# ANALYSIS OF ACOUSTIC PATTERNS IN HONEY BEES- AN INVESTIGATION

*Bijoyaa Mohapatra, **Nisha Sudhi, ***Liveem M. Tharakan, ****Sri Pallavi M., *****Anil Kumar & ******Yeshoda K.

**Abstract**

*'Communication' is believed to be the exchange of information between two partners. The broad field of animal communication encompasses most of the issues in ethology. Honey bee communication has been of special interest to ethologists. The purpose of this study is to determine the acoustic characteristics of the honey bees buzz in a species of Apis dorsata dorsata in natural and induced environmental conditions. The results revealed that change in the external conditions led to characteristic changes in the acoustic properties of the sounds produced by the honey bees. The mean fundamental frequency of bee buzz increased in the induced conditions compared to natural condition whereas amplitude variations were not consistent across conditions. These variations in communication patterns in honey bees across different conditions (pleasant or threatful situations) gives us good reason to call the communication pattern in honey bees as 'language'.*

***Key words: Ethology, honey bee, communication***

Every living being in this universe communicates as a quest for its survival. 'Communication' is believed to be the exchange of information between two partners. The Universal Communication Law as posited by Scudder (1980) rightly, states that, "All living entities, beings and creatures communicate", i.e. all the living bodies in this universe communicate through sounds or movements, reactions to physical changes, verbal language or gestures, breath, etc. Thus, 'communication' proves as a means of survival.

Communication as of is not restricted to human beings only. All the information exchange between any living organism-i.e. transmission of signals involving a sender and receiver-can be considered a form of communication. There is the broad field of animal communication, which encompasses most of the issues in ethology. 'Zoosemiotics', the study of animal communication, has played an important part in the development of ethology, sociobiology, and the study of animal cognition. Further, the 'biocommunication theory' investigates communicative processes within and among non-humans such as bacteria, animals, fungi and plants i.e. intraspecies or interspecies communication. These various kinds of animal communication are intended for agonistic interactions, territorial invading/ ownership, alarm calls and/ or for metacommunications. Ethologists and sociobiologists have discretely analyzed animal communication in terms of their automatic responses to stimuli, ignoring the fact whether the animals concerned, understand the meaning of the signals they emit and receive.

Honey bee communication has been of special interest to ethologists, in particular the apiologists.

A honeybee colony is a marvelously compact community of around 50,000 individuals, its members are highly social and cannot survive without constant Inter communication, and the more one looks into their methods of conversation, the more remarkable they are found to be. Unlike human voice production, the bee does not have any structures as vocal cords to produce sound. In fact, there have been various postulations regarding the origin of the production of

*Speech Language Pathologist (SLP), All India Institute of Speech and Hearing (AIISH), Manasagangothri, Mysore, email: mail_for_bijoyaa@yahoo.co.in, **Research Officer, AIISH, email: nisha.sudhi@rediffmail.com, ***SLP, AIISH, email: liveeem.tharakan@yahoo.co.in, ****Research Officer, AIISH, email: msripallavislp08@gmail.com, *****SLP&A, Meenakshi Speech & Hearing Clinic, Pvt. Ltd, Ludhiana, Punjab, email: anilkumar.1085@ gmail.com, ******Lecturer, Dept. of Speech Language Sciences, AIISH, Mysore, email: k_yeshoda@hotmail.com

sound in the honey bees. The fact that bees make sound by ejecting air through their spiracles is refuted by various experiments. The more pronounced possibility of the bee sound is the wing-vibration theory that is put forth which states that the vibration of the bees wings are responsible for the production and amplification. Both, sounds made by wing vibrations as well as the tail wagging, seem to be used to communicate distance and direction of feeding sites.

Bees communicate by performing dance patterns to direct their hivemates to a source of food. The dance pattern types performed by honey bees are the waggle dance and round dance. These vary based on the location (distance) of the food source, (Wenner, 1964). Further, it has been proved that they also transmit information by means of sound. The earliest work done on bee communication by Charles Butler (1609) has been registered in his book the "Feminine monarchy" where he describes two sound patterns produced by the bees. Huber (1972) named these sound patterns as the tooting (produced by the first/head queen bee) and the quacking (produced subsequently by the younger ones). Together these honeybee sounds are called as 'queen piping' (tooting and quacking) which are broadcast in the bee's nest as vibrations of the combs. The temporal patterns and a frequency spectrum of these signals reveal that these are more or less pure tones at low frequencies equal to 400 Hertz. (Michelsen, Kirchner & Lindauer, 1986). These were produced by rapid contractions of the thoracic muscles, and transmitted directly to the substratum of the honey bee. Thus, the foraging bee's communication to its fellows in the hive are made up of two elements: the dance patterns and the accompanying sounds.

An experiment by Wenner (1964) indicated a strong correlation between the rate of pulse production and the strength of the sugar concentration in a food source. It may turn out that the foraging bee's entire message is carried by the sound signals. Broadbent (1962) in his article on "Attention and Perception of Speech" have compared the bee sound with that of human speech in terms of the varying emphasis and overlay of overtones in the sound produced by both. Nieh (1993) has even opined that human like stop sounds are also emitted by the tremble dances of honeybee which again forms a part of their communication system.

The review article by Kirchner (1993) traced the research works of different authors in the field of honey bee communication between 1774-1993. His work gives an account of communication patterns in honey bees, specifically among the members of the colony. It also explains the significance of sound signals in dance communication.

Various studies on bee buzz have revealed the fact that a bee's buzz is not simply a noise rather it constitutes of modulations and variations. And the pattern varies based on the environmental conditions- when attacked by intruder, near a source of food, exposure to intoxicating fumes, inside the hive etc. When an individual bee is aroused to attack, its buzz rises in pitch and fluctuates in intensity. Even the sound produced by different species of bees has been noted to be different in its frequency and intensity. As well, the acoustic patterns of a queen honey bee will differ from that of younger bees or from that of a virgin queen bee (Wenner, 1964).

These very interesting information and facts motivated us to study the acoustic characteristics of the honey bees buzz in a species of *Apis dorsata dorsata* in natural and induced environmental conditions.

**Aims of the study**

1. To analyse the acoustic parameters of sounds produced by honey bees (*Apis dorsata dorsata*) in different conditions.
2. To compare the recordings of acoustic parameters obtained across different conditions (natural and experimental/ induced).

## Method

**Species of bees included for the study**: *Apis dorsata dorsata*

The hive in one of the campus buildings which was closer to the lab in Speech Language Sciences department of the institute was chosen. The pictures of the hive with honey bees were sent to the Entomologist to ascertain the species of the bees.

***Site:*** The audio recording of the honey bees was made in a quiet condition close to the hive.

***Timings:*** Recordings were done twice in a single day. Trial 1: between 12 am to 12:30 am, Trial 2: between 4:30 am to 5 am.

**Procedure**

***Conditions***

**Condition 1:** Natural condition- swarm of bees hovering near a light source (tube light)

**Condition-2:-**Induced-environmental conditions-

(a) Swarm of bees when presented with concentrated sugar syrup.

(b) Swarm of bees disturbed when exposed to fumes from incense sticks.

***Audio Recordings**:* Instrument used: Sony mini IC recorder (Sony Corp, China) Model No. ICD-UX71F. The audio recordings were obtained in the following two conditions:-

***Condition 1:*** The audio recordings of the bee buzz were done when a group of about 100 honey bees were gathered around a tube light (natural condition). Three recordings of 5 minutes each were obtained.

***Condition 2a:*** *Food/* Concentrated sugar syrup was placed in a bowl at a distance of 2 meters from the swarm of bees. Three recordings of 5 minutes each was done after the bees settled. The microphone was positioned at a distance of 5cms from the swarm.

***Condition 2b:*** Incense sticks were lighted close to the swarm of bees settled on the bowl of sugar syrup. The buzz of the swarm was immediately recorded when the bees began moving away from the bowl.

**Data Analysis**

The recorded samples were transferred onto the computer memory. Cool edit pro version 2.0 software was used to convert the MP3 files to wave files for further analysis. Real Time Pitch analysis software of CSL Model 4500 was used for acoustic analysis. The recorded samples were line fed into the CSL module with a sampling rate of 44100 Hz (16 bit resolution). Eleven acoustic parameters were extracted and they were as follows:

*Pitch parameters*

1. Mean fundamental frequency (MF0-Hz)
2. Minimum Frequency (Min-Hz)
3. Maximum Frequency (Max-Hz)
4. Standard Deviation of F0 (S.D of F0)
5. Variation Fundamental frequency (vF0)
6. Relative Amplitude Perturbation (RAP)

*Energy Parameters*

1. Mean Amplitude (Mean dB)
2. Minimum Amplitude (Min dB)
3. Maximum Amplitude (Max dB)
4. Standard Deviation of Amplitude (S.D of Amplitude)
5. Shimmer (Shim %)

**Results and Discussion**

The acoustic data obtained from the honey bees across various conditions were analyzed and extracted using Real Time Pitch Analysis and CSL 4500. Table 1 gives results based on the conditions.

**1. Natural Condition**

The mean fundamental frequency in the natural condition when the swarm of bees started to hover around the light source was recorded to be 189 Hz with minimum and maximum varying from 125 to 334 Hz (SD of 92.69 Hz). The vF0 was found to be 0.41, and RAP 2.92. The mean energy of the buzz was 66.36 dB, with mean minimum and maximum mean varying from 62.95 to 70.77 (SD of 92.69 Hz). The mean shimmer value was 1.81dB.

**2. Induced Condition**

***2a) Concentrated sugar syrup condition***: The buzz of the swarm when near the concentrated syrup was found to be 268 Hz, range varying between 200 to 393 Hz (SD of 64.38). The vF0 and RAP were found to be 0.23 and 0.91 respectively. The mean energy of the buzz was 69.88 dB, with minimum and maximum mean varying from 66.89 to 72.30 (SD of 1.81 dB). The mean shimmer was 1.60dB.

***2b) Incense stick fumes condition***: In this condition, the mean F0 was 336.32, ranging from a minimum mean 302.05 to a maximum of 397.30Hz (SD of 37.14). vF0 was 0.11, RAP 4.41. The mean energy was found to be 63.32 dB. Minimum energy was 61.91 dB, with the maximum energy being 65.67 dB (SD of 1.20 dB). The mean shimmer value was 2.10 dB.

**Comparison across conditions**

***Natural Vs concentrated sugar syrup***

When conditions 1 & 2a were compared, it was

| Sl. No | Parameters | Natural condition - 1 | Induced condition (Concentrated sugar syrup -2a) | Induced condition (Incense stick fumes - 2b) |
|---|---|---|---|---|
| | *Pitch parame ers* | | | |
| 1. | Mean F0 | 189.02 | 268.90 | 336.32 |
| 2. | Min | 125.28 | 200.45 | 302.05 |
| 3. | Max | 334.09 | 393.75 | 397.30 |
| 4. | S.D of F0 | 92.69 | 64.38 | 37.14 |
| 5. | vF0 | 0.41 | 0.23 | 0.11 |
| 6. | RAP | 2.92 | 0.91 | 4.41 |
| | *Energy parameters* | | | |
| 1. | Mean | 66.36 | 69.88 | 63.32 |
| 2. | Min | 62.95 | 66.89 | 61.91 |
| 3. | Max | 70.77 | 72.30 | 65.67 |
| 4. | SD of Ampl | 2.19 | 1.81 | 1.20 |
| 5. | Shim % | 1.81 | 1.60 | 2.10 |

Table 1*:* Mean, Standard Deviation of the Frequency & Amplitude parameters for different conditions

observed that for the frequency parameters, there was an increase in mean F0, mean minimum and mean maximum F0, but SD of F0 reduced in the induced condition (2a) compared to natural condition. vF0 and RAP also decreased in induced condition (2a). Among the energy parameters, there was an increase of mean energy**,** mean minimum and mean maximum energy in 2a condition. However, the SD and shim% values reduced in 2a compared to natural condition. The characteristic 'hum' of a swarm of bees is of low frequency, estimated to be having a basic frequency of 250 Hz and is often associated with overtones (Kirchner, 1993; Wenner, 1964). But in the present study the Mean F0 was lower in natural condition, and then increased when food source was located.

The range of fundamental frequency was highest in the natural condition (209 Hz), followed by 2a (193 Hz) and 2b (95 Hz). Location of food resulted in an increase in the Mean F0 in 2a when compared to natural condition. Even in human voices, emotions like fear and anxiety may increase the habitual frequency of voice. The disturbance in honey bee has been manifested in the form of an increase in frequency and slight increase in loudness (from 66 to 69 dB), probably due to the enhanced wing vibrations by the bees. However, though these values are slightly more than the frequency produced in the natural condition, it is still comparable with the earlier estimations by Wenner (1964).

***Natural Vs Fumes from Incense sticks***

Mean F0, mean minimum and mean maximum F0, RAP was observed to be highest in 2b condition than natural condition. S.D of F0 and vF0 was however lesser in 2b condition. For energy parameters, mean energy, mean of minimum, maximum energy, SD was reduced in 2b condition. There was a subsequent increase in shimmer value in 2b condition compared to natural condition.

***Concentrated sugar syrup Vs Fumes of Incense stick***

In 2b condition, the mean F0, mean minimum and mean maximum F0, RAP was greater than 2a condition. SD of F0, and vF0 were lesser in 2b condition. There was a decrease in all energy parameters (mean, minimum, maximum intensity, SD), except shimmer which increased in 2b condition.

The present study revealed that, the buzz frequency of the honey bee increased maximally under conditions of threat, with variations in energy parameters. This observation is further strengthened by the findings of Wenner (1964) wherein the F0 of honey bees buzz varies depending on different environmental conditions (such as inside a hive, near a source of food, exposure to intoxicating fumes etc).

## Conclusion

The present study is a preliminary attempt in documenting the acoustic characteristics of bees buzz (in a species of *Apis dorsata dorsata*) in different environmental conditions, some of which were induced artificially. The study documents that change in the external conditions led to characteristic changes in the acoustic properties of the sounds produced by the honey bees. The mean fundamental frequency of bee buzz was highest in the induced condition 2b (fumes from incense sticks) followed by induced condition 2a (concentrated sugar syrup) and the natural condition (1). The relative amplitude perturbation also varied similarly. The above finding could be attributed to the very reason that animal behavior is likely to change depending on the environmental conditions. Reflecting while discussing in reference to the present context, it was noticed that when a bee was aroused to attack, or harmed, its buzz is likely to rise in pitch and fluctuate in energy unlike to that of a pleasant condition, where, the bee produces a comparatively lower pitch and intensity when a source of food is being introduced to it. These facts give us strong indication to call this communication system of the honeybee '*a language'.* The existence of a true language in honeybees in the form of a symbolic arbitrary one has also been proved by Gould & Gould (1988). Human communication is primarily verbal, whereas bee communication is acoustical in nature (at times chemical or pheromonal also). The use of verbal or acoustic mode for communication is immaterial of the fact that they are different, rather highlight on the importance of use of complex ways to ensure the exchange of information among organisms of the same group.Therefore, such a study is expected to throw some light in unraveling the mysteries of the communication patterns of these creatures. Further research would help understand various interesting facts regarding the complex yet fascinating communication system and strategies of such organisms in a variety of behavioral context.

## References

Broadbent, D. E. (1962). Attention and the perception of Speech *Scientific American*, 206: 143-51

Butler, C. (1609). *The feminine monarchie*. Joseph Barnes; Oxford.

Gould, J. L. & Gould, C. G. (1988). *The Honey Bee.* New York: Scientific American Library.

Huber, F. (1972). *Nouvelles observations sur les Abeiless*. Paschoud , Geneve

Kirchner, W. H. (1993). Acoustical communication in honeybee. *Apidologie,* 24, 297-307.

Michelsen, A., Kirchner, W. H. & Lindauer, M.(1986). Sound and vibrational signals in the dance language of the honeybees, *Apiis mellifera. Behavioral Ecology and Sociobiology*, 18, 207-212.

Nieh, J. C. (1993). The stop-signal of honey bees: reconsidering its message, *Behavioral Ecology and sociology,* 33, 51–56.

Scudder, S. F. (1980). Universal communication law. Website:http://ezinearticles.com/?communication-Theory & id=4762990.

Wenner, A. M. (1964). Sound communication in honey bees. *Scientific American,* 210, 116-124.

## Acknowledgement

We are heartily thankful to the Director of All India Institute of Speech and Hearing, Dr. Vijayalakshmi Basavaraj for allowing us to conduct the study. Our heartiest gratitude to Mr. Girish, Dept. of Horticulture, AIISH, for providing us with valuable information regarding the honey bees and sincere thanks to all who have directly or indirectly contributed to the successful completion of the study.