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# THE HISTORICAL CONTRACTION OF PERIODICAL CICADA BROOD VII (HEMIPTERA: CICADIDAE: *MAGICICADA*)

JOHN R. COOLEY, DAVID C. MARSHALL AND CHRIS SIMON

Department of Ecology and Evolutionary Biology, The University of Connecticut, Storrs, Connecticut 06269

*Abstract*.—We discuss periodical cicada (*Magicicada*) Brood VII, which is becoming extinct from much of its historically-reported range in upstate New York. During searches in June of 2001, we found *Magicicada* adults in only 10 of 37 sites (and two of eight counties) where periodical cicadas had been reported previously, and dense populations were restricted to a small region south of Syracuse and centered on the Onondaga Nation. We suggest possible explanations, including land clearing and climate change, for the decline of this brood and the extinction of other *Magicicada* broods.

*Key words:* *Magicicada*, extinction, Pleistocene climate change.

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Patterns in the biogeography of periodical cicada (*Magicicada* spp.) broods[1] in eastern North America are a source of inferences about the processes of life cycle change and speciation in *Magicicada* (e.g., Cox and Carlton, 1988; Marshall and Cooley, 2000; Simon et al., 2000, Cooley et al., 2001; Cox and Carlton, 2003; Marshall et al., 2003), and recent changes in brood distributions can provide valuable insights into these phenomena.

Periodical cicada broods have likely undergone considerable range shifts in response to postglacial climate change, because the deciduous forests required by these species were assembled gradually over the last 10,000 years (Delcourt and Delcourt, 1981; Shuman et al., 2002a, b; Toney et al., 2003). Within recorded history, there is evidence of recent range contraction (Young, 1958; Simon, 1988; Nelson, 2004) and brood extinction that is likely attributable to anthropogenic and climatological factors. Brood XXI, a 13-year brood occupying the Apalachicola Valley in Florida, became extinct some time after 1870 (Marlatt, 1923). Brood XI, which formerly occupied southern New England, experienced significant or total extinction from known collecting localities after 1954 (Manter, 1974). Both of these extinct broods were located at the margins of the *Magicicada* range limit—no present day brood occupies a more southern territory than Brood XXI did, and Brood XI was at the northern limit of periodical cicadas.

Recent observations suggest a new case of brood decline, again involving populations along the edge of the *Magicicada* distribution. Brood VII is currently the northernmost periodical cicada brood, and is unusual in that it is completely allopatric to all other periodical cicada broods (see Simon, 1988 for brood distribution maps). Historical records report the presence of only *M. septendecim* in this brood, which had been recorded from eight counties in and around the

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[1] *Magicicada* populations are grouped into largely parapatric broods that emerge on different 17- or 13-year schedules. 17-year broods are arbitrarily designated by Roman numerals I–XVII, and 13-year broods are designated XIX, XXII, and XXIII. For example, members of Brood I emerge once every 17 years, and always one year before members of Brood II. While broods do not tend to overlap, most broods adjoin others.

Finger Lakes region of central New York (records reviewed in Pechumen, 1968). Pechumen (1968) raised the possibility that this brood was becoming extinct, because many populations were sparse and scattered; such populations are unlikely to satiate predators and are unlikely to persist for generations (Lloyd and Dybas, 1966; Karban, 1982; Williams et al., 1993). Observations of the 1984 Brood VII emergence (Pechumen, 1984; C. Simon, unpubl. notes) provide further evidence for the disappearance of Brood VII. During the 2001 emergence, we documented the current distribution of this brood and evaluated the evidence for its decline.

## MATERIALS AND METHODS

Periodical cicada emergences are usually dense and easily located due to the sheer numbers of cicadas present (up to 1 million per hectare; Dybas and Davis, 1962) and the activity and acoustical power of their choruses. Our primary method for locating cicadas was to visit historically documented emergence locations and listen for male songs under sunny, warm (>70°F) conditions appropriate for *Magicicada* chorusing (methods similar to those in Marshall et al., 1996). We chose 37 distinct locations where adult periodical cicadas had previously been recorded, on the basis of field notes from the 1984 emergence (C. Simon) and published records (Pechumen, 1968, 1984). If the exact locations of past records could not be determined, surrounding areas of deciduous forest were surveyed. Between 9 June and 20 June 2001, we visited each site at least once, listening for a minimum of 5 minutes and noting the presence/absence of adult cicadas and whether scattered individuals were calling, whether there was a light chorus (enough individuals calling for their calls to overlap with no intervening silences), or whether strong choruses of more typical density (thousands or more per hectare) were present. If no songs were heard, we searched each site for emergence holes, shed nymphal skins, non-singing adult cicadas, cicada body parts, or cicada eggnest scars on twigs. Cicadas were recorded as absent only if such negative records were obtained under sunny, warm conditions and in appropriate habitat of mature, deciduous woods. We recorded our travel route and all negative records in a 1:150,000 scale map of New York State (DeLorme, 1993), and we used the map to estimate Lat/Lon for all locations. There were 10 additional locations where periodical cicadas had been noted before 1984 that we were unable to visit in 2001.

## RESULTS

Periodical cicada Brood VII is presently restricted to 10 of the 37 searched sites, all located within only two counties (Table 1, Fig. 1). In Onondaga County, NY, extremely dense choruses were found throughout the Onondaga Nation and in patches near the town of Nedrow. In Livingston County, NY, scattered calling adults were present along Nations Road and Roots Tavern Road, in the same locations where light choruses were observed in 1984. Several Cayuga county locations, in which light to moderate emergences were noted in 1984, showed no evidence of periodical cicadas in 2001. Details of the localities in Fig. 1 are included in Table 1.

## DISCUSSION

Periodical cicada Brood VII has declined significantly in the past century, since 27 of 37 previously recorded locations were devoid of cicadas in 2001. The disappearance of cicadas from some local areas is recent; at least 5 localities reported by Pechumen (1968) as having emergences in 1967 showed no evidence of *Magicicada* in 2001. The low-density populations

Table 1. Brood VII periodical cicada records, with decimal Lat./Lon. and year of last reported record.

| Lat | Lon | County | Description |
|---|---|---|---|
| *Magicicada* present in 2001 and before | | | |
| 42.83 | −77.81 | Livingston | Nations Rd. 0.5 miles S. of J. Cox Creek |
| 42.84 | −77.81 | Livingston | Roots Tavern Rd. 1.5 miles W. of Rte. 39 |
| 42.92 | −76.22 | Onondaga | Peppermill Gulf, at sharp bend in Rte. 80. |
| 42.93 | −76.18 | Onondaga | Route 11A, earthen dam 3 miles N. of Jct. Rtes. 20 and 11A |
| 42.93 | −76.10 | Onondaga | Quarry Rd. SW. junction US 11 and I-81 |
| 42.94 | −76.20 | Onondaga | Just N. of Griffin's Corners |
| 42.96 | −76.18 | Onondaga | Onondaga Nation, Commissary Rd. |
| 42.97 | −76.16 | Onondaga | Rte. 80, approx 1 mile N. of the Onondaga Nation |
| 42.97 | −76.19 | Onondaga | Near intersection of Makyes Rd. and Yenny Rd. |
| 42.98 | −76.14 | Onondaga | Nedrow |
| *Magicicada* present in 1984 or before and absent in 2001 | | | |
| 42.78 | −76.68 | Cayuga | Intersection of Sands, Levanna, and Cooney's Corner Rds. (1967) |
| 42.78 | −76.71 | Cayuga | Levanna (1984) |
| 42.79 | −76.68 | Cayuga | Cooney's Corner Rd. (1984) |
| 42.80 | −76.68 | Cayuga | Jct. Dill's Rd. and Cooney's Corner Rd. (1984) |
| 42.80 | −76.63 | Cayuga | Chase Rd. (1967) |
| 42.81 | −76.67 | Cayuga | Intersection of Gully Rd. and Truesdale Rd. (1984) |
| 42.82 | −76.68 | Cayuga | N. Side Great Gully (1967) |
| 42.84 | −76.69 | Cayuga | Union Springs (1899) |
| 42.85 | −76.64 | Cayuga | Union Springs, 0.4 miles E. of Waldron Rd. on Spring St. (1899) |
| 42.87 | −76.70 | Cayuga | 2 mi N. of Union Springs (1899) |
| 42.92 | −77.75 | Livingston | Avon (1899) |
| 43.15 | −77.47 | Monroe | Penfield, Baird Rd. (1899) |
| 43.20 | −77.50 | Monroe | West Webster (1916) |
| 42.72 | −77.35 | Ontario | Opposite Vine Valley (1882) |
| 42.80 | −76.98 | Ontario | Billsboro, town of Geneva (1916) |
| 42.83 | −77.10 | Ontario | Stanley (1899) |
| 42.90 | −77.43 | Ontario | East Bloomfield (1916) |
| 42.92 | −77.50 | Ontario | Baker Rd. S. of Ionia (1916) |
| 42.93 | −77.32 | Ontario | S. of Padleford at stream (1916) |
| 42.97 | −77.23 | Ontario | Manchester (1899) |
| 42.97 | −77.32 | Ontario | Near Farmington (1899) |
| 42.97 | −77.37 | Ontario | Mertensia (1916) |
| 42.98 | −77.40 | Ontario | Victor (1916) |
| 42.67 | −76.92 | Yates | Long Point (1899) |
| 42.67 | −76.98 | Yates | Mays Mill (1899) |
| 42.68 | −76.95 | Yates | Vine Valley (1882) |
| 42.75 | −77.02 | Yates | Bellona (1899) |
| *Magicicada* present before 1984; locations not revisited in 2001 | | | |
| 42.73 | −76.70 | Cayuga | Ledyard, 7.5 mi S. of Union Springs (1899) |
| 42.85 | −76.60 | Cayuga | Mapleton (1916) |
| 42.93 | −76.57 | Cayuga | Auburn (1916) |

Table 1. Continued.

| Lat | Lon | County | Description |
|---|---|---|---|
| 42.67 | −77.77 | Livingston | Groveland (1916) |
| 42.68 | −77.83 | Livingston | Sonyea (1916) |
| 42.72 | −77.95 | Livingston | 5 mi W. of Mount Morris (1916) |
| 42.78 | −77.72 | Livingston | Conesus Lake nr. Long Point (1916) |
| 42.80 | −77.82 | Livingston | Geneseo (1916) |
| 42.80 | −77.86 | Livingston | River Rd. 1 mi S. of Craig Rd. near Piffard (1967) |
| 42.82 | −77.86 | Livingston | River and Craig Rds., near Piffard (1916) |
| 43.05 | −75.87 | Madison | Chittenango (1899) |
| 43.15 | −77.62 | Monroe | Rochester (1899) |
| 43.22 | −77.58 | Monroe | Irondequoit (1916) |
| 43.05 | −76.15 | Onondaga | Syracuse (1967) |
| 42.62 | −76.62 | Tompkins | Lansing, Lake Ridge Area (1916) |
| 42.68 | −76.95 | Yates | Dresden (1916) |

found in Livingston County during the 2001 emergence are not typical of *Magicicada* emergences; such low-density populations are unlikely to satiate predators or persist for generations (Lloyd and Dybas, 1966; Karban, 1982; Williams et al., 1993), so we expect that few if any *Magicicada* will emerge at these locations in 2018. Is the apparent decline of Brood VII the product of flawed historical records, or does it reflect actual extinction events? Erroneous historical records can create the false impression of significant range expansion or contraction (Marshall, 2001). Yet the isolation of Brood VII from other broods eliminates an entire class of spurious records (confusion with other broods), leaving only records based on mistaken species identification. Pechumen (1968) reviewed records for the past several generations of Brood VII, checking emergence dates in order to remove any erroneous records of potentially confusing, non-periodical *Okanagana* and *Tibicen* species present in the area. Thus, all available evidence suggests that Brood VII has become extinct in many previously reported localities. This extinction, occurring within the span of only a few generations, indicates that, even given their typically large population sizes, these animals may be vulnerable to rapid decline.

Two factors may help account for the decline of Brood VII, land-use patterns and climate change. The recent contraction of this brood has restricted it to a range almost entirely within the Onondaga Nation (Onondaga County, NY). Even though farming and clearing have occurred within the Onondaga Nation, historical land use patterns there may have differed from those in the surrounding farmland. The role of land use patterns in shaping periodical cicada distributions is unclear. Much of the range of other periodical cicada broods has, at one time or another in the past 300 years, been converted into cleared farmland or suburban housing, yet periodical cicadas persist, sometimes in greatly altered habitats such as suburban Chicago, Cincinnati, and Washington DC. However, anthropogenic effects may be magnified at the margins of the periodical cicada range, and land-use patterns remain a possible explanation for the decline of Brood VII (as well as for the losses of Broods XI and XXI, Long Island populations of Brood X [Nelson, 2004], and Wisconsin populations of Brood X [CS, unpubl. obs.]). Full evaluation of this hypothesis will require more detailed study of historical land use patterns, and a search for associations between the density of Brood VII relict populations and the timing and intensity of land clearing.

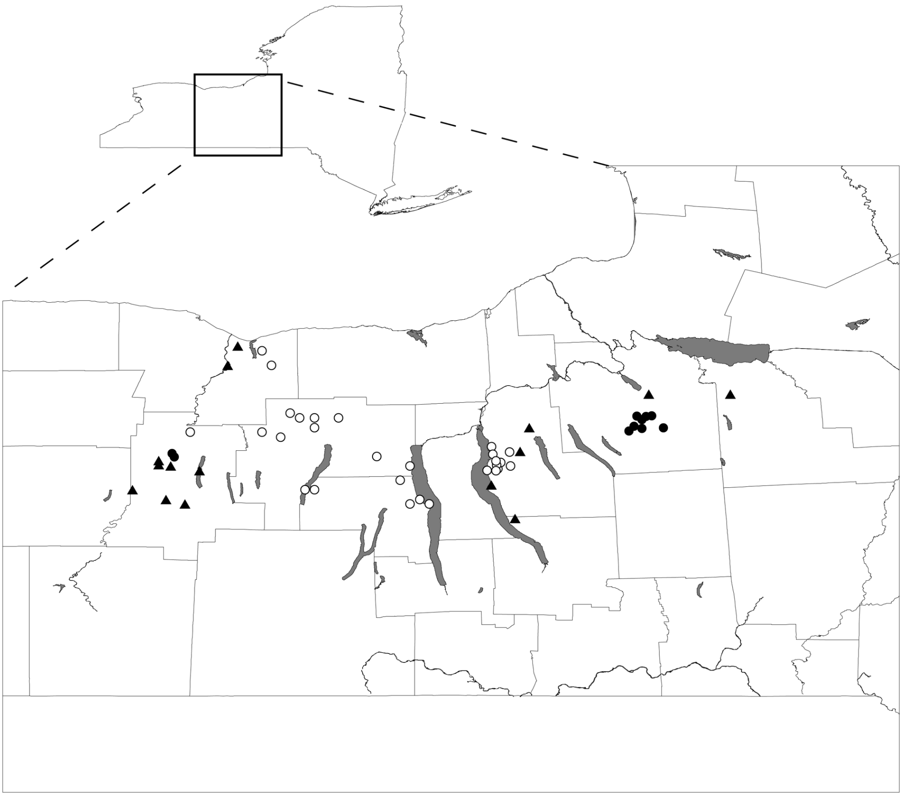

Fig. 1. Brood VII periodical cicada records. Filled circles: *Magicicada* present in 2001. Open circles: Historical record for Brood VII, no *Magicicada* present in 2001. Filled triangles: Historical records not visited in 2001.

Climate change, and its effects on marginal periodical cicada populations, is another possible explanation for the near-extinction of Brood VII. In general, during Pleistocene cooling periods, periodical cicada range shifts likely involved extinctions at northern brood margins accompanied by range expansions along southern margins, resulting in a net movement southward; the reverse process would have allowed periodical cicadas to invade deglaciated areas (see Hewitt, 1996). Yet because most periodical cicada broods are contiguous with one or more other broods while overlap between broods is rare, range shifts for any given brood may be inhibited or blocked by the presence of other broods. Trapped by neighboring broods in an area of fluctuating or deteriorating climate conditions, marginal broods may enter a self-reinforcing cycle of declining population numbers; as their numbers decline, the periodical cicada strategy of reliance on predator satiation becomes ineffective, and eventually low-density populations become vulnerable to annihilation by predators (Lloyd and Dybas, 1966; Karban, 1982; Williams et al., 1993).

The interaction of geography and climate change suggests a hypothesis for the fragmentation and decline of Brood VII. Climatological data suggests a recent (<3000 yr) cooling trend affecting New York (Toney et al., 2003). Brood VII occupies an area of deep valleys and highlands; during periods of mild climate, conditions may be appropriate for periodical cicadas to invade large areas by spreading across the highlands and into neighboring valleys. But when conditions deteriorate, *Magicicada* may become trapped in the milder climatic "islands" of valleys or south-facing slopes; if so, as the climate cooled, the cicadas would have become increasingly excluded from the highlands. The biogeographic evidence in support of this hypothesis is that areas in which cicadas were noted in 1967 and 1984 (but not in 2001) were somewhat shallow valleys, while the only dense emergence noted in 2001 was in the Onondaga Nation, which occupies a deeper valley with a south-facing aspect, although there is no simple correlation between elevation and local extinction. Meteorological data from 1952 for the Syracuse airport (http://cdo.ncdc.noaa.gov/CDO/cdo) are more ambiguous, and show no obvious warm or cool periods associated with cicada disappearance. Clarifying the present status of locations not visited in 2001 (Table 1), most of which were upland sites, may provide further support for this hypothesis, as would a detailed geographic and climatological study of this brood's historical and remaining range.

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