoology, and Western Illinois University.

The three species of leopard frogs in Illinois are distinguished by a combination of morphological character states: presence or absence of vestigial male oviducts, and dorsolateral folds continuous or broken (on one or both sides) just anterior to the thigh and displaced medially (Table 1; Brown and Brown 1972). Although displaced dorsolateral folds (Fig. 1) alone morphologically distinguish *Rana blairi* from *R. pipiens* and *R. sphenocephala*, the possibility of natural hybridization necessitated that we open the abdomens of leopard frogs to check for the presence or absence of vestigial male oviducts.

Fieldwork was carried out from 1968–1989, primarily in central and southern Illinois, although a number of field trips were taken to northeastern Illinois. Numerous specimens were captured alive or picked up DOR (dead-on-the-road) and examined.

Table 1. Distinguishing morphological character combinations for the three species of leopard frogs in Illinois.

Species	Dorsolateral folds	Vestigial male oviducts
<i>Rana blairi</i>	displaced	absent
<i>Rana pipiens</i>	continuous	present
<i>Rana sphenocephala</i>	continuous	absent

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The species-specific mating call of males is an important isolating mechanism in frogs and toads (Blair 1958a, 1964). Consequently, listening for the mating call (Littlejohn and Oldham 1968; Brown and Brown 1972; Mecham et al. 1973; Dunlap and Kruse 1976) provided a means for us to locate *Rana blairi*. The mating call (Fig. 2) has been described as sounding like "chuck-chuck-chuck" (Conant 1975). It usually is relatively low in volume and resembles the pounding of a nail by a single carpenter in the distance. In contrast, the mating call of *R. pipiens* is a "long deep rattling snore," and that of *R. sphenoccephala* is a "short



Figure 1. Plains leopard frog (*Rana blairi*) from Spring Lake, Tazewell County, Illinois, showing broken dorsolateral fold that is displaced medially just anterior to the thigh. Photograph by Dr. Douglas W. Whitman.

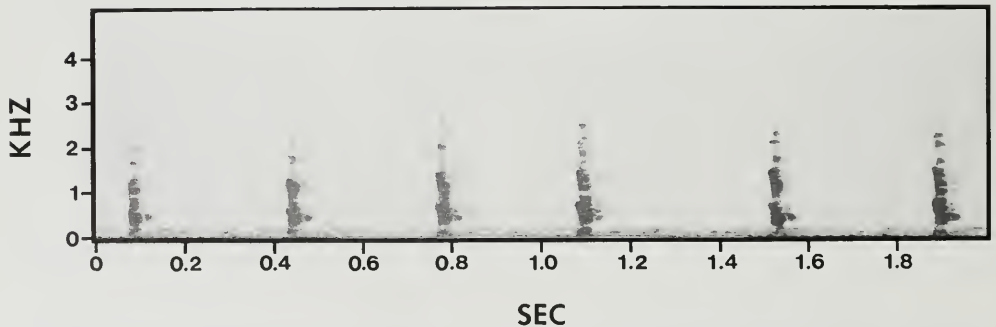


Figure 2. Audiospectrogram (narrow band) of the mating call of a male plains leopard frog (*Rana blairi*) recorded on 24 April 1970 in a farm pond 3.49 km (2.17 mi) east of U.S. Highway 51 and 0.87 km (0.54 mi) north of McLean County Highway 8 (SW  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , Section 2, T25N R2E), Hudson Township, McLean County, Illinois. Frequency (in kilohertz) is along the vertical axis; time (in seconds) is along the horizontal axis. The complete first sequence (first four notes) and the initial part of the second sequence (last two notes) are illustrated. Cloacal temperature = 16.1°C; air temperature = 9.4°C; water temperature = 16.0°C (the male was calling in the water). Snout-vent length = 68 mm (measured alive). Recorded by L.E. Brown; photographed by Gerald B. Liebenstein.

chuckle-like, guttural trill" (Conant 1975). Quantitatively, the much lower pulse rate (average of less than six pulses per sec below 24°C—Mecham et al. 1973) of the mating call of *R. blairi* distinguishes it from the mating calls of *R. pipiens* and *R. sphenoccephala*.

Mating calls of *Rana blairi* were recorded at a number of locations in central Illinois using a Stancil-Hoffman Minimate M9 tape recorder with Altec 633A and Electro-Voice 644 microphones at a speed of 19 cm (7.5 in) per sec. Cloacal, air, and water temperatures were taken with a Schultheis quick-reading thermometer to the nearest 0.1°C immediately after recording calls. A Kay model 6061A Sona-Graph was used to analyze mating calls.

### Distribution

*Rana blairi* has been found at 194 localities in Illinois. The species is distributed (Fig. 3) mainly in a wide band across the middle of the state with a southern extension along the Mississippi River to extreme southern Illinois (Alexander County). Smith's (1961) zone of intergradation between the two leopard frog taxa he recognized in Illinois (*R. pipiens pipiens* and *R. pipiens sphenoccephala*) shows considerable overlap with the distribution of *R. blairi* across the center of the state. We found many of the specimens from this area that had been examined by Smith (1961) to be *R. blairi*. Clearly Smith (1961) often considered *R. blairi* as intergrades between *R. pipiens pipiens* and *R. pipiens sphenoccephala*. (L.E.B. came to this conclusion as distributional data on leopard frogs in Illinois began to accumulate; P.W. Smith and M.A.M. independently came to the same conclusion [Morris et al. 1983].)



*Rana blairi* is not panmictic in Illinois, and we have not found it to be abundant at any locality in spite of the large number of distributional records (greater than for any other state). Insufficient appropriate habitat (see the following section, Habitat) probably is responsible for this lack of abundance. In contrast, *R. sphenocéphala* is numerous at many localities in southern Illinois where much of the environment is considerably less disturbed by humans.

Along the northern edge of its range in Illinois, *Rana blairi* is sympatric at some localities with *R. pipiens*. Sympatry appears to be more extensive between *R. blairi* and *R. sphenocéphala* than between *R. blairi* and *R. pipiens*. *Rana blairi* and *R. sphenocéphala* occur together along the Illinois River in west-central Illinois, along the Mississippi River in southern Illinois, and at some localities along the southern edge of the range of *R. blairi* in central and eastern Illinois.

### Habitat

Breeding sites that we found to be commonly utilized by *Rana blairi* in Illinois included roadside and drainage ditches, marshes, rain pools, flooded areas, farm ponds, and sometimes lakes. Some sites were ephemeral, and all were lentic. Outside the breeding season we found individuals near the breeding sites as well as on bottomlands, along creeks, in old fields, and in variable habitats that often showed past disturbance (nonagricultural) by humans. We never found *R. blairi* a great distance from water.

Two major types of environments in Illinois apparently are not occupied by the species. We never encountered the frog in mature upland forests or in tillable fields (e.g., corn, soybeans). One of us (L.E.B.) has carried out a number of herpetological surveys for the Illinois Department of Transportation in central and northeastern Illinois. These surveys frequently involved traversing arable land, but *Rana blairi* was never seen. *Rana blairi* was also never encountered in tilled fields by either of us over many years of other fieldwork in central Illinois. Moreover, K.A. Brown, L.N. Brown, and G.L. Paukstis (personal communications) spent a great many days in several different years roguing and detasseling corn in central Illinois without coming across *R. blairi* (although American toads [*Bufo americanus*] were occasionally seen, usually near the edges of fields). The absence of *R. blairi* from cultivated fields could be the result of alteration of the soil structure through tilling and/or compaction from heavy farm machinery, application of agricultural chemicals (anhydrous ammonia and other fertilizers [see Berger 1989], herbicides [see Hazelwood 1970], and insecticides), tiling of fields to reduce water content of the soil, seasonal aridity (particularly mid through late summer), lack of appropriate cover, or a combination of these and other factors.

The devastating effect of the moldboard plow on soil structure was emphasized by the well-known agricultural conservationist Louis Bromfield (1955). The steel moldboard plow was of considerable significance in the establishment of agriculture in the midwestern prairies because it greatly facilitated the turning of prairie sod (Broehl 1984). Bromfield (1955) pointed out that the pressing action of the moldboard plow produces an artificial compacted layer ("hardpan") some 17.8–20.3 cm (7–8 in) below the surface of

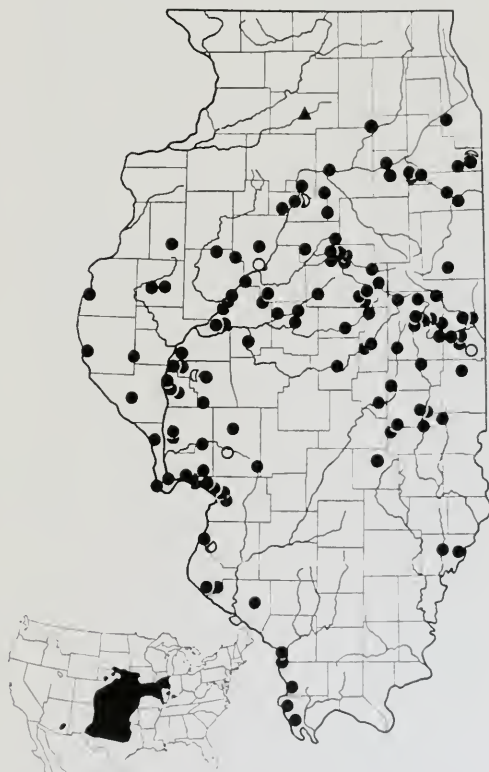


Figure 3. Distributional records for the plains leopard frog (*Rana blairi*) in Illinois. Closed circles represent localities for preserved specimens we examined in museums and collections and for frogs heard in the field, recorded in the field, DOR (dead-on-the-road), or caught, examined, and released in the field. A number of circles represent two or more records that are too close together to plot separately. Open circles represent five other literature records and two unpublished records (based on specimens we did not examine) that are believed to be valid. The closed triangle represents a record for *R. blairi* (a museum specimen examined by us) with locality data that we regard as questionable. The entire known range of *R. blairi* is shown in the lower left corner.

the soil. The depth is variable depending upon how deep the plow is set. Bromfield (1955) mentioned a minimum depth of 5.1 cm (2 in). The typical depth in central Illinois is 20.3–30.5 cm (8–12 in) at present (T.E. Alt, personal communication). Much agricultural land in Illinois has probably been underlain with hardpan because of the extensive use of the steel moldboard plow for well over a century. The hardpan is 5.1–7.6 cm (2–3 in) thick and is not easily penetrated by water and plant roots (Bromfield 1955). Consequently, penetration of this impacted layer by amphibians (e.g., *Rana blairi*, *Pseudacris triseriata*, *Ambystoma texanum*) seems doubtful should these animals seek subterranean shelter (e.g., for winter hibernation or to escape desiccation).

The distribution of *Rana blairi* is primarily in the Great Plains (Brooks 1976; Dixon 1987; Dunlap and Kruse 1976; Hillis 1981; Lardie 1982; Littlejohn and Oldham 1968; Lynch 1978; Mecham et al. 1973; Pace 1974; Post and Pettus 1966), with an eastward extension into the Prairie Peninsula (this paper; Axtell 1976; Brown and Brown 1972; Johnson 1987; Pace 1974). Prior to European settlement, this vast area was mainly prairie and was likely the predominant habitat occupied by *R. blairi*. All of the range of *R. blairi* as presently known in Illinois, except for areas along the Mississippi and Illinois rivers, occurs within the borders of the presettlement prairie mapped by Anderson (1970). Much of the prairie in Illinois was notable for its poor drainage, which resulted in extensive marshes and potholes (White 1978); hence it was sometimes called “muck prairie” (Smith 1961). The Illinois prairies were mostly unoccupied by humans until the decade 1850–1860 when the precipitous establishment of railroads facilitated the rapid settlement of the area (Barrows 1910; Wyman 1988). As late as 1871, prairie was still common in certain areas of Illinois but by 1883 much had been converted for agricultural use (Ridgway 1889). The continuing advancement of agriculture, of course, destroyed nearly the entire prairie ecosystem in Illinois. The ability of *R. blairi* to occupy areas peripheral to prairies and intense agricultural cultivation probably allowed the species to continue to survive in the state.

### Zoogeography

Blair (1958b, 1965) was a foremost proponent of an influential Pleistocene zoogeographic theory, which suggested that southward glacial advances caused the displacement of many warm-adapted, terrestrial, vertebrate species into refugia in Florida and Mexico. *Rana blairi* (or its evolutionary precursor) may have been one of those taxa that withdrew to the south. However, the present northern limits of the range of

*R. blairi* (as far north as southern South Dakota—Dunlap and Kruse 1976) suggest that the species has considerable cold tolerance, at least in its northern populations. Thus, the retreat of the entire species into Mexico during the Pleistocene glaciations seems unlikely. After the Wisconsinan glaciation, it was possible for *R. blairi* to expand its range northward in the Great Plains. Smith (1957) proposed that a number of prairie-adapted species of the Great Plains moved eastward into the Prairie Peninsula during the subsequent Xerothermic Period. *Rana blairi* probably was one of those species that moved eastward, as evidenced by its present distribution in the Great Plains and Prairie Peninsula. However, Pace (1974) suggested that *R. blairi* may have made this range expansion during or after the post-Pleistocene development of the Prairie Peninsula. The warm, arid climate during the Xerothermic would probably have been unfavorable for major amphibian migrations. Thus, it seems likely that *R. blairi* moved eastward after the Xerothermic and after establishment of prairie.

The present extension of the range of *Rana blairi* south of the Prairie Peninsula along the Mississippi River in southern Illinois is somewhat puzzling because Anderson (1970) did not map presettlement prairies in that area. However, other evidence (R.C. Anderson, personal communication; Evers 1955; Gleason 1922; King and Allen 1977; Schroeder 1983; Transeau 1935) indicates the presence of some prairies along the Mississippi River in southeastern Missouri and southern Illinois during the Holocene. Thus, the ability of *R. blairi* to occupy areas peripheral to prairies, as well as the presence of scattered prairies, apparently allowed the species to colonize this area, most likely by an unusual southerly migration from the Prairie Peninsula in the mid-Holocene.

Pace (1974) reported two apparently isolated localities for *Rana blairi* in southeastern Illinois (“Wabash Co.: 2 mi N of Mount Carmel”) and southwestern Indiana (“Warrick Co.: Scales Lake, near Boonville”). These localities are, respectively, ca. 1.2 km (0.8 mi) or less SW of the Wabash River, and ca. 17.4 km (10.8 mi) NE of the Ohio River. These populations may have originated by dispersal of *R. blairi* southward from the Prairie Peninsula along the Wabash River and/or perhaps even northeastward up the Ohio River from Alexander County in extreme southern Illinois. Anderson (1970) and Transeau (1935) reported scattered presettlement prairies in and adjacent to Wabash County, Illinois, but Lindsey et al. (1965, 1969) did not recognize any in southwestern Indiana or in near Warrick County (although presettlement prairies did occur not too far away in adjacent Illinois—Anderson 1970).

## Summary

Examination of museum specimens, fieldwork, and literature records revealed 194 distributional localities for the plains leopard frog (*Rana blairi*) in Illinois. The species is distributed in a wide band across the center of the state with an elongated extension along the Mississippi River to extreme southern Illinois. Sympatry between *R. blairi* and two other leopard frog species (*Rana pipiens* and *Rana sphenocephala*) occurs at some localities.

The present distribution of *Rana blairi* in the Great Plains and Prairie Peninsula suggests that prairie was its main habitat prior to European settlement. *Rana blairi* presently occupies a variety of habitats (often showing disturbance by humans) that are peripheral to arable land. This distribution probably reflects the nearly complete destruction of the prairie ecosystem in Illinois by advancing agriculture, which *R. blairi* apparently cannot tolerate. We did not find the species to be abundant at any locality in the state.

*Rana blairi* probably colonized the Prairie Peninsula in Illinois after the warm, arid Xerothermic Period during the Holocene. The ability of *R. blairi* to occupy areas peripheral to prairies as well as the presence of scattered prairies during the Holocene apparently allowed the species to disperse along the Mississippi River into southern Illinois and southeastern Missouri.

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