An adult female 17-year cicada. Note the egg slits in the twig made by the ovipositor (which can be seen near the end of the body). The tube-like proboscis through which the cicada sucks sap can be seen on the underside of the head. When there are many egg-slits, the twig may dry up and die.
(Photo by Miss Claire Cotterill)

population explosion— 17-year locust style

by Henry Dybas, Associate Curator of Insects

Seventeen-year periodical cicadas (or '17-year locusts') always attract a lot of popular interest and press coverage when they appear. So it is worth noting that the largest and geographically most extensive brood of 17-year cicadas (Brood X, as it is called by entomologists) is scheduled to appear this year—within a few weeks in fact. As shown on the accompanying map, there are three main areas in Brood X. One is in the southern Appalachians, another is centered in eastern Pennsylvania and Virginia, and the third occupies nearly all of Indiana and the western part of Ohio. Museum members or friends planning a vacation or an automobile trip through any of these areas in late May or June, should take the opportunity along the way to see this spectacular natural phenomenon.

Seventeen-year cicadas are not hard to find in a cicada year. They occur in woodlands and orchards, and the males form large singing choruses that can be heard for some distance on warm afternoons. During the last appearance in the Chicago area, one gas station proprietor, across the highway from a cicada chorus, told me that quite a few drivers coming from the open country to the east, stopped at his station to investigate the noise that seemed to suddenly develop in their cars.

Seventeen-year cicadas are large insects with a wing spread of about three inches and they are conspicuously colored with black body, orange-yellow wings, and bright red eyes. The bizarre red eyes seem to be the feature that most impresses people that have not seen these insects before.

The best place to watch periodical cicadas is in a clearing or along a woodland edge where the foliage comes down to eye-level, and where there is exposure to the afternoon sun. There are a number of kinds of activities like singing, mating, feeding, egg-laying and so on, that can be easily observed. Most of these can be readily photographed because the cicadas are not particularly shy and because they can be incredibly numerous (there may be a hundred thousand per acre, for instance). Males exhibit a characteristic 'sing-fly' behavior. They sit horizontally on a twig and sing one or several song phrases, while the abdomen bobs up and down in time. Then they flutter off and change perches between songs. During the peak of the day, the 'sing-fly' activity can be extraordinarily intense. In one species the thousands of males synchronize their songs, forming one great crescendo of sound. After the sound dies down, the tree-tops seem to explode as thousands of males flutter up together and change positions before they sing again. Drs. Moore and Alexander, of the University of Michigan, have likened this behavior, in one of their technical reports, to a 'gigantic game of musical chairs.' It is an indescribable experience to find oneself in the middle of one of these 'games.'

The life history of these unusual insects has been extensively investigated. The female lays its eggs in slits cut in twigs with its blade-like ovipositor. The eggs hatch in six to seven weeks and the tiny white nymphs launch themselves (like paratroopers) into the air and float to the ground. Each nymph is only about a twelfth of an inch long at this time. It works its way into the soil and attaches to the rootlet of a tree, whose sap it sucks with its beak. For the next 17 years the nymph grows slowly in its solitary underground cell. Early in the 17th year, it constructs a vertical escape tunnel up to near the surface of the ground, sometimes capping it with a turret (much like a crayfish turret). There it waits until some warm night in May or early June when, with thousands of other nymphs, it crawls out of the ground about dusk. Each brown nymph climbs up a nearby tree-trunk or other plant stem, leaving a smooth, round exit hole in the ground about ½ inch in diameter. It fixes itself firmly, the skin splits down the middle, and the soft white adult with red eyes emerges. The wing pads are pumped out by blood pressure and the wings become fully expanded. The body colors and hardens and, the following morning, the adult flies up to the tree-tops. A few days later song is heard and mating and egg-laying begin. Adults live only a few weeks, even if birds and other enemies don't get them, and by late June or early July they are gone for another 17 years. The exit holes and empty nymph skins,

along with browning twigs from egg-slit damage, remain behind as evidence of the emergence.

Essentially, the entire underground population emerges the 17th year within a few weeks time. Normally, only a few stragglers come out the wrong year. A notable exception occurred last year in the Chicago area when many thousands of cicadas, scheduled to emerge in 1973, made a mistake and emerged four years early. Hundreds of Chicago area residents supplied the Museum with critical evidence on this unique event as reported in the August, 1969, BULLETIN (reprints of this article are still available on request). But otherwise the 17-year schedule for all recorded broods has been absolutely rigid. Brood X, for instance, was first recorded in 1715. Two and a half centuries later, on its last appearance in 1953, it was still precisely on its 17-year schedule of emergence.

Our present thinking is that the synchronized appearance above ground of enormous numbers of cicadas after 17 years serves to satiate the birds and other enemies. They can eat only a part of the cicada population before the rest have reproduced and died a natural death. If the same number of cicadas were spread out over a number of years, the reasoning goes, the predators could account for a higher proportion, leaving few for reproduction. Periodicity in cicadas can therefore be regarded as a special strategy that has been evolved, so to speak, to foil predators.

Periodical cicadas have been studied a great deal in the last century—there are hundreds of technical papers written about them. It therefore comes as something of a surprise to discover that some of the most striking things about them escaped detection for most of that time. For example, only in the last ten years has it been firmly established that there are *three* distinct species of 17-year cicadas and not just one. These three species not only have the same 17-year life cycle, but they mostly occur together and, in a given locality, all three invariably emerge above ground the same 17th year. In the South, periodical cicadas have a 13-year life cycle and again all three species occur together and are synchronized on the same emergence pattern.

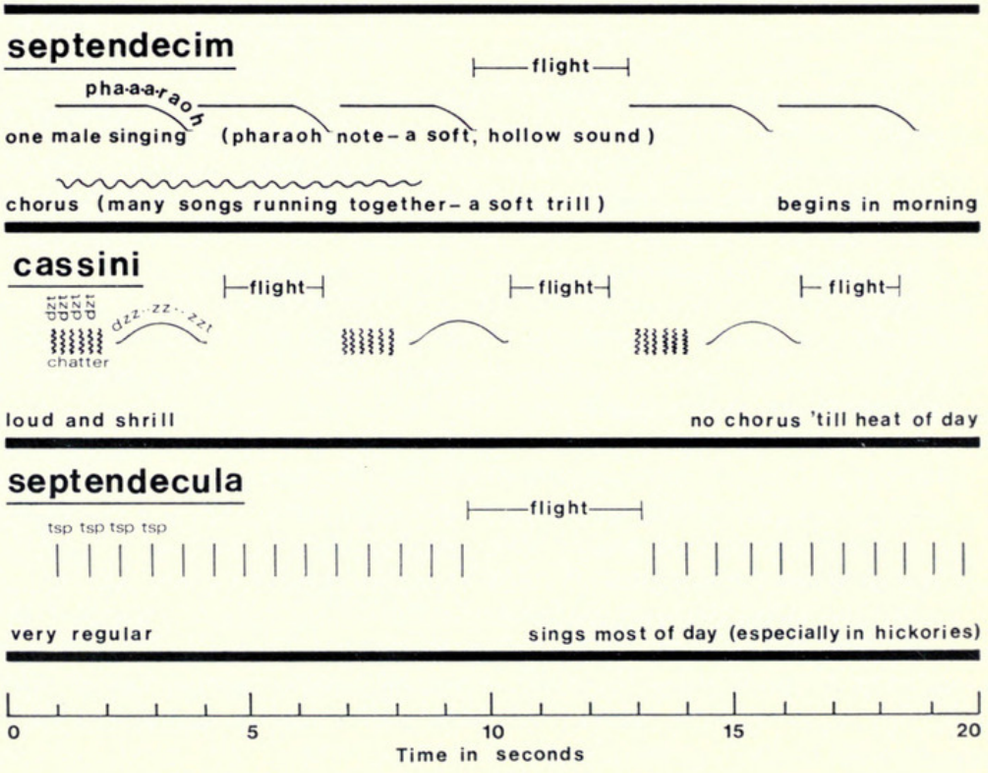
Now that we know that there are three distinct species, some puzzling facts about their ecology and behavior can be clarified. The three species are quite similar in appearance, but one prefers bottomland woods, another occurs on a wide variety of trees in upland forests, and the third species selects upland hickories. The songs of the males are very distinct. Once one is attuned to these differences in song it is possible to go into a woods and identify the kinds present just by hearing them.

It is usually not practical to describe songs in words but the pattern of the three songs is so distinct that, hopefully, the diagram on this page will serve to identify them in the field. Most of the individuals can also be separated on the basis of size and color. Incidentally, females differ from males in having a pointed body behind, with an ovipositor or egg-layer underneath.

The oldest known species is *Magicicada septendecim*, named by the great Swedish naturalist, Carolus Linnaeus in 1758. It is larger than the other species—about 1½ inches long to tip of closed wings, and can be positively identified by the *reddish stripe* between the eye and base of wing. Its belly beneath has yellow cross-banding.

The other two species *lack this stripe* and are smaller, usually about 1¼ inches long to tip of closed wings. One, *Magicicada cassini*, has the belly *dark* underneath or with only traces of pale banding. It is found mostly in lower places along streams. The other, *Magicicada septendecula*, is *yellow banded* underneath. It is usually associated with hickory trees and is almost always much less numerous than the other two species.

With our new knowledge and hindsight about these three species, it is easy to wonder how our predecessors



The three kinds of 17-year cicadas have been confused until a few years ago, but they can be easily recognized in the field by their song. It is the males that sing, and usually only on warm, sunny days. The females are attracted to the trees where the males are chorusing. The song diagrams are also reflected in movements of the abdomen. If one observes a singing male septendecim *in profile, for instance, the abdomen is held high in the beginning of the 'pharaoh' call and dips down when the song ends on a lower pitch. Similarly in* septendecula, *the abdomen dips with each 'tsp,' 'tsp' note. (The diagram is based on the acoustical studies of Drs. Moore and Alexander of the University of Michigan.)*

could have failed to see what is so obvious to us now. The original cicada described by Linnaeus (*septendecim*) was known for a hundred years before the second species, *cassini*, was formally recognized and named. An ornithologist by the name of John Cassin, who was associated with the Philadelphia Academy of Sciences, encountered this second species in Delaware County, Pennsylvania in 1834 (during an emergence of our same Brood X, eight cicada generations ago) and recognized it as distinct from *septendecim*. As a student of birds he was probably able to appreciate song differences, as well as slight color differences between closely related species better than his entomological colleagues of the time. Seventeen years later, when Brood X next appeared, he evidently was able to convince one of the Philadelphia entomologists, who then formally described and named this species *cassini* (in honor of John Cassin, the discoverer). This, by the way, is the species which plays the game of 'musical chairs' in its synchronized choruses. *Cassini* had only a short period of recognition though before being put into limbo. Two famous entomologists of the day, Benjamin Walsh and Charles Valentine Riley, soon became aware that *cassini* (like the long-known *septendecim*) also had a 17-year life cycle and moreover emerged the exact same 17th year with *septendecim* in each and every locality where it occurred. This was too much of a coincidence for Walsh and Riley, so they dismissed the notion that there could be *two* such unusual species and *cassini* became buried and unrecognized for another three-quarters of a century. Since then, several entomologists have independently studied *cassini* (including Dr. Monte Lloyd of the University of Chicago and myself), and it is now clear that it is a perfectly distinct species in song, color, size, structure, ecology, and mating behavior.

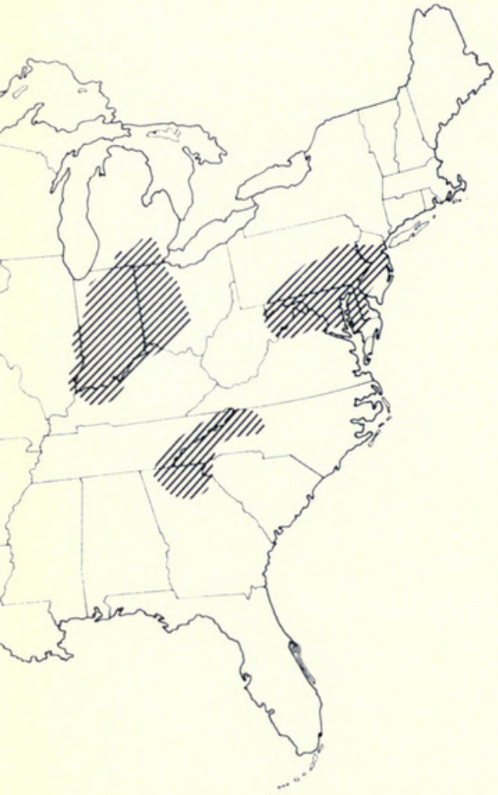
The third and longest overlooked 17-year cicada is *septendecula*, described and named only as recently as 1962 by Drs. Moore and Alexander (it appears that every hundred years we discover a new 17-year cicada in our midst). In the years since 1962, it has been found in many different broods and areas from Kansas to Virginia, and in the 13-year populations as well. In spite of its resemblance to *cassini*, its yellow-banded (instead of dark) belly and its very different song should have served to distinguish it. How could such a large, abundant, and widespread species which calls attention to itself by a distinctive song remain unrecognized throughout a century of intensive work on periodical cicadas? It makes one pause and think.

How does one resolve the 'coincidence' problem that troubled Walsh and Riley a century ago? The answer, it appears to us, is that there is an advantage for the three 17-year species to pool their resources and to satiate the birds and other predators with their combined numbers and protoplasm when they emerge the same 17th year, rather than to 'go it alone' on separate years. This, of course, is not a conscious decision but a result of natural selection favoring individuals whose emergence coincided as against those which didn't.

So if you travel and do some 'cicada-watching' in the coming weeks, be aware of the possible complexities of the periodical cicada story as well as of the drama of a great natural spectacle. Possibly the cicadas may still have further surprises in store.

An adult cicada emerging after dark from a nymph skin, which represents the stage in which the ciada lives underground for 17 years. The wings will be expanded and the body will darken and harden by morning when the cicada will fly to the tree-tops. The empty nymph skins remain and are a conspicuous feature of a cicada emergence.

(Photo by D. D. Davis)



The approximate areas where 17-year cicadas ('locusts') of Brood X are expected to appear above ground in May and June this year. The discontinuous distribution into separate regions is not typical of other broods. The areas in between are occupied by 17-year cicadas that emerge in other years.

Note: The distribution map is based on old records made before the status of the three species of 17-year cicadas was clarified. Therefore we need new distribution information, this time for each of the three species. Hence we will very much appreciate cicada records (exact locality, date, collector, abundance) accompanied by specimens that can be identified as to species.