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WINGBEAT FREQUENCY OF *APIS DORSATA* IN EASTERN UTTAR PRADESH

Isaac L. Mathew, Deepak Singh*, Atin Dubey

Department of Zoology, St Andrew's College, Gorakhpur, Uttar Pradesh, India.

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***Corresponding Author**
Dr. Deepak Singh
Department of Zoology, St. Andrew's College, Gorakhpur, Uttar Pradesh, India- 273001.

ABSTRACT

Sound and vibrations has been found to be an important way of communication in honey bees other than the well studied chemical communication by pheromones. Wingbeat frequency reflects flight activity and efficiency in foraging and plays an important role in auditory communication of bees. The average wingbeat frequency of local *Apis dorsata* was estimated to be 131.56 ± 4.7 Hz with the frequency ranging from 118Hz to 142 Hz.

KEYWORDS: *Apis dorsata*, wingbeat frequency, aerodynamics, auditory communication.

INTRODUCTION

For bees, the wing sound has been found to serve as a very fine mode of communication with other bees. Through the buzzing of the wing bees shows their behaviour and their emotions depending upon the situation before them. Acoustical signals have been found to be used for communication among bees in a number of behavioral contexts (Kirchner, 1993). Pheromones, on the other hand, are known to serve as a mode of chemical communication to exchange information in many other situations (Free, 1987).

Information transmission in *Apis mellifera* has been shown to transmit information in the darkness of their nests through airborne sounds (Kirchner and Sommer, 1992; Michelsen et al, 1992; Dreller and Kirchner, 1993a), which are perceived by the dance attenders through Johnston's organ, an auditory sense organ located in the antennae (Dreller & Kirchner, 1993b). *Apis dorsata* also emit dance sounds which contain the information about the location of the food source (Kirchner & Dreller, 1993). *A. dorsata* has been found to forages and dances not only during the daytime, but also during moon-lit nights (Dyer, 1985).

The measurement for the frequency of bee wingbeat has been varying as seen in five different sources. Chapman (1969) described the wing beat frequency of Apis as about 190 Hz. According to the book "Invertebrate insect" (1987), the number of wing beats in insects varies greatly from 4-20 in butterflies to 190 beats/seconds in bees and up to 1000 beats/seconds in small fly. Charles Micucci (1995) described "A honey bee has two pairs of wing that can beat 250 times/seconds". William J Romoser in "The science of Entomology" (1973) has estimated the bee's wingbeat varying between 190Hz, 108-23 Hz and 250 Hz. Robert H Smith, in his book "Time life for children: Understanding Science and Nature (1993)" described the bee's wings are small for its body which beat 200 times per second letting the bee fly or hover in one spot.

Although all of the measurements contained in each of the five sources were close in their values, some variations did exist. There may be many reasons why these numerical values vary even if it is only a slight difference. Varying age of bees, anatomy, body size and mass, ambient climatic factors are a few of many factors which may cause these variations.

MATERIAL AND METHODS

The materials used were Insect trapping net, bioclimatic chamber, high-quality digital recording device with microphone and a computer with audio analysis software.

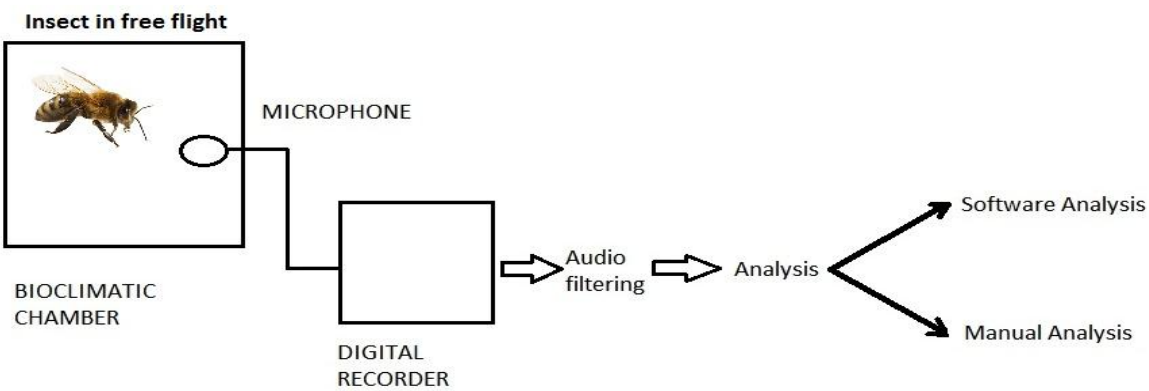

Fig 1: Schematic set-up for recording and analysis of Honeybee flight sounds.

Insect Collection

The honeybees visiting the flowers were trapped and collected during April-May at four locations in the eastern part of the state of Uttar Pradesh, India (26.85°N 80.91°E). The bees were trapped one by one using an insect trapping net and used immediately for the determination of wing-beat frequency. An empty glass cabin of 30 x 25 x 30cm was used as the bioclimatic chamber. The bees were of same species having slight difference in size and weight. The recordings were carried out in the morning hours with completely dry weather and temperature of nearly 25^0 C along with humidity around 40 %.

Sound Recording

The audio produced during bee's flight was recorded (as shown in Fig.1) using a high-quality condenser microphone digital recorder attached to a high end windows smartphone device as high quality digital recorder. The audio was recorded in wav. Format using high quality recording application set at 44,000 Hz sampling rate with a bit depth of 16 bit. The microphone was placed within the bioclimatic chamber and the bees were allowed, one at a time, to fly freely within. Audio sample clips were taken of about 15 second duration. The bees were allowed spend time in the cabin along with the recorder.

Acoustical Measurement and Analysis

For acoustical analysis RAVEN LITE version 1.0 for windows from the Cornell Lab of Ornithology-Bioacoustical Research Program was used. The audio files recorded in wav. format (44000 Hz sampling rate ,16-bit) was equalised and filtered using digital graphic equalizer to filter out unwanted frequencies at low and high range of audio spectrum. The filtered audio was analysed for the average frequencies using spectrogram analysis and were reanalysed manually using online tone generator program (plasticity.szynalski.com/tone-generator.htm). This program was used to generate pure tone to match with the filtered audio of bees' wing beat.

OBSERVATION AND RESULT

Table 1: Table showing the frequency of wingbeat in bees.

Bees	Frequency during flight (Hz)			
	Location 1	Location 2	Location 3	Location 4
1	134	135	136	129
2	142	124	129	137
3	133	136	130	132
4	118	133	135	132
5	130	128	127	135
6	136	129	133	129
7	133	132	136	136
8	129	127	123	132

Result

The wing beat frequencies during free flight of *Apis dorsata* bees of eastern part of the state of Uttar Pradesh, India, lie between 118Hz to 142 Hz. The average wingbeat frequency was estimated to be 131.56 ± 4.7Hertz.

DISCUSSION AND CONCLUSION

Flight of any insect is very important feature because it impact longevity and fitness such as the ability of forage and hunt, compete for a mate and evade predators (Price, 2011). Foraging is one of the most important feature for insects. In honeybee the life is nearly completely depend upon the foraging ability and flight of honeybee help them to get that thing. For flight the wings are the only structure which is useful. The scientists have gone through a long debate to get the exact anatomical precursor of insect wing. The dominant view that the wing arose from rigid lateral extension of the notum. The sound that produce by the vibration of wings is buzzing of honeybee. This buzzing sound helps bees to express themselves to their mate and to us as well. Flight is a central phenomenon through which the bees do all their important functions. There have been a lot of important factors which determines the flight ability in bees. In all these mechanism there are present kinematic mechanisms of Aerodynamics (Dickinson et al., 1999). There are present so many complexity regarding the flight of bees like fuel and oxygen delivery to the insect during flight. Oxygen is very important factor for insects because they need more oxygen to meet their oxygen demand. The energy requirement for insects is fulfilled by food which somewhat depend upon their lifestyles. There are so many biotic factors at work upon the flight performance and lifestyle. One of the most important biotic factors is temperature. The temperature affects the bees very much. Some other factors like age and behavioral development also affect the flight performance of bees. The flight mechanism is sole precursor for the wing sound of honeybee.

One reason for the difference in wingbeat frequency as seen in Table.1 is the varying ages of the bees used in the experiments. It stands to reason that the older the bee the slower the wing beat frequency because of the effects of aging on the anatomical components of bee wings. Variations can also be accounted for by slight variations of the size of the bee itself and of the wings as well. The larger the bee and its wings the lower the frequency will be because it will take more time for longer wings to complete one full up and down motion, therefore beating fewer times per second. Yet another reason for the discrepancy between each literature source may be that different types of bees were used as models during the experiments. For example one book may have studied the wing beat frequency of Bumble Bees, while another studied the wing beat frequency of a Honey Bee. Wing structure, width, length and muscular components may be different in each type of bee. There may also be a difference in the wing beat frequencies of workers, drones, and queen bees. The variation may be small but any change can alter the calculated frequency.

A measurement such as the frequency of bee wings can never be universally accepted. There are many different sources which contain conflicting information on this subject each with valid data or references to back their measurements up. It cannot be determined which source has the correct value, but it has to be realized that there are many underlying reasons as to why the data on wingbeat frequency of *Apis* varies.

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REFERENCES

1. Chapman RF. The Insects: Structure and Functions. New York: American Elsevier: 1969.
2. Dickinson MH, Lehmann FO, Sane SP. Wing rotation and the aerodynamic basis of insect flight. Science, 1999; 284(5422): 1954-60.
3. Dreller C, Kirchner WH. How honeybees perceive the information of the dance language. Naturwissenschaften, 1993a; 80(7): 319-21.
4. Dreller C, Kirchner WH. Hearing in honeybees: localization of the auditory sense organ. Journal of Comparative Physiology A, 1993b; 173(3): 275-9.
5. Dyer FC. Nocturnal orientation by the Asian honey bee, Apis dorsata. Animal behavior, 1985; 33(3): 769-74.
6. Free JB. Pheromones of Social Bees. Cornell Univ Press, Ithaca, NY: 1987.
7. Invertebrates: Insects. The World Book Encyclopedia of Science, The Animal World Edition. Chicago: 1987.
8. Kirchner WH, Sommer K. The dance language of the honeybee mutant diminutive wings. Behavioral ecology and sociobiology, 1992; 30(3-4): 181-4.
9. Kirchner WH. Acoustical communication in honeybees. Apidologie, 1993; 24: 297.
10. Kirchner WH, Dreller C, Grasser A, Baidya D. The silent dances of the Himalayan honeybee, Apis laboriosa. Apidologie, 1996; 27(5): 331-9.

11. Kirchner WH, Dreller C. Acoustical signals in the dance language of the giant honeybee, Apis dorsata. Behavioral ecology and sociobiology, 1993; 33(2): 67-72.
12. Michelsen A, Andersen BB, Storm J, Kirchner WH, Lindauer M. How honeybees perceive communication dances, studied by means of a mechanical model. Behavioral Ecology and Sociobiology, 1992; 30(3-4): 143-50.
13. Micucci Charles. The Life and Times of the Honey Bee. United States, Houghton Mifflin: 1995.
14. Price PW, Denno RF, Eubanks MD, Finke DL, Kaplan I. Insect ecology: behavior, populations and communities. Cambridge University Press: 2011.
15. Romoser William J. The Science of Entomology. New York, Macmillan: 1973.
16. Smith Robert H. *Time* Life for Children: Understanding Science and Nature. United States, Time: 1993.