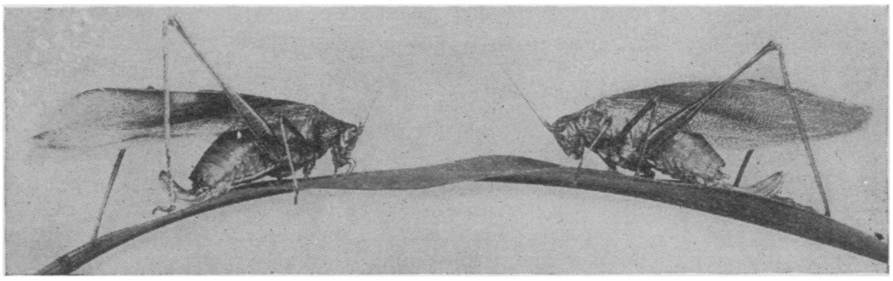
Singing Insects Hear With Front Legs

Entomology



"KATY DID!" "SHE DIDN'T!" These tireless advocates argue with their wings and listen with ears located in their legs

When the great katydid chorus breaks loose in the treetops these moonlight nights of August, presaging thereby, according to the folklore of the country, a frost in six weeks, few in the audience realize that the synchronism of the insect orchestra is maintained by a complicated little mechanism on the green fiddlers' fore limbs.

For science has established that katydids hear with their front legs.

The whole question of how insects hear, see, smell and otherwise exercise their sensory functions has been the occasion of much learned entomological wrangling. Some have even declared that they did not hear at all. But an enterprising young entomologist at Iowa State College, who has recently moved to the State College of Agriculture of North Carolina, Dr. B. B. Fulton by name, decided to settle the question by actual experiment.

There are on the front pair of legs of certain insects of the grasshopper type, organs similar in structure to those used for hearing in higher animals. Only the species having stridulatory or singing organs have also the tympani on the foremost pair of legs. Whether they actually served this purpose or not, however, has been disputed vigorously. One student advocate of the auditory as well as ambulatory function of grasshopperine legs summed up the problem succintly by the remark, "If they aren't ears, then what are they?"

Close comparison of concerts participated in both by de-legged performers and those with the full complement of extremities was the method chosen by Dr. Fulton for "getting the dope" on the green-winged violinists.

It has been shown recently that various moths and butterflies appear to perceive sounds, he pointed out. Caterpillars of at least two species have been found to react to sounds, though one failed to do so when the body hairs were loaded with water, showing that these hairs are concerned in sound perception.

"The fact that certain species of singing Orthoptera (the name given by scientists to insects of the grasshopper type) synchronize their notes seemed to me conclusive evidence that thy could hear each other," Dr. Fulton explained. "Such a simultaneous sounding of notes could hardly be a matter of accident. Neither is it an auditory illusion as some writers have claimed. While studying the songs of the tree cricket and a couple of other singing insects, I was impressed with the idea that here was excellent material for testing the auditory powers of the tympani on the foremost legs. Accordingly, I set about collecting males of all such species as were available in this locality."

The first demonstration was staged with ten male katydids of a sort commonly found on the prairies. They were placed in a cage where night after night they exhibited almost perfect synchronization.

"This insect," said Dr. Fulton, "starts singing in the afternoon and as evening approaches the number of singers increases. The song is under ordinary conditions a series of 20 to 30 short metallic rasps at the rate of four per second. Each series of notes lasts about five to seven seconds and is followed by a period of rest of about five seconds.

"The synchronization of my ten caged singers was practically perfect. The song of the group was continuous and as each individual started its series of notes anew it would fall in with the general cadence. It was only by detecting slight variations in the quality and volume of the chorus that one could be aware of the pauses in the individual songs.

"After observing the song of the whole group for two nights I removed four males to another cage at some distance from the first and cut off their front pair of legs close to what corresponds to the thigh. For the two following nights only one of the mutilated katydids was heard singing at one time. On the third night two sang more or less continuously. The notes were not synchronized except as they happened to sound together at times. The two males happened to have slightly different normal rates, so that if they started their series of notes in unison they would usually be sounding them alternately at the close. I observed 36 consecutive periods when both males were singing at once and of these there were only two when the notes did not interfere at some time during the period. Following these observations I went back to the cage of normal insects and listened carefully to four singers for ten minutes. During this time there were only two short intervals during which a few notes were sounded out of cadence as one of the singers began a series of notes.

"In order to be doubly sure that my senses did not deceive me I requested some one who had no knowledge of the experiment to listen for a few minutes at each cage to se if they could detect any difference in the songs. This observer noted at once that the song was rhythmical and synchronized in the first cage but not in the second."

The insects did not seem to be greatly disturbed by the loss of their front members, for those so operated upon lived as long as those that possessed all their legs intact, a condition which argues in favor of the often-repeated statement that insects are not very sensitive to pain. Grasshoppers, it is well known, rather frequently kick off one or more legs voluntarily to escape capture.

The next batch of victims were snowy tree crickets, the collective authors of that shrill melody of sound that seems to come from nothing out of everywhere out-of-doors on summer evenings when the shadows begin to darken. This music is probably the most familiar of all insect sounds, but the musicians themselves are little known to the public. They were divided in two lots like their predecessors and put into separate cages.

"After waiting a few days," Dr. Fulton went on, "to see that both cages contained willing singers, I amputated the fore- (*Turn to next page*)

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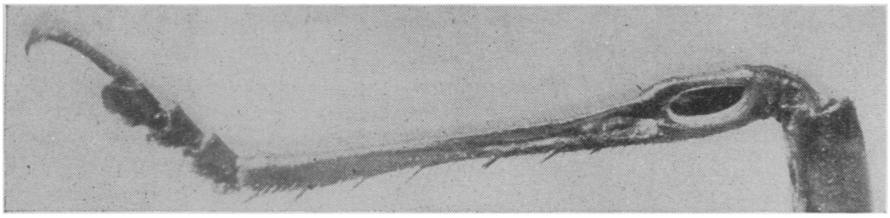

THE KATYDID'S EAR, located on his front leg, just below the knee joint

limbs of one lot and removed their cage from the vicinity of the other lot. The results were essentially the same as with the preceding experiment. When only two of the mutilated males were singing at once the effect was that of being synchronous at regular intervals separated by periods during which the notes sounded alternately. This effect is produced by any two sets of rhythmically repeated sounds having a slightly different frequency. Each cricket sang at its own individual rate uninfluenced by the song of others in the same cage. When three or more mutilated males were singing at once an utter confusion of notes resulted, so that the rhythmical quality of their song was entirely obscured.

"The song of the normal tree crickets in the other cage presented a striking contrast. Each individual sounded its notes in unison with others, as if a single cricket were singing."

The third insect used in the series, a grasshopper of the plains known as the Nebraska conehead, proved to be the most remarkable synchronist of all.

"Their song," said the entomologist, "consists of rasping buzzing notes, each lasting a little over a second and separated by about equal intervals of silence. The length of the notes and their low frequency makes this species an easy one to study.

"At a temperature of 76 degrees Fahrenheit there were only 23 to 24 notes per minute. I have observed them in the field synchronizing their notes at a distance of 20 paces.

"I used only four males for my experiments this time. It is rather difficult to select Nebraska coneheads, for they sing only at night and each specimen has to be captured by careful stalking while it is singing. I placed my quarry of four in individual cages and separated them into two groups, which were kept out of hearing from each other. After testing all of them for synchronism, which proved to be perfect, the front legs were removed from two of them.

"On the second evening after the 'operation' both coneheads were singing with conspicuous lack of coordination. For about a minute at a time the notes of the two would sound alternately, then gradually one song would catch up to the other, so that for another similar period the notes would sound simultaneously.

"At the same time the normal coneheads were keeping up perfect synchronism. Sometimes one note could be observed to start a fraction of a second ahead of the other, but never once did I hear them entirely separated."

Such a simultaneous sounding of notes as the uninjured insects produced can hardly be a matter of accident, Dr. Fulton declared, and appears to be conclusive evidence that they can hear each other.

The structure in the tympanum on the leg, believed to be actually responsible for hearing, resemble exceedingly minute pegs. Each one is hollow and filled with a watery liquid and has an axis-fiber or nerve-fiber running through it. The end of the fiber nearest the body connects with the insect's central nervous system.

The structures in the tympanum led early investigators to believe that they were hearing organs, though actual demonstration has been lacking until now. Structures containing auditory pegs have been found in a number of other insects, for instance, in the basal segment of the antenna or "feeler" of the male mosquito. It was even shown as far back as 1874 that the bristles that cover the outer segments of the antenna could be made to vibrate by certain musical notes, the shorter bristles near the tip vibrating at a higher pitch than the longer basal bristles. However, there was no way to tell whether the male mosquito perceived any sensation of sound, so even this evidence was circumstantial.

Another interesting fact about the music of the Orthoptera is that the pitch and also the frequency of notes vary directly with the temperature just as the speed of a chemical reaction does. Since the insects do not regulate their body temperature like the warm-blooded animals, their rate of metabolism is subject to the whims of the weather. With insects like the snowy tree cricket which sing a continuous rhymthical series of notes, this correlation is very evident.

When neighboring crickets are synchronizing, Dr. Fulton pointed out, they adjust their individual rates to meet the needs of the chorus, though this adjustment is possible only to the extent of a few notes per minute.

"I have found," he added, "that in the case of this cricket there is such a thing as a geographical variation in song. In general, the frequency of notes at the same temperature increases as one goes from east to west. I have had living crickets from Ohio, Arizona and Oregon caged side by side and it was interesting to hear them try to synchronize. Their natural rates of song were so different that they found it impossible to make sufficient adjustment. While the snowy tree cricket of Oregon sings at the most rapid rate of any I have observed, there is a distinct variety there which sings only about half as fast."

The katydids, however, constitute the real aristocracy among the singers of the six-legged world. In Europe the true katydid is unknown, his family being simply styled the long-horned grasshopper to distinguish them from their short-horned, heavy-bodied brethren.

Their musical instruments are located on the overlapping bases of the front wings. They are the special gift of the males, the females having to content themselves with the primitive wing structure common to the rest of the Orthoptera group. The fore part of the right wing of the favored sex consists of a thin crisp membrane with a stiff ridge on the basal angle. On the left wing one of the veins is thickened into a close series of ridges on the under side which convert it into a veritable file. The wings of katydids are always folded with the left overlapping the right in such a position that the file of the former lies above the ridge of the latter. When the wings are moved sideways, the file grates on the ridge or scraper, causing a rasping sound, and this is the way the katydid produces its famous song. The tone and the volume are probably due largely, however, to the thin membranes in the base of the wings.

The instruments of the different families of songsters vary somewhat in the details, but in general the notes produced by the (*Turn to next page*)

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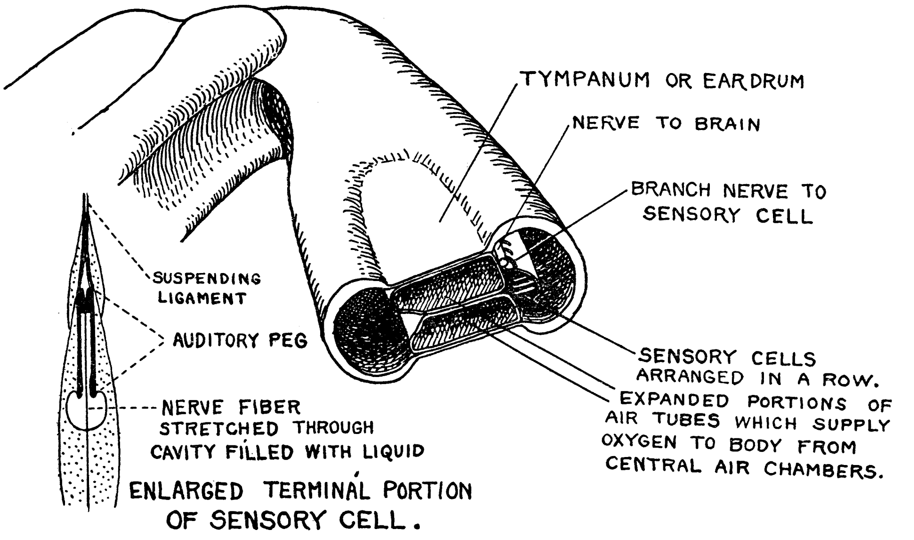

DIAGRAM OF THE HEARING APPARATUS in the foremost pair of legs in the singing insects

different owners have a range out of all proportion to the variations in the musical apparatus. The stridulating instruments are not developed until maturity when the performer starts in to play his inherited tune without any preliminaries. As one entomologist has remarked: "He never disturbs the neighbors with doleful notes by practicing."

The member of the numerous katydid clan known far and wide to the American public as the greatest of insect singers, is called by scientists by the mellifluous name of *Pteropyhlla camellifolia.* Whether he is a great musician or not depends on the personal taste of the critic, but of his fame there is no question. Certainly, nothing could be plainer than his vociferous "Katydid" with its endless repetitions and variations, "Katy," "Katy didn't," "Katy she did."

Though the audience of the katydid has a wide range, few claim the privilege of personal acquaintance, from the fact that he has selected for his stage the tallest treetops and seldom descends from his chosen orchestra circle. Country-raised boys and girls and hard-hunting field entomologists know him, but not many more. In color he is plain green with a dark brown triangle on the back covering the stridulating area of the wings. His body is fully one and three-quarters inches long, while his long hair-like antennæ measure well over two and a half inches. The rear edges of the leaf-green wings are evenly rounded with their sides plumped out as if to cover a corpulent rotund body. This is a false alarm, however, for the space between them is mostly empty and probably forms a resonance chamber to give tone and volume to his musical performances. He has a row of prominent waistcoat buttons down his front, or rather his underneath, that rhythmically heave and sink with each breath.

Another insect singer much in the public eye is the black field cricket, a friendly soul of garden and dooryard, not averse to taking refuge in the house itself on cool autumn evenings. His European cousin is the famous cricket on the hearth of Dickens' story. The ancient Greeks and Romans called him Gryllus, a name which he bears to this day. His musical organs are much like the katydid's but, unlike the latter, he has them equally developed on each wing. So that he can apparently play with either wing uppermost, though in actual practice most crickets consistently wear the right wing uppermost, just the reverse of the katydid custom.

The snowy tree cricket that played a prominent role in Dr. Fulton's concert is really green, but of such a pale shade that he looks white at night. In the great out-of-doors orchestra on warm summer nights, a careful listener may distinguish a short blast repeated a hundred or more times a minute. This strenuous performance is produced by this pale little ghost of an insect no more than half an inch long. The singer raises his wings vertically above the back and vibrates them sideways so rapidly that they are momentarily blurred with each note. He repeats regularly and monotonously all night long. When he first begins singing in July there are about 125 beats per minute, but later on hot nights the rate will go as high as 200. As fall comes on it decreases to around 100 and finally as the nights grow cold, the notes end in hoarse bleats repeated slowly and tremulously, though still rhythmically, as if the singer were numb with cold or pain. With the coming of the first frosts they die away altogether.

Science News-Letter, August 18, 1928

Birthplace of Icebergs

Geography

The birthplace of the icebergs that menace the transatlantic steamers has been located by the oceanographic expedition of the U. S. Coast Guard on board the steamship Marion.

The ship is now well above the Arctic Circle and has just proceeded across Diske Bay between hundreds of towering ice islands.

"We are now viewing the birthplace of the icebergs of the North Atlantic, the entrance of Jacobshavn Fjord, which is literally jammed with thousands of bergs so close that we cannot penetrate with the vessel," Commander Edward H. Smith, in command, explained in his report to Science Service.

The Marion on its voyage northward in Davis Strait between Labrador and Baffin Land on the west and Greenland on the east, has noted the number of icebergs. The scientists aboard have also charted the ocean currents that bring the icebergs southward to endanger the steamship tracks. The contour of the sea floor that sometimes allows the great ice masses to ground and be delayed in their southward journey is also being investigated.

Commander Smith will shortly head a landing party that will investigate the Greenland ice cap at this point. The rate of movement of the glaciers that drop the icebergs into the sea will be measured. New knowledge of the rate at which icebergs are born of the ice cap is expected as a result of these studies.

Amateur radio station 2WI, operated by William A. McClintock at Westfield, N. J., cooperated with the Marion expedition and Science Service in establishing radio contact with the Marion's radio station, NITB.

Science News-Letter, August 18, 1928

A bronze lock found on a tomb near Jerusalem and dating back to the early Christian era is pronounced a safety device of an elaborate type not known in modern Europe before the end of the eighteenth century.