Research suggests complex genetic heritage in three cicada species

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Ecology and evolutionary biology professor Chris Simon has co-authored a paper showing that despite striking similarities, three species of periodical cicadas evolved independently and at different times. Credit: Sean Flynn/UConn Photo

(Phys.org) —A paper co-authored by ecology and evolutionary biology professor Chris Simon, two UConn research associates, and other colleagues, offers genetic proof that three common species of cicada, although each has 13- and 17-year life cycles and each is found in eastern, middle, and western geographic regions, evolved independently

and at different times from each other.

The paper, "Independent divergence of 13- and 17- year life cycles among three periodical cicada lineages," was published in the March 18 issue of the *Proceedings of the National Academy of Sciences* (*PNAS*).

The research presented indicates the presence of a common genetic basis for the three species groups of periodical cicadas (Decim, Cassini, Decula) – all members of the genus Magicicada – but it also shows there has been considerable genetic divergence leading to separate 13- and 17-year populations among the species despite the fact that each group exhibits similar phylogeographic patterning.

"Originally it was thought that the three different species groups must have developed simultaneously," says Simon, "because members of all three species groups emerge together every 13 or 17 years in multiple broods (or year-classes) located throughout the U.S., east of the Great Plains. The three species groups have pretty much the same geographic distribution, and they do everything together. But in our lab we were able to determine that the 13- versus 17-year Decim DNA divergence was much deeper than the 13- versus 17-year Cassini or Decula divergence, so I knew they hadn't developed at the same time as the others."

Working with colleagues in Japan, the UConn researchers looked at DNA from the 30 years of samples represented in frozen collections at UConn. They did geographic sampling of all three species, and when they compared them using nuclear and mitochondrial DNA markers they discovered that the three species groups had first diverged about 3.9 million years ago.

Initially, the Decim group diverged from the ancestor of Cassini and Decula, and then Cassini and Decula separated into different species groups about 2.5 million years ago. The mitochondrial gene genealogy

shows further divergence associated with geographic regions and, partly, with life cycles.

Some cicadas in the extensive collection of carefully preserved insects held by the Department of Ecology and Evolutionary Biology. Credit: Sean Flynn/UConn Photo

The paper further reports that all three species groups experienced at least one episode of life cycle divergence since the last glacial maximum – the end of the ice ages – some 20,000 years ago.

"In the Decim species, the 13-year Decim in the southern region – roughly North Carolina, South Carolina, Georgia, Alabama, Mississippi, Louisiana, Tennessee, and Arkansas – actually survived as a separate group during the last ice age," Simon says. "The comparative DNA divergences tell us that the 13-year Decim formed earlier than the

13-year Cassini and the 13-year Decula."

Earlier, the UConn research group found two independent derivations of the 13-year form life cycle in the Decim group, one of which was after the end of the ice ages. The current work adds that there were three independent derivations of the Decula 13-year life cycle (east, middle, and west) but only one derivation of the Cassini 13-year life cycle (from the west). All Casini and Decula 13-year cicadas that exist today were derived after the end of the ice ages from the 17-year memberships of their species groups.

The major implication of this work is that life cycle genetics, with the tendency for four-year time jumps and a long, synchronized life cycle, evolved in the common ancestor of all three species groups, but that the 13- and 17-year lineages of Decim, Cassini, and Decula seen today evolved not only later but at different times in each species.

Brood II nearing 17-year cycle

The timing of the research paper coincides with the adult emergence of 17-year Brood II – of 15 known existing broods – in states including Connecticut, New York, Pennsylvania, New Jersey, Delaware, Maryland, and North Carolina. Magicicada periodical cicadas are seen in the spring and early summer when adults emerge from underground where they have undergone five different developmental nymph stages, or instars, during their 17-year development. During this time they grow from approximately the size of an ant to their adult size of 25-50 mm – approximately one to two inches – depending on the species.

Nymphs emerge, sometimes by the millions, and find vegetation where they molt into mature adults. This process usually occurs in hardwood trees, where the adults then mate and the females lay their eggs. As part of this process males 'sing' to attract mates. This is done by vibrating

ridged membranes, or tymbals, and the resulting cacophony is often described as "deafening" by those within hearing range of an emerging colony.

In Connecticut, Brood II is located west of the Connecticut River around New Haven, North Haven, and northward toward interstate 84. The insects will emerge in early June, once the soil temperature reaches approximately 55 degrees Fahrenheit, and they will live approximately three weeks during which time they will complete their life cycle.

As to why the insects live carefully regulated lives and emerge from the soil for a roughly 20 to 30 day period every 13 to 17 years, Simon comments, "There is safety in numbers. There are two published studies that strongly support the idea of a complex strategy of predator avoidance. Everything likes to eat Cicadas … birds, box turtles, and in certain societies, even people. By emerging by the millions, there are bound to be some that survive long enough to lay eggs and perpetuate the species."

Not all species of cicadas are of the 13- or 17- year variety, according to Simon, and many live more typical non-synchronized life cycles lasting anywhere from two to eight years, meaning that every year some individuals appear. However, it is the periodical cicadas, often incorrectly referred to as 'locusts', that capture the imagination due to their huge numbers, long absence, loud songs, and interesting black and orange markings.

Anyone spotting the cicadas emerging from Brood II this summer is encouraged to report sightings to the website www.magicicada.org created by one of the paper's co-authors, John Cooley, a postdoctoral research associate in UConn's Department of Ecology and Evolutionary Biology.

Listen to three species of cicadas:

Chorus of Magicicada septendecim

Chorus of Magicicada cassini

Chorus of Magicicida septendecula

More information:
www.pnas.org/content/early/2013/03/15/1220060110

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