

A Northern Range Expansion for the Green Tree Frog (*Hyla cinerea*) and Trends in Distributions of Illinois Reptiles and Amphibians

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ABSTRACT

The green tree frog (*Hyla cinerea*) is reported from Stump Lake in Jersey County, Illinois, 110 km north of the previous northernmost record in Illinois. Comparing range maps from two studies of Illinois herpetology published almost 40 years apart tested the hypothesis that herpetological range expansions in Illinois are primarily northward. Thirteen species were found that had new records primarily to the north and six with new records primarily to the south supporting the hypothesis. Four of the six latter species are prairie specialists that could also be expected to benefit from warmer, drier conditions further strengthening the suggestion that climatic change may have influenced herpetological distributions in Illinois.

INTRODUCTION

The green tree frog (*Hyla cinerea*) is widely distributed in the southern United States (Conant and Collins, 1991), but in the central United States, it reaches the northern limit of its range in Illinois (Smith, 1961; Phillips et al., 1999). Recently, we discovered a large population of this frog at Stump Lake, a backwater of the Illinois River, in Jersey County, Illinois (Tucker et al., 2006), about 110 km north of the previous northernmost record in Clinton County, Illinois (Phillips et al., 1999). This and other unspecified populations of the green tree frog could be introduced as the species is widely sold in the pet trade (Phillips et al., 1999). Moreover, tadpoles may occur in fish stockings (Phillips, pers. comm.). The origin of this newly discovered population is not important. Instead, persistence and establishment of a large population of such a southern species relatively far from its usual range in the context of climatic change is important. Changes in distributions in response to climatic change have received much attention on a theoretical level (e.g. Huntley et al., 2004; Kiritani, 2006) and from a practical standpoint (e.g. Battisti et al., 2005; LaVal, 2004).

Climatic change is occurring in Illinois. Angel (2004) reported a 1.2°C per decade increase in average February temperatures over a thirty-year period between 1971 and 2002. Such climatic warming may have contributed to more frequent passages of tropical systems over Illinois (Angel, 2006). Avian migrations in east-central Illinois may also reflect changing climatic conditions (Barrie Hunt, 2006). Such climatic changes make predictions of crop yields difficult (Changnon and Hollinger, 2003) and complicate modeling of fish communities in Illinois (Herricks and Bergner, 2003). Thus, it is reasonable to examine changes in distributional patterns in Illinois' reptile and amphibian populations.

Our discovery of this population so far north of the former range of the species suggested an obvious hypothesis about the distribution of other reptiles and amphibians in Illinois. Given a scenario of climatic warming, northerly range expansions should be more prevalent than southerly ones. In this paper we examine the evidence for such trends in distributions of Illinois reptiles and amphibians.

Illinois is uniquely suited to provide a test of this question. First, the state is 615 km long from north to south and bisects most of the biotic provinces found in the mid-continent (Smith, 1961). More importantly, two comprehensive studies of Illinois herpetology have been published (i.e., Smith, 1961; Phillips et al., 1999) both of which contain detailed range maps based on voucher specimens. Consequently, changes in ranges for most of the species occurring in the state can be identified from a nearly 40-year time span. In this paper we test the hypothesis that herpetological range expansions in Illinois are primarily northward in possible response to climatic changes.

METHODS AND MATERIALS

Range maps for each species were compared between Smith (1961) and Phillips et al. (1999). For each species, new distributional records in Phillips et al. (1999) were scored as primarily southern, primarily northern, or neutral based on Smith (1961). Neutral distributions include those species with records about evenly distributed between the northern and southern halves of the state. Most of these species occur in nearly every county in Illinois. Distributions considered primarily southern have the bulk of the locality records in the southern half of the state, whereas those considered primarily northern have most of the records in the northern half of the state. In some instances, nomenclature changes complicated comparisons (e.g. *Rana pipiens* complex). In those few instances, comparisons could not be made. We also considered new records not included in Phillips et al. (1999), which are cited herein. We used a chi-square test to compare the number of northward versus southward range changes. A one-tailed test was used because the hypothesis is that there would be more northerly range changes than southerly ones, not that there would be absolute differences in numbers of changes.

We used climatic data for Illinois from the web site of the Illinois climatologist (Illinois State Water Survey, 2006). We used average annual temperatures for the monitoring station in Jerseyville, Jersey County to illustrate climatic trends. Jersey County is located in west-central Illinois and its climate is reasonably representative for all of Illinois. Trends

in climatic data were determined using regression analysis. All statistics were performed using SAS for Windows (SAS, 2000).

RESULTS

The population of green tree frogs is at GPS coordinates: N 0711520 and W 4318112, zone 15 using NAD27 CONUS map datum in UTM's, which is in lower Stump Lake, Jersey County, Illinois. We collected more than 30 males, many of which were calling from stems of rough cocklebur (*Xanthium strumarium*). Seven individuals were deposited in the collections of the Illinois Natural History Survey (INHS 20652-20658). At the voucher location numerous other males were calling. Moreover, we heard further large choruses in upper Stump Lake and in other portions of lower Stump Lake. Consequently, the species is represented by many thousands of individuals. Reproduction was confirmed because tadpoles were dip netted on 10 July 2006. Transforming froglets were observed on 20 July 2006.

We scored range maps for a total of 102 species of reptiles and amphibians. Of these, 83 were scored as neutral. In contrast, 13 were scored as new records primarily northward and six as new records primarily southward (Table 1). These differ significantly (chi-square = 2.59, $p = 0.0456$). Although the statistical significance is marginal, the result does support the hypothesis that new records of reptiles and amphibians in Illinois have been primarily northward rather than southward.

Climatic data suggest that average annual temperatures have varied considerably in Jersey County with no clear trend between 1960 and 2005 (Fig. 1). However, average annual temperatures have increased significantly between 1992 and 2005 (Fig. 2). We selected this period for regression analysis. The regression analysis was significant for the Jerseyville station (slope = 0.12 degrees C per year, $R^2 = 0.39$, $p = 0.01$).

DISCUSSION

Our research provides preliminary evidence that herpetological distributions in Illinois are more likely to extend northward than southward. This is consistent with theoretical models incorporating climatic warming (Huntley et al., 2004; Salinger, 2005). We do not mean to imply that newly reported records represent a relentless march north by these animals. More likely, these populations could have been present when Smith prepared his herpetology. However, climatic change may have allowed them to reach and maintain detectable levels, which has happened for butterflies (Crozier, 2004). Such changes have not been previously noted for Illinois reptiles and amphibians. Nonetheless, climatic warming has been shown to have profound effects on reptiles and amphibians from other locations (Brown and Shine, 2007; Haenel, 2007; Wake, 2007).

These comments do not apply to two of the records that we used. The record for the pallid softshell turtle (*Apalone spinifera pallida*) and the discovery of the green tree frog populations could be due to human intervention (Phillips et al., 1999). In the case of the turtle, the single adult male collected appears to be a waif, i.e., a lone individual. Nonetheless, it survived in this northern area about 800 km north of its usual range long enough to be discovered by us. Moreover, being an adult male in a large population of

spiny softshell turtles (*Apalone spinifera spinifera*), it may have made a genetic contribution to the local Illinois population (Lamer et al., 2006).

The green tree frog populations have obviously been at Stump Lake for an extended period of time considering the huge numbers of frogs that are present. However, it likely postdates the record flooding along the Mississippi and Illinois Rivers in 1993. This event had important effects on anurans in river backwaters in this region (Tucker et al., 2001a). Certainly, the species was not heard during calling surveys conducted in the region between 1994 and 1996 (Tucker et al., 2001a). Although possibly introduced, the species has been able to establish a large population in Stump Lake. Walker et al. (2006) suggested that range expansions for this species in Indiana were natural. However, there were nearby source populations in Kentucky. In the instance we report for Jersey County, Illinois, there are no nearby populations known.

Our comparison of north versus south range changes somewhat under-emphasizes the changes over the last 40 years. Four of the six species with new records primarily to the south are prairie specialists (Smith, 1961; Phillips et al., 1999; Table 1). These species may actually benefit from climatic warming. Climatic warming may emulate the glacial hypothermic periods, which are thought to have allowed the prairie peninsula to expand in Illinois (Schmidt, 1938; Smith, 1957 and 1961). Certainly prairies are not expanding in Illinois but warmer, drier summers may allow outlier populations in remnant prairies to reach detectable levels.

We note that we selected a single station out of more than 110 monitored in Illinois to act as a model for Illinois climate change. Other stations may not show the same degree or direction of change especially given that any regression would be based on only 14 data points. However, the slope for Jersey County (0.12 degrees C increase per year) is identical to the slope reported for Illinois as a whole by Angel (2004) of 1.2 degrees C increase per decade between 1970 and 1987.

In Illinois, climatic warming has had at most a minor effect on distributions of reptiles and amphibians. However, these effects do seem to be occurring and have reached levels that are detectable. Similar changes may also be occurring in fish distributions (Tucker, 1993). Moreover, as southern species continue to be afforded opportunities by human transport and other means to reach northern regions, further dramatic changes in distributions can be expected.

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Table 1. Reptiles and amphibians that have more southerly or more northerly known distributions in Phillips et al. (1999) compared to range maps in Smith (1961).

Taxon (common name)	Change
<i>Ambystoma texanum</i> (smallmouth salamander)	Northerly
<i>A. opacum</i> (marbled salamander)	Northerly
<i>Siren intermedia</i> (lesser siren)	Northerly
<i>Hyla cinerea</i> (green tree frog)	Northerly
<i>Scaphiopus holbrookii</i> (eastern spadefoot)	Northerly
<i>Apalone spinifera pallida</i> (pallid spiny softshell)*	Northerly
<i>Pseudemys concinna</i> (river cooter)**	Northerly
<i>Terrapene carolina</i> (eastern box turtle)	Northerly
<i>Scincella lateralis</i> (ground skink)	Northerly
<i>Lampropeltis calligaster</i> (prairie kingsnake)	Northerly
<i>L. getula</i> (common kingsnake)	Northerly
<i>Nerodia rhombifer</i> (diamondback water snake)	Northerly
<i>Virginia valeriae</i> (smooth earth snake)	Northerly
<i>Hemidactylium scutatum</i> (four-toed salamander)	Southerly
<i>Ambystoma laterale</i> (blue-spotted salamander)	Southerly
<i>Pseudacris illinoensis</i> (Illinois chorus frog)***	Southerly
<i>Heterodon nasicus</i> (western hognose snake)***	Southerly
<i>Thamnophis radix</i> (plains garter snake)***	Southerly
<i>Clonophis kirtlandii</i> (Kirtland's snake)***	Southerly

* reported by Lamer et al., 2006

** northernmost record reported by Tucker et al. (2001b) from the Mississippi River in St. Charles County Missouri

*** prairie-peninsula species; common names follow Phillips et al. (1999) where possible

Figure 1. Average annual temperatures measured at the monitoring station in Jerseyville, Jersey County, Illinois between 1960 and 2005, which covers the time span from publication of Smith's and Phillips et al.'s studies of Illinois herpetology. The regression between year and average annual temperature is not significant ($R^2 = 0.02, p > 0.05$).

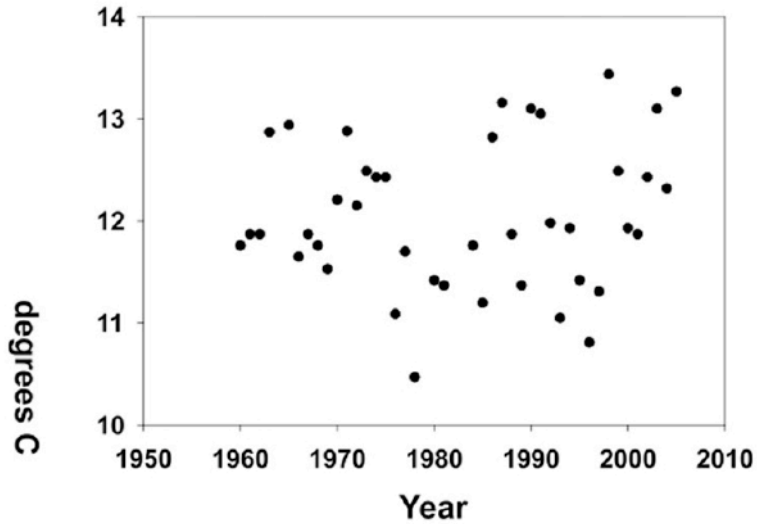


Figure 2. Recent trends in average annual temperatures at the monitoring station in Jerseyville, Jersey County, Illinois for the years between 1992 and 2005. The regression is significant (slope = 0.12 degrees C per year, $R^2 = 0.39, p = 0.01$).

