administration of the drug. In both cases, as shown by the time course of the central action of the drug, a significant and variable alteration of cortical function has probably taken place.

Unrecognized central actions of gallamine may be responsible for inconsistent or conflicting results from different laboratories. The significance of gallamine-induced alteration of central function is illustrated by a controversy concerning the reproducibility of duration of afterdischarge. Rosenbleuth and Cannon (*4*) and others (*5*) stated that if intensity, frequency, and duration of electrical stimuli to cortex were constant, constant durations of cortical afterdischarge were obtained. Other workers found variability even with constant stimulating parameters (*6*, *7*). To investigate the sources of this variability, Straw and Mitchell (*7*) considered species difference, region of cortex stimulated, intertrial interval, and presence of anesthesia. Many workers have not considered the use of gallamine as a possible variable in their experimental design. Using "chronically" implanted electrodes, we demonstrated the effect of this variable.

The action of gallamine in prolonging the duration of afterdischarge from both neurologically isolated and intact cortex is evidence for its direct central action. Peripheral action was probably not responsible for the central effect, in view of the fact that no change in any of the physiological parameters monitored could be related to the prolonged durations of afterdischarge observed with the use of gallamine. A slight to moderate tachycardia with no remarkable changes in aortic pressure was present (*8*) prior to the central effect but had disappeared while the central effect was still present. The acute cardiovascular changes with rapid administration of gallamine were avoided by slow administration of the compound over a 2-minute period. No central effects were noted during or immediately after administration of the drug. Changes in durations of afterdischarge did not become apparent until 10 to 15 minutes later. The effect increases to a maximum in ½ to 1 hour and may outlast recovery from paralysis by an hour.

Reproducibility of the effect in a single animal shows that the central action is reversible to a large degree and is related to the time of drug administration. Repeated heavy doses of gallamine (12.5 mg/kg) intravenously administered to another animal resulted in an afterdischarge which developed into a generalized electrographic seizure lasting 6 minutes. Thus, the central action of gallamine may be cumulative, as it is peripherally (*8*), producing instability of central mechanisms.

The fact that gallamine does have a direct central effect must now be taken into consideration in the interpretation of data from experiments with this agent. In addition, the use of this agent in humans predisposed to convulsive disorders should be reevaluated.

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Ant Stridulations and Their Synchronization with Abdominal Movement

Abstract. *Two techniques for accurately correlating movements with vibrations produced by* Pogonomyrmex occidentalis *show three characteristics of the stridulations: alternation of mean chirp intensity, higher frequencies during the upstroke, and interruption of chirps into distinct pulses. These pulses are produced by briefly stopping the gaster during a chirp.*

Ants of the subfamily Myrmicinae stridulate by raising and lowering the gaster (posterior part of the abdomen) causing a series of ridges on the medial dorsal area of the gaster to rub against a scraper near the border of the preceding segment (postpetiole). Ants are much more sensitive to substrate vibrations than to aerial vibrations; and any transfer of vibrations from a stridulating ant to a receiving ant is almost certainly done by passing the "message" through a substrate (*1*). The only demonstrated function of the vibrations is that they attract other workers to the stridulating ant which, under experimental conditions, has always been trapped (*2*). Under natural conditions, ants must often be trapped by cave-ins and predators.

In that analysis of sound spectrograms showed that there are distinct differences in intensity and construction between the stridulation (or chirp) pro-

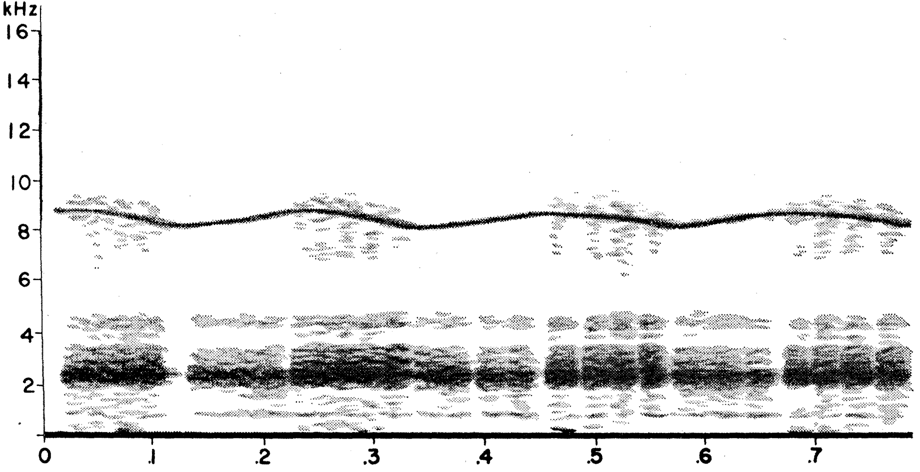

Fig. 1. Sound spectrogram of worker ant. Downward movement of upper line indicates upward movement of gaster. Abscissa, time in seconds; ordinate, frequency.

duced when the gaster of the ant moves upward and when it moves downward; a method was needed to identify the chirp produced by each movement (*3*). The rate of movement, about 100 msec per chirp or 200 msec per complete cycle, made it impossible to identify accurately by eye which movement produced the more intense vibration. I now report techniques that make it possible to correlate the direction and uniformity of movement of the ant's gaster with fluctuations in frequency and intensity occurring during chirps.

The western harvester ant, *Pogonomyrmex occidentalis* (Cresson), is 5 to 8 mm long; it stridulates readily whenever grasped and held and occasionally while moving freely in colonies. The sound pressure between 20 hz and 20 khz was less than the background noise (25 to 26 db) measured by holding a stridulating worker with forceps 1 cm from the microphone in a sound-resistant room (reference: 0.0002 μbar = 0 db) (*4*). The intensity was much lower than the 80 db for *Atta cephalotes* reported by Markl who used the same reference, but his figure included ultrasonic vibrations between 20 and 60 khz (*2*).

Because of the low level of aerial sound and the evidence for transmission through substrates, transducers contacting the stridulating ant were used (*5*). The vibrations with the greatest energy appeared between 1 and 4 khz, and varied with the size of ant, the attaching arrangement, and the transducer. A change in any of these three variables changes the resonance frequency of the system. Under natural conditions ants must be subject to similar variations. Although certain arrangements of the apparatus gave a frequency response potential to 50 khz, no vibration energy was detected above about 15 khz. Since higher frequencies disintegrate much more rapidly than lower frequencies (*6*), the relatively low frequencies produced by this ant can be transmitted greater distances with less energy and may compensate for the low intensity.

A 0.5-mm beam of light and a Clairex 505L cadmium sulfide (CdS) photoconductive cell were used to control a signal of one varying frequency that correlated stridulation vibrations with gaster movement on sound spectrograms (*5*). I constructed an audio signal generator producing a single, constant frequency. Frequency of the unit was controlled by the resistance capacitance (*RC*) time constant of a potentiometer and a fixed capacitor. A subminiature closed-circuit phone jack, insulated from the chassis, was connected in series with the frequency-controlling potentiometer. When the photoconductive cell was plugged into the jack, its resistance was added to that of the potentiometer. Any fluctuations in shadow that was cast by the ant gaster changed *R* in the *RC* circuit, with consequent change in the frequency of the signal. An increase in light decreased the resistance of the photocell and caused a corresponding increase in the frequency produced. The frequency was set above the principal frequencies produced by the stridulating ant by connecting a proper value capacitor and adjusting the potentiometer.

A piece of stiff plastic, 30 by 7 by 0.5 mm, was slotted at both ends. The thorax of a worker ant was inserted in one slot, and a "Pixie" transducer was inserted in the other end (*5*). The ant was positioned so that when it stridulated, the dorsal surface of its gaster moved up, partially intersecting the beam of light, and cast a shadow on the photocell. The light source was held by a micromanipulator to facilitate fine adjustment. The transducer output was connected to the microphone input of the tape recorder, and the output from the signal generator was connected to the recorder's 10-mv sensitivity input. That arrangement permitted each input signal to be quantitatively controlled separately by the two recorder controls.

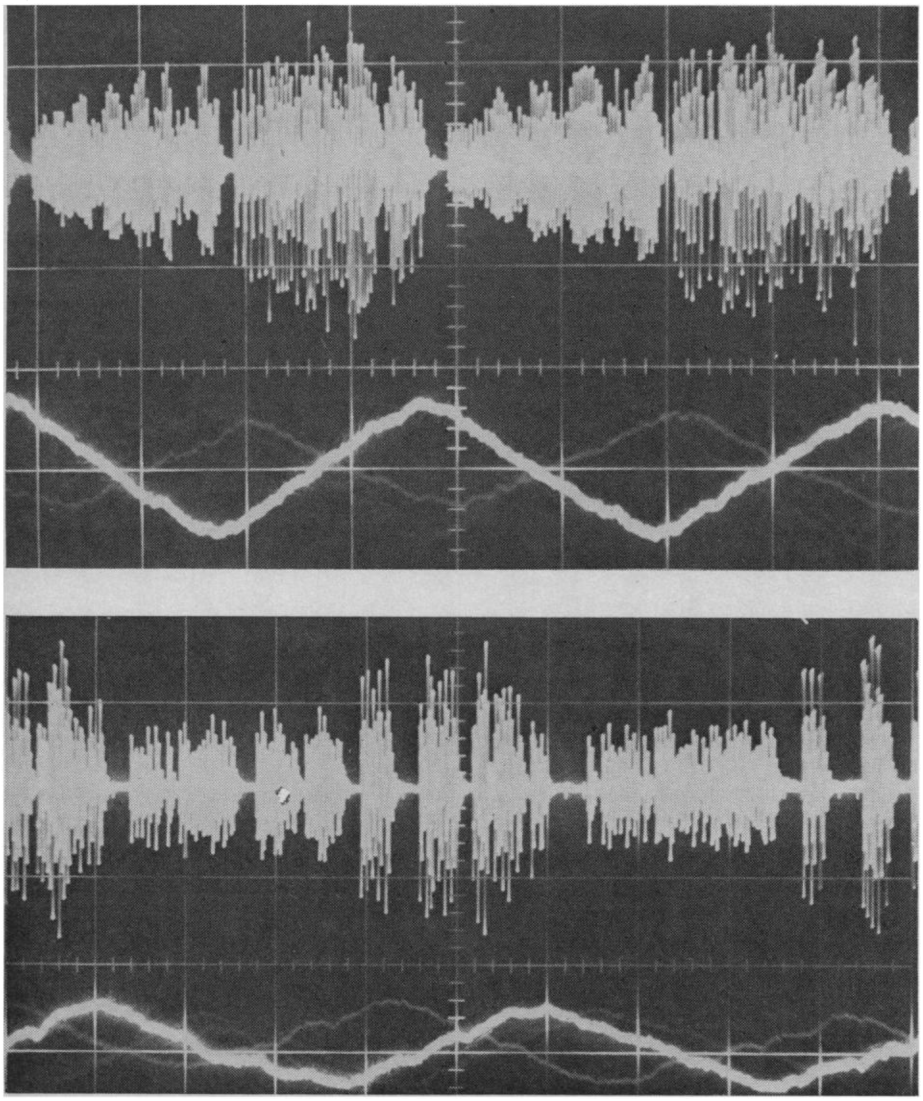

Fig. 2. Ant stridulation on upper beams. Upward movement of lower beams indicates upward movement of gaster. (Top) Chirps not interrupted. (Bottom) Chirps interrupted by gaster stopping. Sweep speed of each above 50 msec/cm.

A sound spectrogram, time-scaled to one-half recorded speed, doubled the frequency range and divided the time axis (Fig. 1). The downward direction of the upper line corresponds to the upward movement of the gaster; an upward direction corresponds to a downward movement of the gaster. Interruption or subdivision of chirps is clearly shown. The interruptions occurred somewhat more frequently and clearly on the upstroke than on the downstroke.

The sound spectrogram shows that the vibrations of greater intensity (indicated by the pattern darkness) occurred on the upstroke of the gaster. The sound spectrogram also shows the frequencies of the vibrations, and it reveals higher frequencies on the upward stroke. There was a slight lag between the movement of the gaster and the response of the photocell. This is not a serious drawback as the line of the sound spectrogram indicating a single frequency is broad, so precise measurements are not possible.

Another light-sensitive device was used with a dual-beam oscilloscope to provide a more instantaneous response (*5*). By connecting the positive terminal of the solar cell (International Rectifier S1M) to the base of a PNP transistor (GE 2N1144), an increase in light increased resistance from collector to emitter. A 50-kilo-ohm potentiometer controlled the collector-to-base bias, and thus the operating point. The result was a much faster rise-and-fall time than the CdS cell had, and the action reversed. Increased light intensity increased resistance.

The collector-to-emitter resistance was set at 1500 ohm by adjusting the collector-to-base bias potentiometer in total darkness. A Heath VOM (volt-ohm-milliammeter) Model EUW-26 was used for the measurement, and it was left connected to serve as a power supply and series resistance. The collector was connected to the negative terminal of the VOM and to the oscilloscope input. The emitter was connected to the positive VOM terminal and to the oscilloscope ground. The oscilloscope was set at a-c mode, since that setting provided adequate frequency response and eliminated the need for another power supply to provide a bucking voltage.

With the device operating, I attached a worker ant by a slotted plastic strip to a magnetic transducer (*5*) attached directly to a low-noise transistor preamplifier, so that the 0.5-mm beam of light passed across the dorsal surface of the ant's gaster and struck the solar cell. That magnetic transducer-preamplifier combination had an RCA 2N220 transistor to provide about 200 to 500 mv of signal output from a stridulating worker to connect to the upper beam of the oscilloscope, thus reducing the pickup of a-c hum to a minimum. On the oscilloscope screen, any movement of the abdomen was simultaneously shown with the stridulation produced, and the deflection of the lower beam was positively correlated with the up-and-down movements of the gaster. When a chirp was interrupted (Fig. 2), the lower beam showed that the movement of the gaster was not smooth at these points, but actually stopped for the intervals indicated by horizontal movement of the lower beam. Sometimes, on upstrokes the lower beam not only stopped traveling upward but moved slightly downward.

It is evident that vibrations produced by a stridulating ant have several previously unreported features. First, the alternation of high- and low-intensity chirps corresponds to the up-and-down motions of the gaster. Although the ratio between them was only about 3 db—a small difference to the human ear—such a change in intensity might be significant to the vibration receptors of an ant. Second, the high-intensity chirps also include higher frequencies as shown on sound spectrograms; but it is not known whether they are within the range of frequencies detected by the ants. Third, each chirp may be subdivided into pulses, and pauses between the pulses frequently are as great as those between chirps. The staccato reiteration has a pulse repetition rate about four times the rate of 8 to 10 chirps per second or 32 to 40 pulses per second. Since the stridulating ant can control the separation of pulses by the moving of its gaster, it may thus produce stridulations for different messages or functions. The pulse frequency of about 40 per second should be transmitted much farther in soil than the higher frequencies of 1 to 4 khz are, and thus may be detected by the ants more easily than noninterrupted chirps are (*7*).

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Brain Lesions in Birds: Effects on Discrimination Acquisition and Reversal

Abstract. *Bobwhite quail* (Colinus virginianus) *with lesions of the cortex and the dorsal portion of the hyperstriatum (or "wulst") showed a considerable deficit in ability to reverse a learned discrimination between horizontal and vertical stripes. Two birds that had been run on 25 such reversals before ablation showed the same result. Lesioned birds did not, however, differ from controls in the original acquisition of the discrimination. Analysis of performance indicated that the reversal deficit was not due to difficulties in discrimination, interference with motor ability, or lack of motivation. The deficit appeared to be based on perseveration of response to the previous positive stimulus during reversal training.*

No function has as yet been established for the area classified as "cortex" in birds. Rogers (*1*), for example, found that no voluntary motor responses could be elicited by electrical stimulation anywhere in the cortex of the pigeon, nor did he observe differences in general behavior after their cortexes were completely extirpated. Tuge and Shima (*2*) found that cortical ablations had no effect on the establishment of defensive conditioned reflexes in pig-