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THE USE OF CITIZEN SCIENTISTS TO RECORD AND MAP 13-YEAR PERIODICAL CICADAS (HEMIPTERA: CICADIDAE: MAGICICADA) IN SOUTH CAROLINA

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Citizen science is the process in which citizens are involved in science as researchers (Carr 2004). This can range from involvement in a collaborative effort from academic and government agencies in the assessment of a common environmental (community) concern to the management of common natural resources (Conrad & Hilchey 2011). Traditionally, the use of citizen scientists involved the collection of data on species detection and habitat. This is due to the difficulty of a single monitoring agency in obtaining accurate data for proper population assessment (Conrad & Hilchey 2011). Increasing concern regarding the effect of climate change and land development on biodiversity has raised interest in assessing evolutionary responses of plants and animals, particularly for species that are absent in some years but abundant in others (Heliovaara et al. 1994; Lepetz et al. 2009).

Brood XIX of periodical cicadas (Hemiptera: Cicadidae: *Magicicada*) consists of 3 species (*M. tredecassini*, *M. tredecim*, *M. tredecula*) that emerge synchronously every 13 years. Historically, Brood XIX has been recorded to span along the United States east coast from Maryland to Georgia and in the Midwest from Iowa to Oklahoma (Simon 1988). Males and females emerge from the ground close to their host tree and eclose into their adult form. Adults are approximately 4

cm long with red eyes, orange-veined wings and black bodies (Fig. 1). They live above ground for approximately 4-6 wk. The males produce species-specific calls that attract both sexes in the forest canopy resulting in large aggregations in areas of high population densities. After mating, females disperse to nearby trees and lay eggs into slits cut into the branches. Nymphs hatch from eggs after 6-8 wk and drop to the ground where they feed on root xylem fluids for another 13 yr (White & Strehl 1978; Williams & Simon 1995).

In South Carolina, the 1985 emergence began around 21 Apr in Abbeville and Saluda counties. Cold weather delayed the emergence in 1998 resulting in fewer sightings. Based on anecdotal and general accounts, periodical cicadas were suspected to emerge in approximately 25 South Carolina counties (Gorsuch 1998). The anticipated 2011 Brood XIX emergence provided a unique opportunity to apply the use of citizen scientists in obtaining a more accurate assessment of the species range in South Carolina. The aim of the project was to use voluntary internet reports of sightings to examine spatial and temporal patterns of periodical cicada emergence and document citizen's impressions of the Brood XIX emergence.

Three South Carolina state institutions established internet sites for citizens to report sightings (Clemson University: [The image consists of two side-by-side black and white photographs. The left photograph shows a periodical cicada nymph in the process of molting into an adult on a tree trunk. The nymph's body is light-colored and segmented, with its legs and antennae visible. The adult cicada is partially emerged, showing its dark, segmented body and long, thin legs. The right photograph shows an adult periodical cicada resting on a rough, textured rock surface. The cicada has a dark, oval-shaped body, long legs, and transparent wings with visible veins. Its head is turned slightly to the right.](http://clemsoncicada.word-</p></div><div data-bbox=)

Fig. 1. Periodical cicada nymph from Brood XIX in South Carolina molting into the adult stage. Photos by Gerry Carner, Clemson University.

press.com/; University of South Carolina: <http://cricket.biol.sc.edu/cicada/>; and the South Carolina Forestry Commission: www.state.sc/forest). Local, public media that spanned into Georgia, South Carolina and North Carolina were used to inform citizen scientists of websites for reporting emergences. In addition, emails were sent out to professional groups such as County Extension Agents, Master Gardeners, the South Carolina Pest Control Association and the South Carolina Nurseryman's Association to inform them of the websites. Sightings were biologically validated with pictures, sound recordings, descriptions and in some cases by visiting locations and capturing individuals. Citizen scientists were asked to report the county, address, GPS coordinates and/or street intersections of emergence locations. Reports were categorized into fine or coarse scale depending on details available in the report. If not provided, decimal latitude and decimal longitude coordinates were determined using Google Earth software (Google Inc., Mountain View, California) and plotted onto a geographic information systems (GIS) map.

Citizen scientists' perception of the emergence event was categorized qualitatively via assess-

ment of general comments. Responses were categorized as positive if comments included words such as "enjoyable", "amazing", "exciting", "neat" and "interesting". Negative comments included "terrible", "infestation", "irritating" or "nuisance". Responses were categorized as neutral if citizen scientists only gave basic information about the sighting with no or vague impressions about the emergence.

Reports of emergences occurred from early Apr to early Jun with the majority of sightings occurring from mid-Apr to mid-May. Overall, 191 location reports were received from 129 individuals from South Carolina, Georgia and North Carolina. In South Carolina, the emergence occurred primarily in the Piedmont region from 129 site locations and reported by 113 individuals (Fig. 2). Of those reporting, 90 reported on their experience or feelings about the emergence. From those comments, 30 (approximately 33%) perceived the experience as positive, 17 (approximately 19%) perceived the experience as negative and 43 (approximately 48%) did not comment on their perception of the experience.

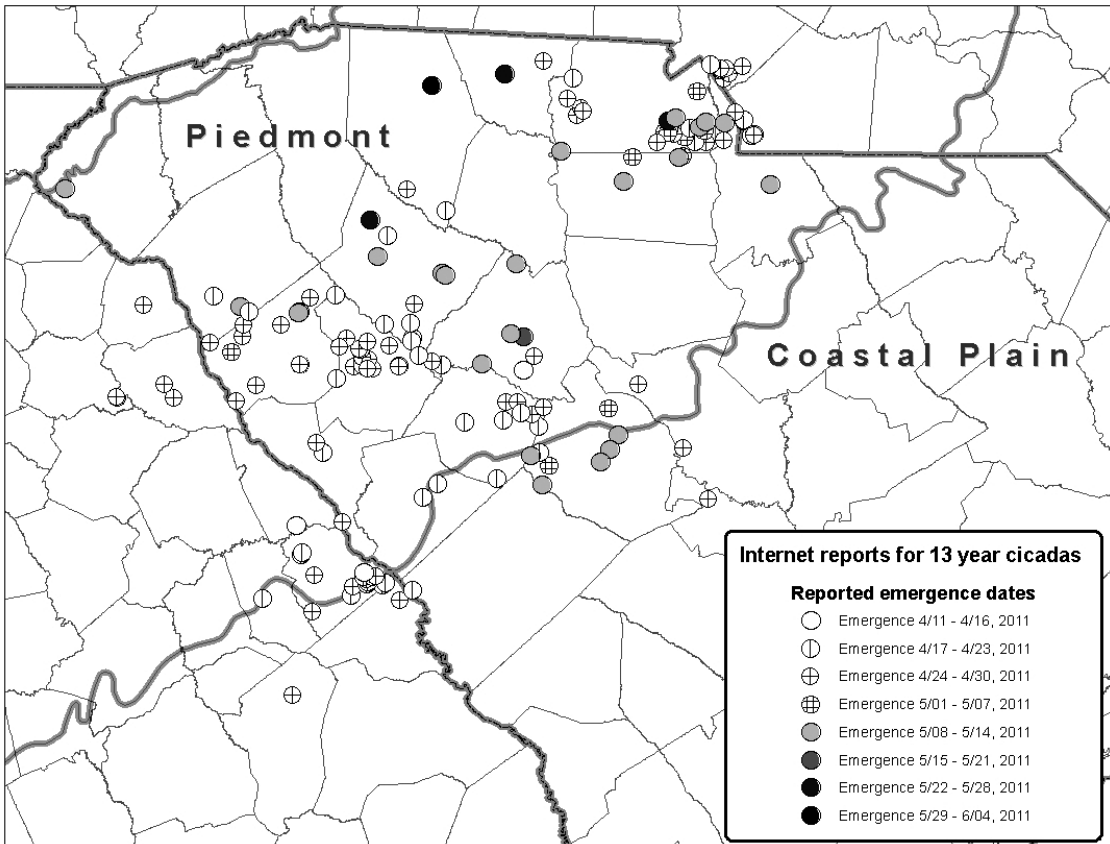


Fig. 2. Location and emergence dates of the 2011 13-year periodical cicada (Brood XIX) in South Carolina

The need for citizen science has increased due to various factors including the need for decision makers for timely information regarding the local environment, cuts in funding to monitoring programs and the desire for citizens to contribute to environmental protection/conservation (Whitelaw et al. 2003). Additionally, due to the rare and sporadic sightings of some species of interest, local citizen scientists are often best placed to monitor ecological patterns as they occur (Carr 2004). In 2011, periodical cicada emergences were reported in 19 South Carolina counties. Due to lack of exact location sightings from previous emergences (1998, 1985, 1972), we cannot determine if the current population suffered declines due to factors such as climate change, land development and timber harvests. However, the data and field experience obtained in this collaborative effort provides a significant benchmark for future studies on periodical cicada ecology and behavior in South Carolina. For example, the literature suggests that periodical cicadas rarely fly distances greater than 50 m from where they emerged (Karban 1981), however reports and field observations suggests a greater than anticipated dispersal ability.

The cicada monitoring project also presented an opportunity for scientific public outreach. Citizen scientists expressed a range of positive accounts of the periodical cicada emergence from rescuing emerging adults from predation, photography, home-school education opportunities, to a willingness to provide additional monitoring information throughout the emergence event. Citizen scientists also actively engaged in scientific inquiry by presenting hypotheses regarding the cicada's behavior (i.e. attracted to light, attracted to large and/or oak trees) based on their observations and in some cases, pursued independent research via internet sources. Negative accounts such as expressing irritation about the noise level, concern about property damage and/or danger to pets and requesting information about insecticides indicate opportunities for promoting better understanding about cicada biology.

Recommendations for improving future cicada monitoring projects include: 1) coordinating interested South Carolina institutions and agencies in 2023 to create one common website with one supervisor, 2) implementing early outreach efforts to inform citizen scientists on what to expect from the upcoming emergence to reduce negative reactions and 3) include a short questionnaire to

more accurately assess citizen scientists' perception of the emergence experience.

The authors thank the many citizens of South Carolina, Georgia and North Carolina that took the time to report their sightings, provide pictures and sound recordings and invite researchers to their homes for sample collection. We also thank Ken Allen and Lucy Linkowski for their contributions in plotting and analyzing the data.

SUMMARY

In the spring 2011, Brood XIX of the 13-year periodical cicadas (Hemiptera: Cicadidae: Magicicada) emerged in the Piedmont counties of South Carolina. Three South Carolina state institutions established internet sites to encourage citizen scientists to report periodical cicada sightings and to document public perception about the emergence. The internet sites received approximately 191 reports from counties in South Carolina, Georgia and North Carolina with comments on the emergence ranging from positive to neutral.

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