References and Notes

1. This work was supported by contract No. 14-19-008-2475 with the Pacific Oceanic Fishery Investigations (POFI), U.S. Fish and Wildlife Service. We wish to express our appreciation to A. L. Tester and other members of the staff of POFI, and to F. Jermann of Hawaiian Tuna Packers, for aid in this work.
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3. E. H. Winslow and H. A. Liebhafsky, *ibid.* 21, 1338 (1949).

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Reactions of Honey Bees in the Hive to Simple Sounds

Beekeepers have known since before Aristotle (*1*) that honey bees (*Apis mellifera*) produce characteristic sounds while engaged in certain activities. The possible significance of these sounds for the bees has been a matter of debate (*2, 3*). Indeed, honey bees seem to be insensitive to air-borne sounds, although they are able to receive vibrations through the legs (*3, 4*). Hansson (*3*) has reported that bees in hives stopped normal activities when they were subjected to pure tones at frequencies of 100 to 1500 cy/sec at rather high intensities (audible at distances up to 250 m). The insects stopped moving when the sounds were turned on, but, if the sounds continued, began to move slowly within a few seconds.

Table 1. Effects of sounds on honey bees in an observation hive: 0, no observable effects; +, bees move more slowly; ++, the majority of the bees stop but some still move slowly; +++, almost all bees stop and remain motionless as long as the sound is on. The sound pressure for frequencies with +++ effect are minima needed to induce the effect; other sound pressures are the highest obtainable with the equipment.

Frequency (cy/sec)	Sound pressure (db)	Effect
50	106	0
80	115	0
100	120	+
150	125	++
200	122	++
300	119	+++
400	118	+++
500	116	+++
600	107	+++
800	108	+++
1000	113	+++
1500	124	++
2000	128	+
3000	127	0
4000	117	0
6000	112	0
8000	113	0
10000	102	0

We have confirmed and extended these observations by finding that continuous irradiation of hives with sounds of certain frequencies and of sufficient intensities caused an almost total cessation of movement of workers and drones in the hives for up to 20 minutes (*5*). The quiescence of the bees was so complete that a beekeeper could safely open the hive and carry out routine servicing without the usual treatment with smoke.

Sounds of known frequencies were produced by an audio oscillator that activated through an amplifier either a loudspeaker (for frequencies below 400 cy/sec) or a microphone (for higher frequencies) (*6*). The behavior of the honey bees, all of the Italian race, was observed in an ordinary glass-sided observation hive. The speakers were usually placed about 0.5 to 1 m from the hive, but tests were also made with the speakers in contact with the hive. The results are given in Table 1.

With sounds of sufficient intensity at frequencies of 300 to 1000 cy/sec, the bees stopped moving almost entirely as long as the sounds continued. The most effective frequencies were between 500 and 800 cy/sec. Below 300 and above 1000 cy/sec, the bees either showed reduced activity or were not affected, even with intensities higher than those that sufficed at the proper frequencies. The bees returned almost immediately to normal activities when the sound was discontinued. There were no observable reactions to these sounds by bees at the entrance to the hive or by workers in the field. These observations support the idea that the sounds are received by the bees through the legs after the hive was caused to vibrate by absorption of the air-borne sound. The most effective frequencies in this case, however, were not those found by Autrum and Schneider (*4*) to be most effective in stimulating the subgenual organs in the legs of the honey bee.

The results are like those of Hansson (*3*), except that cessation of activity at the intensities we used was almost complete and persisted as long as the sound continued. It is impossible to determine from Hansson's report the actual intensities he used, but they were probably lower than those we used.

Bees in standard beehives were tested with similar results. With the sounds on, the covers and supers of the hives were removed and the frames lifted out. The bees on the frames remained still as long as sounds of the proper frequencies and intensities continued. It was possible, therefore, to work in hives using only sound. This was done for about 2 months with three hives, using sound at a frequency of 600 cy/sec at about 120 db, which was projected from a speaker alongside the hive. There was no sign of habituation of bees to this sound.

Certainly the equipment used to produce these sounds is much more expensive than that needed for smoking hives. It is possible, however, that inexpensive vibrators attached to hives could be used. The high intensities of these sounds make some form of ear protection necessary, but free use of both hands in working in the hive is possible and there is no need for ventilation of the hive by the bees, as there is with smoke. Sound may thus, under special circumstances, have some use in apiculture.

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References and Notes

1. Aristotle, *Historia animalium,* Book IX, chapt. 40 (625 b 8; 627 a 15; 627 a 23).
2. C. G. Butler [*The World of the Honeybee* (Collins, London, 1954)] and C. R. Ribbands [*The Behavior and Social Life of Honeybees* (Bee Research Assoc., London, 1953)] offer brief reviews. Hansson (*3*) lists and discusses many of the papers on the subject.
3. Å. Hansson, *Opuscula Entomol.* Suppl. 6 (1945); *Nord. Bitidskr.* 3, 68 (1951).
4. H. Autrum and W. Schneider, *Z. vergleich. Physiol.* 31, 77 (1948).
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6. Hewlett-Packard audio oscillator model 200-A; Stromberg-Carlson amplifier model AU42; University loud speaker model PA-30; Altec microphone model 633A. Sound pressures in decibels re 10^{-16} watt/cm^2 were measured at 1 m from the speakers with a calibrated Scott sound-level meter type 410-B.

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