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OBSERVATIONS ON PERIODICAL CICADAS (BROOD XIV) IN INDIANA AND OHIO IN 2008 (HEMIPTERA: CICADIDAE: *MAGICICADA* SPP.)

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ABSTRACT. Brood XIV of the periodical cicadas emerged in nine counties in southern Indiana and 16 counties in southwestern Ohio during late May and June of 2008. The 2008 distribution of Brood XIV established that it overlapped with portions of the distribution of Brood X, which emerged in 2004. Some of this overlap was the result of four-year accelerations of Brood XIV cicadas in 2004. Weather conditions were monitored to determine how air temperatures impact soil temperatures at cicada nymphal depths, and how they can be used to forecast when the nymphs should emerge.

Keywords: Periodical cicadas, *Magicicada*

Periodical cicadas belonging to the 17-year Brood XIV emerged in parts of southern Indiana and southern Ohio during 2008. The brood was first recorded in 1804 in Brown County in Ohio and in 1872 in Crawford County in Indiana. It last emerged in 1991 (Kritsky & Young 1992; Kritsky 1992). All three periodical cicada species (*Magicicada septendecim*, *M. cassini*, and *M. septendecula*) were observed during the 2008 emergence. In keeping with the long history of cicada surveys in Ohio and Indiana, we surveyed both states for emergences and examined the effects of climate on triggering the start of an emergence.

METHODS

Periodical cicada emergences were monitored with surveys of locations where the cicadas had been observed in 1987, 1991, 2001, and 2004. To expand the survey coverage, a media-relations campaign was developed to encourage the public to submit their cicada observations on a website.

The emergence model (Kritsky et al. 2005) that predicts when cicadas should emerge in May was tested by monitoring the news media and the World Wide Web to pinpoint the first day of emergence in ten locations. Once a location was verified, local weather data was obtained from the National Oceanic and Atmospheric Association websites to use for the test.

The relationship between air temperature and soil temperature was tested with three HOBO® dataloggers buried at the average nymphal depth of 15 cm. The dataloggers recorded the temperature every 10 minutes from the first of April until the end of May. The fourth author monitored the locations to observe any cicada activity at the site.

RESULTS AND DISCUSSION

The heavy emergence in Ohio and Indiana started in late May following a two-week period of cool temperatures that kept the soil temperatures below the critical 18.3 °C (65 °F) that would trigger an emergence (Heath 1967; Kritsky et al. 2005). The public, using the web-based reporting system and email messages sent directly to the senior author, provided 884 cicada emergence records in the two-state region. Sixteen counties in southern Ohio experienced cicada emergences, with heavy emergences in parts of Hamilton, Clermont, Brown, eastern Butler, Warren, Clinton, Highland, Adams, Scioto, Lawrence, Gallia, Pike, Ross, and Greene counties (Fig. 1). Scattered numbers of cicadas were reported from Athens and Montgomery counties in Ohio. Three Ohio counties (Washington, Champaign, and Fayette) where only a few cicadas were observed in 1991 did not have emergences in 2008.

The 2008 emergence in Athens County, Ohio was a new county record for the brood. Athens

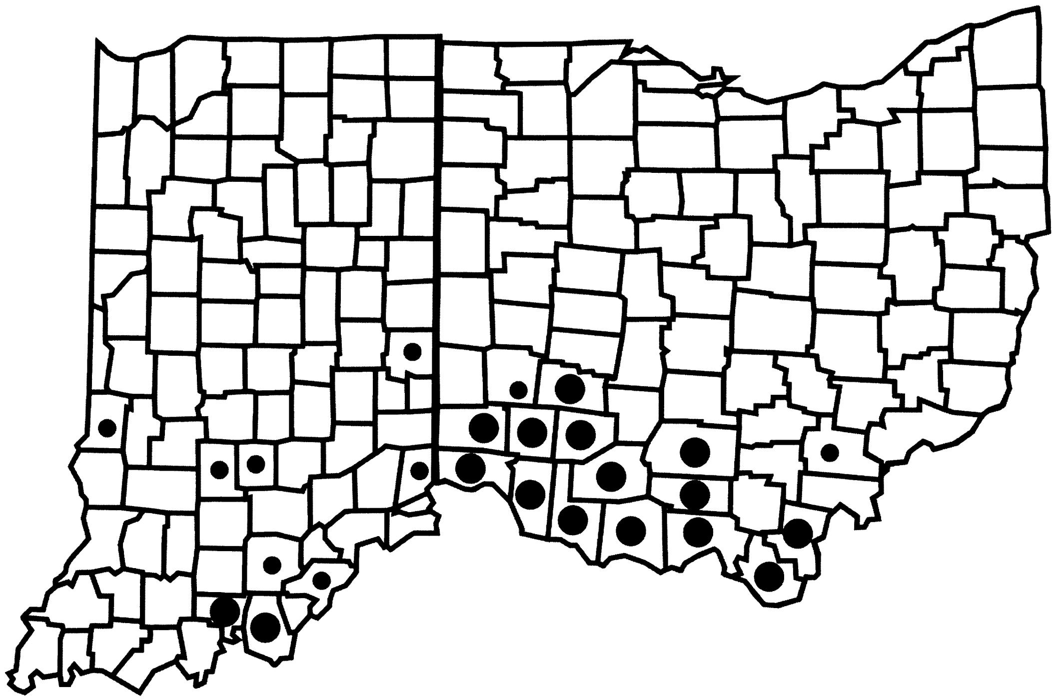

Figure 1.—The 2008 county distribution of Brood XIV in Ohio and Indiana. The large circles represent large, dense swarms of cicadas and the smaller circles represent small, isolated emergences.

County is within the range of Brood V, which last emerged there in 1999. However, a few thousand cicadas did emerge there in 1995 (Kritsky & Simon 1996).

Nine counties in Indiana experienced emergences with the highest densities reported from Harrison and Crawford counties. Light emergences were reported from Brown, Monroe, Dearborn, Clark, Vigo, Washington, and Wayne counties. The recent record of Brood XIV in Indiana is highly variable. In 1991, cicadas were reported from 14 counties; however, the 1974 survey of this brood documented its occurrence in only six Indiana counties (Young 1975). Brown, Crawford, Harrison, and Washington counties were the only counties where cicadas emerged during the last three consecutive emergences of the Brood XIV.

Our survey found considerable overlap between Broods X and XIV in Hamilton and Clermont counties in Ohio. In 2004, a detailed survey was conducted for the eastern boundary of Brood X in Hamilton and Clermont counties. In 2008, a similar survey was conducted to determine the western boundary of Brood XIV. The overlap of the two broods ranged from 10.54 km (6.55 miles) along the Ohio River, 15.26 km (9.48 miles) at its widest, and 5.04 km (3.13 miles) at the northern border of Hamilton County (Fig. 2). The broods were not ecologically isolated in areas of their overlap. We observed cicadas emerging from beneath the same trees where cicadas emerged four years earlier, and we observed oviposition on trees riddled with oviposition scars from the 2004 emergence of Brood X.

Part of this overlap may be the result of four-year accelerations of Brood XIV cicadas, causing them to emerge concurrently with Brood X. To document this potential, the senior author surveyed eastern Cincinnati in 1987, 1991, and 2004. In Madeira, Ohio, the senior author identified trees that were planted after the 1987 emergence of Brood X but before the 1991 emergence of Brood XIV. These trees experienced heavy Brood XIV oviposition damage in 1991, and two- and three-year-old nymphs were collected from the soil under the trees in 1992 and 1993. In 2004, thirteen years later, hundreds of cicadas emerged from under

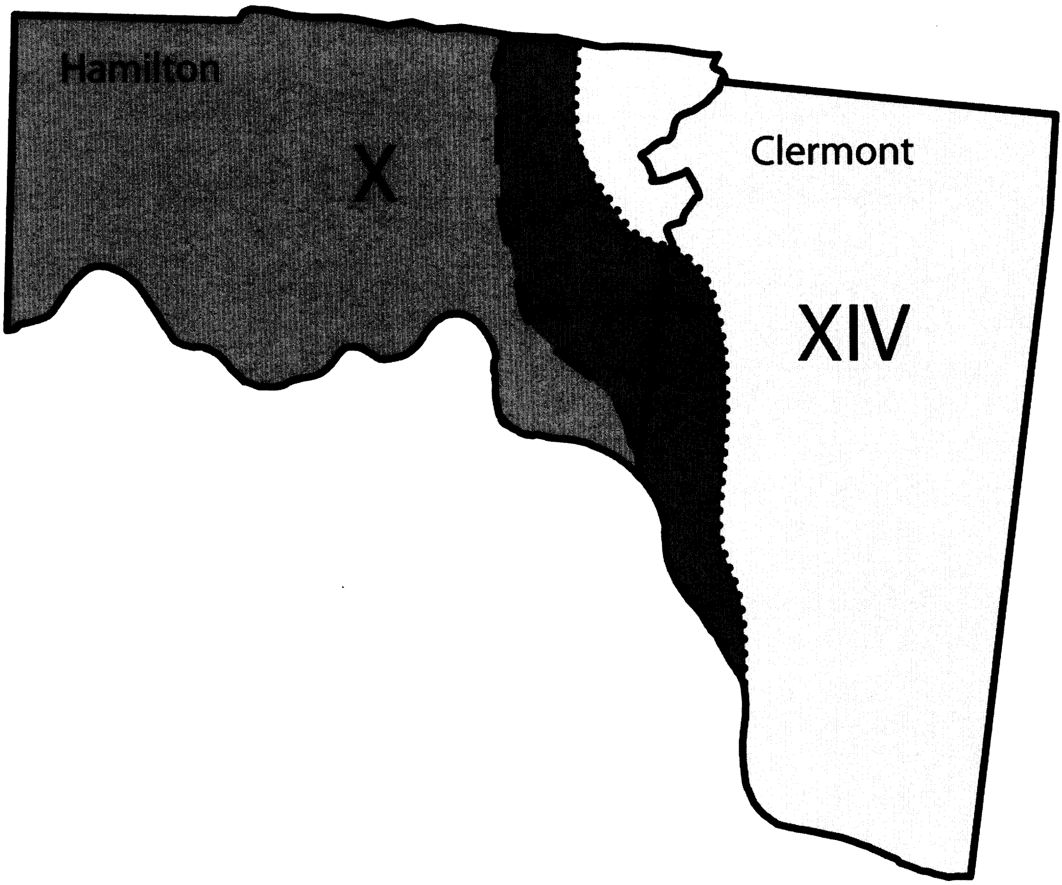

Figure 2.—Broods X and XIV during 2004 and 2008, respectively, emerged in Hamilton and Clermont Counties in Ohio. The eastern boundary of Brood X is shown with the dotted-line, the western boundary of Brood XIV is shown with the dashed-line, and the area of brood overlap is the darker shaded area as indicated by the double arrow.

the trees, and these neighborhoods experienced constant chorusing. Clearly, in 2004, some Brood XIV cicadas had emerged four years early. In 2008, thousands of cicadas emerged from under the same trees and the chorusing was deafening, reaching intensities of up to 90 dB when measured directly under the trees.

There were also isolated emergences of periodical cicadas from several Brood X locations in 2008. In most cases, the evidence was restricted to one or two shed skins, a few emergence holes, and single calls. These isolates may be Brood X cicadas emerging after 21 years (Maier 1985). These late-emerging Brood X cicadas would produce "shadow brood" XIV records found in the literature. Brood X occurs throughout the southern half of Indiana, and these late-emerging cicadas may be responsible for the non-recurring county emergence records in Indiana for Brood XIV.

Some Brood XIV cicadas also emerged a year ahead of schedule. Troutman observed hundreds of periodical cicadas in May 2007 in Loveland and Batavia, Ohio, locations that last witnessed large numbers of cicadas during the 1991 emergence. It is normal to have a few "straggler" cicadas emerge the year prior to a major emergence, but the number of "straggler" cicadas in 2007 was approximately 10 times the number Troutman observed in 1990. This unexpectedly large number of "stragglers" may have been the result of unusually warm weather in late 2006 and early 2007. From 1 December 2006 until 15 January 2007, there were 27 days that were over 10 °C (50 °F), with temperatures reaching a high of 18.3 °C (65 °F)

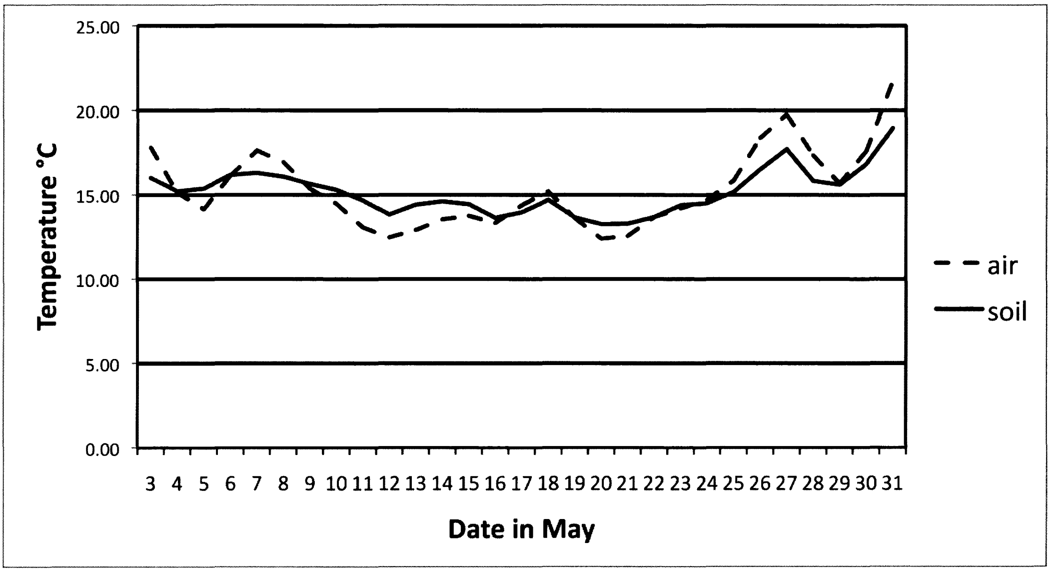

Figure 3.—The mean of the previous two-day and three-day running air temperatures compared to soil temperatures.

on 5 January. Trees throughout the area began to leaf out during this warm period. The mild conditions ceased in late January with a 15-day day cold spell, during which the temperatures did not exceed freezing. Trees that had leafed out during the mild temperatures quickly dropped their leaves after the freeze. Temperatures started to moderate in late February and a warm spring followed. Trees that had leafed out in January produced a second set of leaves during this period, and 17-year cicadas were observed emerging on 15 May 2007 and continued to emerge over the next week. This observation is consistent with the experiment conducted by Karban et al. (2000), who were successful in inducing cicadas to emerge early after forcing a second flowering of peach trees. The production of two leaf sets during the spring of 2007 may have triggered some cicadas to emerge one year early.

The emergence model developed by Kritsky et al. (2005) that predicts the date in May when an emergence should start was tested using ten locations in Tennessee, North Carolina, Massachusetts, Kentucky, and Ohio. The model assumes that April temperatures can serve as a predictor of May's temperatures. We found that the model was accurate to within 72 hours at nine of the ten locations. However, if May's weather should not follow historical trends, the formula may not accurately predict when the soil will reach the emergence threshold of 18.3 °C (65 °F). That occurred in Hamilton County, Ohio during 2008, when a 15-day period of unseasonably cold temperatures kept soil temperatures below the emergence threshold of 18.3 °C (65 °F).

The relationship between air temperatures and subsequent soil temperatures was examined using HOBO® dataloggers placed in the soil at the same depth at which nymphs would be found during May. Kritsky & Noble found that the average of the previous two- and three-day running average air temperatures did reflect the changing soil temperatures (R^2 = 0.89) (Fig. 3). This correlation suggests that it should be possible to fine-tune the emergence forecast in May by using the extended weather forecast information. Such information would prove useful in planning events that would take place in wooded areas within an emergence area.

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