RHYTHM, SYNCHRONISM, AND ALTERNATION IN THE STRIDULATION OF ORTHOPTERA[1]

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Love of rhythm is not solely a human trait for it is also inherent in many species of insects. Since it is unscientific to ascribe an emotional desire to a lowly insect we can say that they are endowed with an innate mechanism causing them to perform certain activities, such as stridulation, in a rhythmical manner.

The songs of katydids and crickets are produced by movement of the tegmina or first pair of wings. This movement is often a rapid vibration like the wing movement during flight, but I am referring here only to the more evident rhythm produced by interrupting or retarding such movement at regular intervals or by single stroke chirps at much slower cadence. The degree of rhythm exhibited by different species varies from those producing notes of irregular length and frequency to those in which uniform notes are repeated with a cadence that does not change perceptibly except as modified by temperature or other external factors. Of the species of Orthoptera whose songs are known, less than half are distinctly rhythmical. In North Carolina there are 11 out of 38 Tettigoniidae or katydids and 16 out of 36 Gryllidae or crickets whose songs exhibit a considerable degree of rhythm. Only a few of these species have a rhythm that can be called constant.

SYNCHRONISM

Several species display a greater talent for rhythm by the apparently useless trait of synchronizing their notes when several individuals are singing within hearing distance of each other. It has been claimed by some that this is only an auditory illusion. That such is not the case can be easily demonstrated by comparing the group song of a synchronizing species with a chorus of mole crickets, which have a constant rhythm but do not synchronize. A more convincing test can be made by removing the auditory organs from several males of a synchronizing species and observing the effect on their song.

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In the United States there are six species of Orthoptera known to synchronize their songs. The most famous of all is the snowy tree cricket, *Oecanthus niveus* (De Geer). It is often abundant in vines and trees about dwellings where its rhythmical mellow notes have been heard and appreciated by many people who never learned the source of the music. Dolbear's (1) publication in 1897 was the first to point out that these cricket's chirp in unison although it is the feature of the song largely responsible for its distinctive quality. The species is known to occur in this state only in the mountain regions where I have heard it singing at several localities from Burnsville to Boone.

Allard (2) first published on the synchronized singing of *Cyrtoxipha gundlachi columbiana* Caudell and *Neoconocephalus exiliscanorus* (Davis). The former is a small pale yellowish green cricket known from specimen records in the state only from Wake and Granville counties. It inhabits forest trees and according to my own experience never within reach of the ground, a fact which explains the scarcity of specimens. I have heard it singing frequently in and near Raleigh and for about 40 miles east and southwest. It sings with brief high pitched chirps about 3 to 4 per second depending on the temperature. It is impossible to even estimate how many of these crickets are singing in a tree for they all sing as one.

During the past two summers I have also listened to the song of *Neoconocephalus exiliscanorus*, which is in some ways the most remarkable of all the insects with synchronized music. All such species except this and one other sing for prolonged periods. With this species each individual repeats a short series of notes at irregular intervals but where several are singing together the chorus is continuous. Rehn and Hebard (3) described the song as "a vibrant rattling note rising and falling in intensity often ceasing as if from exhaustion." This variation in intensity however is not a feature of the individual song but is due to changes in the number of singers operating. The speed is between two and three notes per second.

The song differs also from all other synchronized insect songs that I have heard, in that the speed of the rhythm is perceptibly retarded or accelerated at frequent intervals. In spite of this the individual players come in accurately on the beat for from 3 to 10 notes and drop out again like pieces in a symphony orchestra. Sometimes they sing for longer periods but again one may sound a single note or sound notes on alternate beats for a few times. I have found the species near Raleigh only in moist or swampy woods among canes and shrubs.

Another insect that I can add to the list of synchronous singers is *Neoconocephalus caudellianus* (Davis). Its notes are louder, longer, and less vibrant than the last species. When close, the sound is an ear-splitting buzz. This species stridulates for long periods with unchanging rhythm. On one evening I counted 14 notes in 10 seconds. The species has not been previously reported from the state but has been taken in other states from New Jersey to Alabama. It was found near Raleigh in a marsh and in the surrounding area. At night they sit near the top of weeds or clumps of tall grass and synchronize with their neighbors within a range of at least thirty yards.

Two other species with synchronous songs have not been found in North Carolina. *Neoconocephalus nebrascensis* Bruner has a song similar to the last species but with slower rhythm and not so loud. *Amblycorypha rotundifolia brachyptera* Ball sings in series like *Neoconocephalus exiliscanorus*. The songs of both species have been described in an earlier publication by the writer (4).

ALTERNATION

For the past three summers I have made observations on the songs of certain species of Tettigoniidae, that exhibit another peculiar and equally useless trait. Instead of synchronizing their notes they attempt to keep up a continuous noise by sounding their notes between those of a neighboring singer. For want of a better term I am calling this "alternation."

My first experience with this type of singing was with caged single males of two species of *Orchelimum* from the southern part of the state. One species was *O. militare* Rehn and Hebard, which has long fluttering notes delivered with great irregularity and the other was *O. bradleyi* R. and H., which sings with buzzing notes at a rather regular rate, about one per second. It was evident from the start that *O. bradleyi* refused to sing while *O. militare* was singing. Sometimes *bradleyi* could work in two or three notes between the notes of the other species, but when the latter was singing more rapidly there was an alternation of single notes. *Orchelimum militare* would start a note while *bradleyi* was singing but the latter was always a perfect gentleman and would wait until the other had ceased.

Last summer I brought in from Lakeview several males of both species and kept them for observation. When two males of *O. bradleyi* were placed in a separate room they sang with alternating notes most of the time. When two notes happened to sound together, one of the singers

would pause for a beat and correct the mistake. With more than two singing together, more notes were sounded simultaneously and their coöperative singing was less evident. Alternation is apparently a two-handed game played by neighboring males.

With *O. militare*, two specimens singing together seemed to alternate their notes most of the time, but each would start a new note before the other had finished, keeping up a continuous sound for long intervals by overlapping the notes. It was impossible to tell whether this was accidental or not, for the song does not maintain a very uniform rhythm. One specimen had a tendency to prolong its notes sometimes for 15 to 20 seconds and evidently made no attempt to coöperate with the others. Usually the notes are from 1 to 4 seconds in length with a fairly uniform delivery at any one time but subject to change even under uniform external conditions and apparently according to the mood of the singer.

When listening to the raucous call of the true katydid, *Pterophylla camellifolia* (Fabr.), it seemed to me that the notes sounded simultaneously less often than would be expected under the law of chance. With so many katydids about, it was impossible to be sure of this so I collected two specimens and caged them separately a few paces apart in a place where there were no other katydids. When so isolated it was evident that the song of either one influenced the song of the other. There was a deliberate alternation of notes but it was not as simple as I had expected. At irregular intervals one of the katydids would sing out of turn and both would sound the note in unison or the other katydid would remain silent until the next beat and they would continue to alternate as before. Sometimes this shift would take place several times without any notes being sounded in unison. Again there would be from 1 to 5 simultaneous notes before one singer would pause and bring about alternate singing again. The notes were either clearly separated or exactly in unison as well as I could detect by ear. It was not a case of interference from two rhythmical sounds of slightly different frequency.

By counting the notes of one individual when sounded alone and when in unison with the other, several records were taken of which the following is a sample.

Alone	5	10	3	4	3	3	5	Total 33
In unison	1	1	2	1	3	2	1	Total 11

Other series counted gave the following totals.

Alone	78	322	138
In unison	36	47	33

The largest number of consecutive notes sounded in unison was 5. The largest number of consecutive notes sounded by one individual alone, while alternating, was 38.

At a temperature of 68°F. the katydid duet kept up a fairly regular rate close to 14 notes in 20 seconds, or 7 notes by each katydid. When either one was silenced by shaking the cage the other would continue at a rate of only 10 notes in 20 seconds, but three notes more for the period than it would have sung if accompanied by the other katydid. At 80°F. the rate for the duet was 22 to 24 notes in 20 seconds and the individual rate 14 to 16 notes per 20 seconds. As nearly as I could estimate the rest period between notes was about the length of the note itself when two were singing and about twice as long when one was singing. The length of the note seemed to be the same in either case.

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