

Acoustic analysis of flying Imported Fire Ants

Carrick Talmadge, Roger Hasse, Lichuan Gui, Jack Seiner, and Tom Fink

NCPA, University of Mississippi, Oxford, MS

Anthony Pranschke and Douglas Streett

ARS, USDA, Stoneville, MS

Niels Skals

Inst. Biol., U. South. Denmark, Odense, Denmark

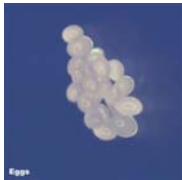


The University of Mississippi

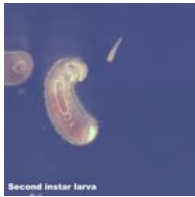
National Center for Physical Acoustics



Fire Ant Development

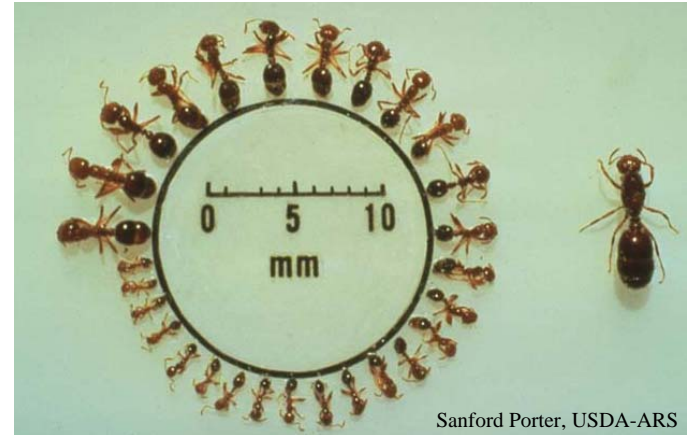
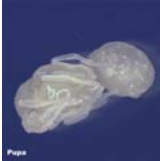


1500 eggs/day

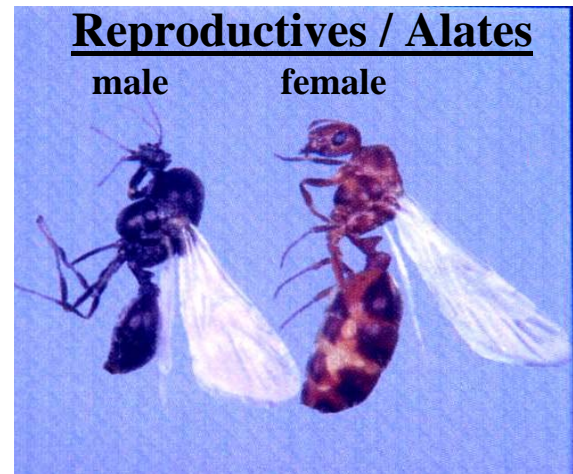


Four Larval stages

Pupa



Polymorphic Workers



Reproductives / Alates

male

female

The University of Mississippi

National Center for Physical Acoustics



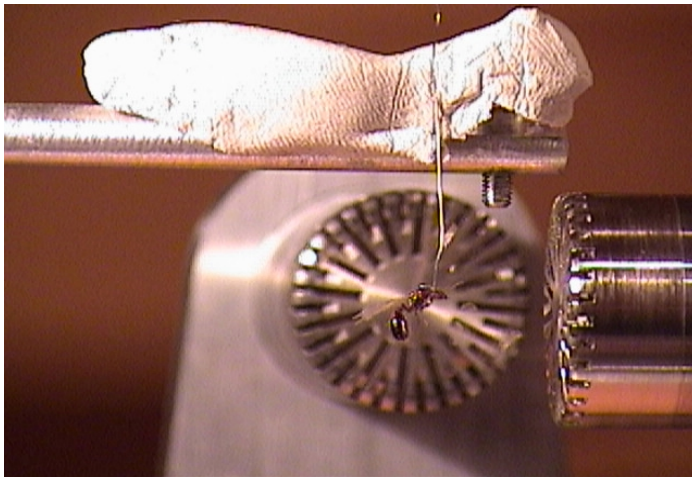
Reproductive Process

- Winged reproductive forms (Alates) will leave the mound after a rain on a mating flight reaching 1000 ft in elevation
- Males will die soon after mating while the fertilized females (Queens) will find a suitable site for a colony
- The Queen will lose her wings, burrow into the ground and then start the new colony
- A mature colony occurs in two to three years containing about 250,000 workers
- Knowledge of mating flights is limited
- **Do wingbeat frequencies and the associated sound fields play a role in the nuptial flights of imported fire ant alates?**



Measurement of Wingbeat Frequencies of Imported Fire Ant Alates

- Measured fundamental frequencies from 80-130 Hz for males and females (differences in species and sex are being studied)
- Both low-frequency sound and ultrasound (≤ 48 kHz) have been measured in experiments to date from wingbeat motions



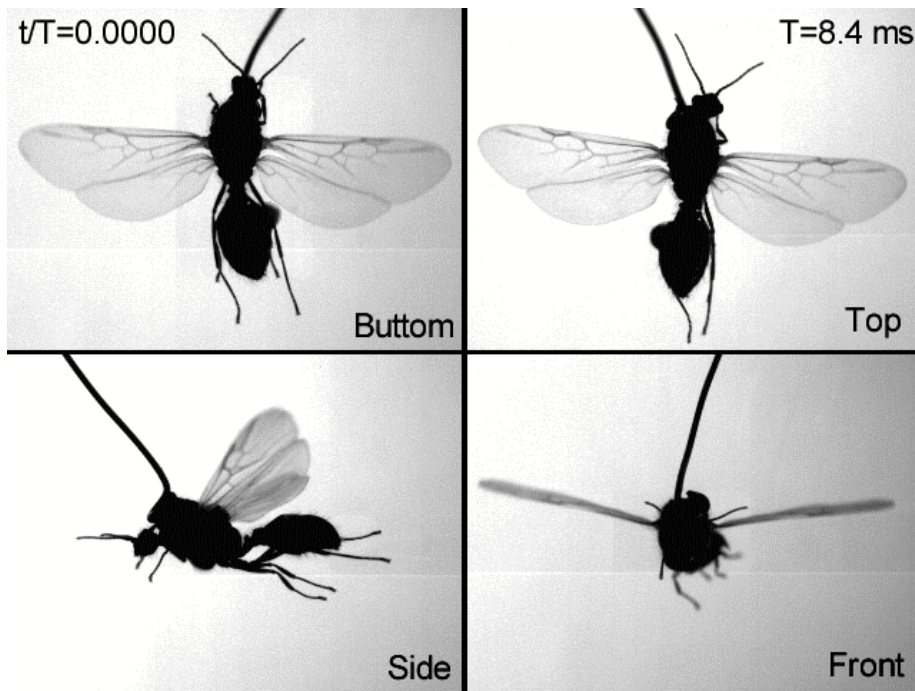
The University of Mississippi

National Center for Physical Acoustics



Measurement of Wingbeat Frequencies of Imported Fire Ant Alates

Tethered Male Fire Ant Flight



10,000 FPS

Current Capability

- Photron APX high-speed camera allows visualization of tethered flight
- High-frame-rate camera provides real-time images of wing-beat motions and behavior
- Analysis of wing-beat motions is crucial in developing a model for sound production
- Long-focal-length, high-resolution microscope provides sub-micron resolution in a non-invasive manner
- The aerodynamics of natural flight will be studied using a wind tunnel

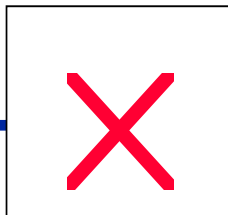
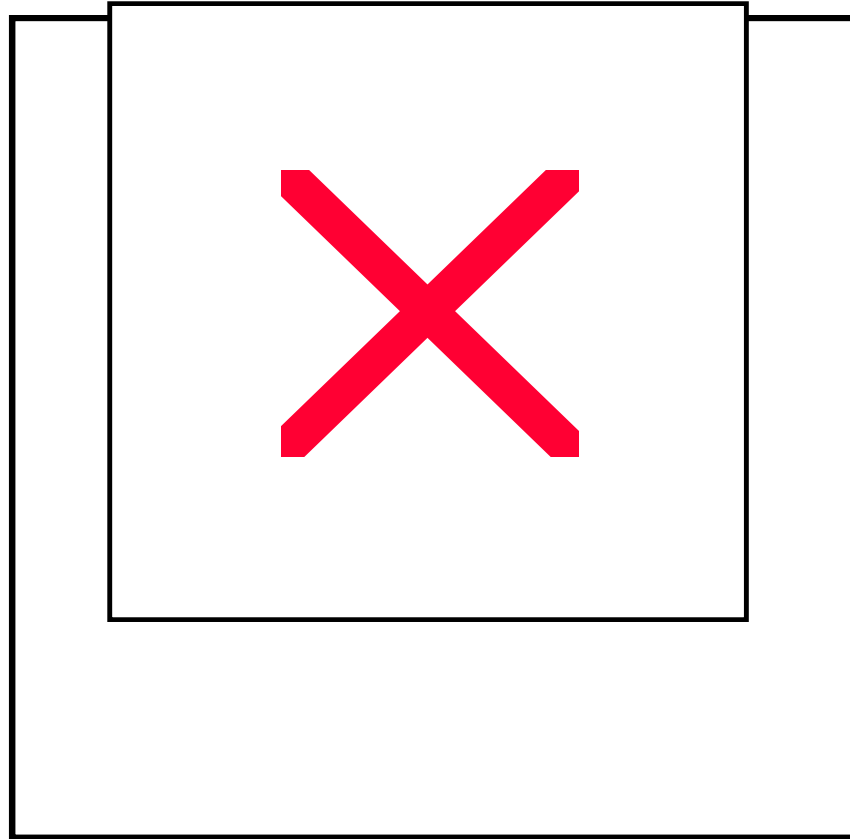


The University of Mississippi

National Center for Physical Acoustics



Alate in Flight

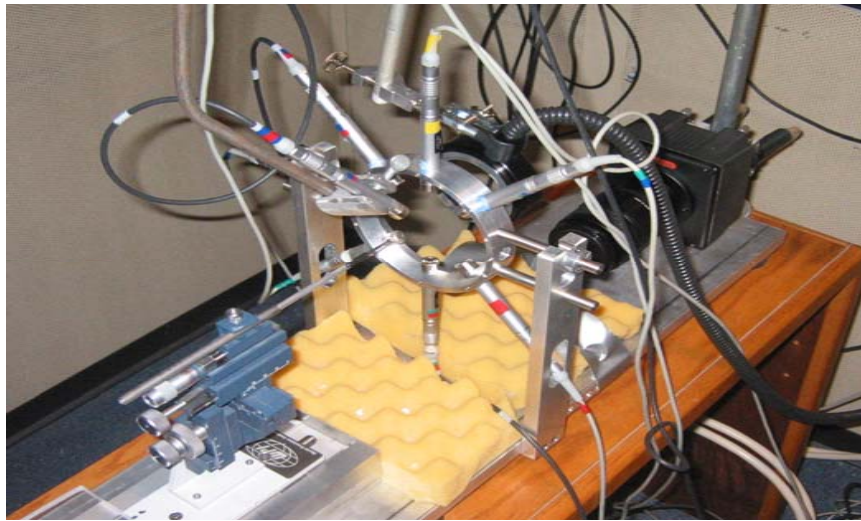


The University of Mississippi

National Center for Physical Acoustics



Sound Directivity of Tethered Alates

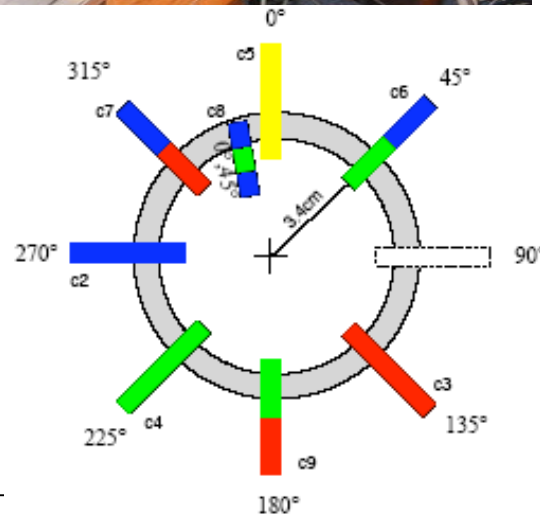


A real-time microphone array is used to determine the acoustic profiles of fire ant alates as small sound sources

Static tethered flights and the associated wingbeat frequencies are expected to be aerodynamically different from actual *dynamic* flights that occur in nature (the study of dynamic flight requires the use of a low-speed wind tunnel)

A model will be developed to predict the measured wingbeat frequencies and associated acoustic profiles of both male and female alates under dynamic conditions (a nonlinear problem)

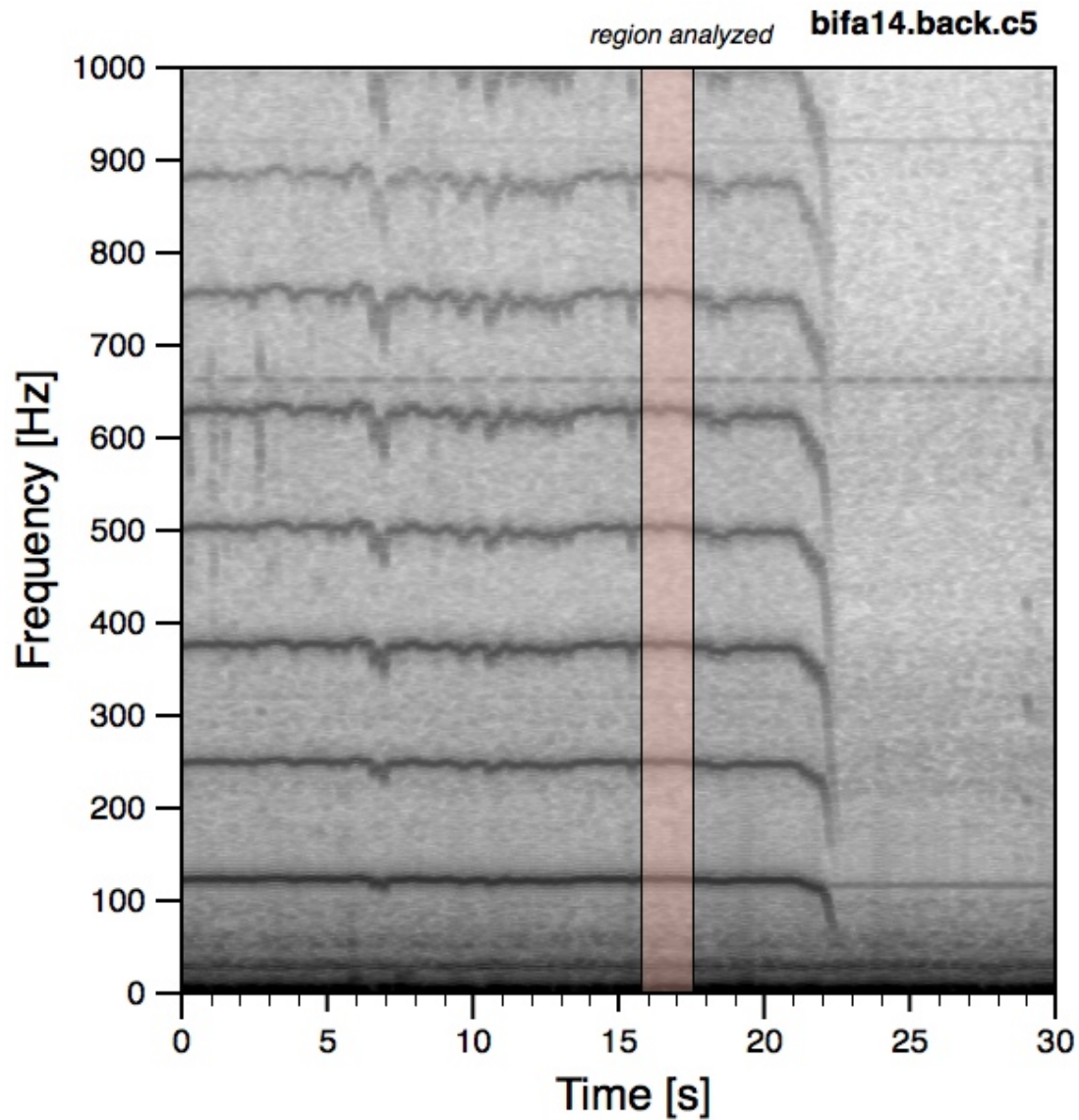
Microphone Array



The University of Mississippi

National Center for Physical Acoustics





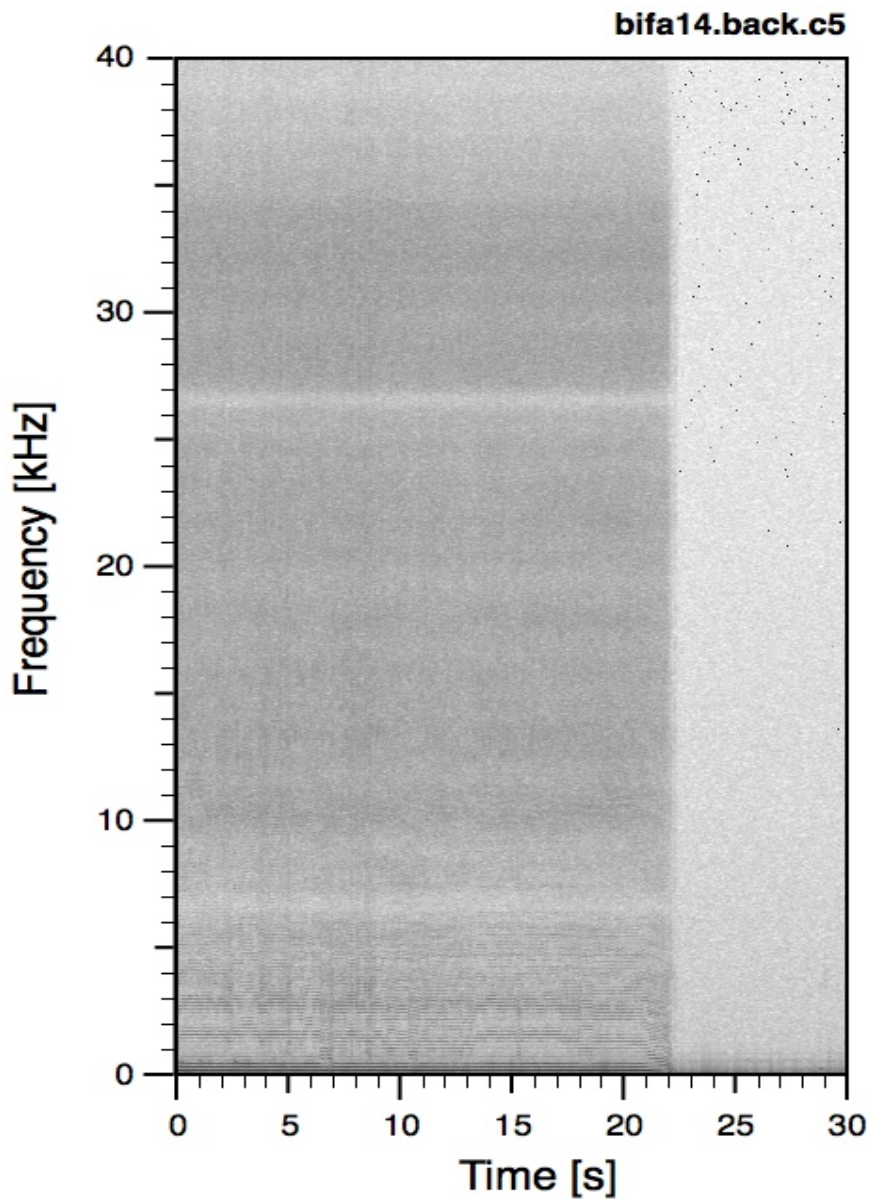
Sonogram of recording from one microphone channel (measured from above).



The University of Mississippi

National Center for Physical Acoustics





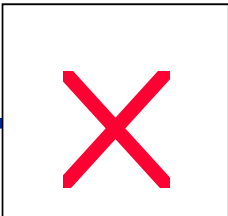
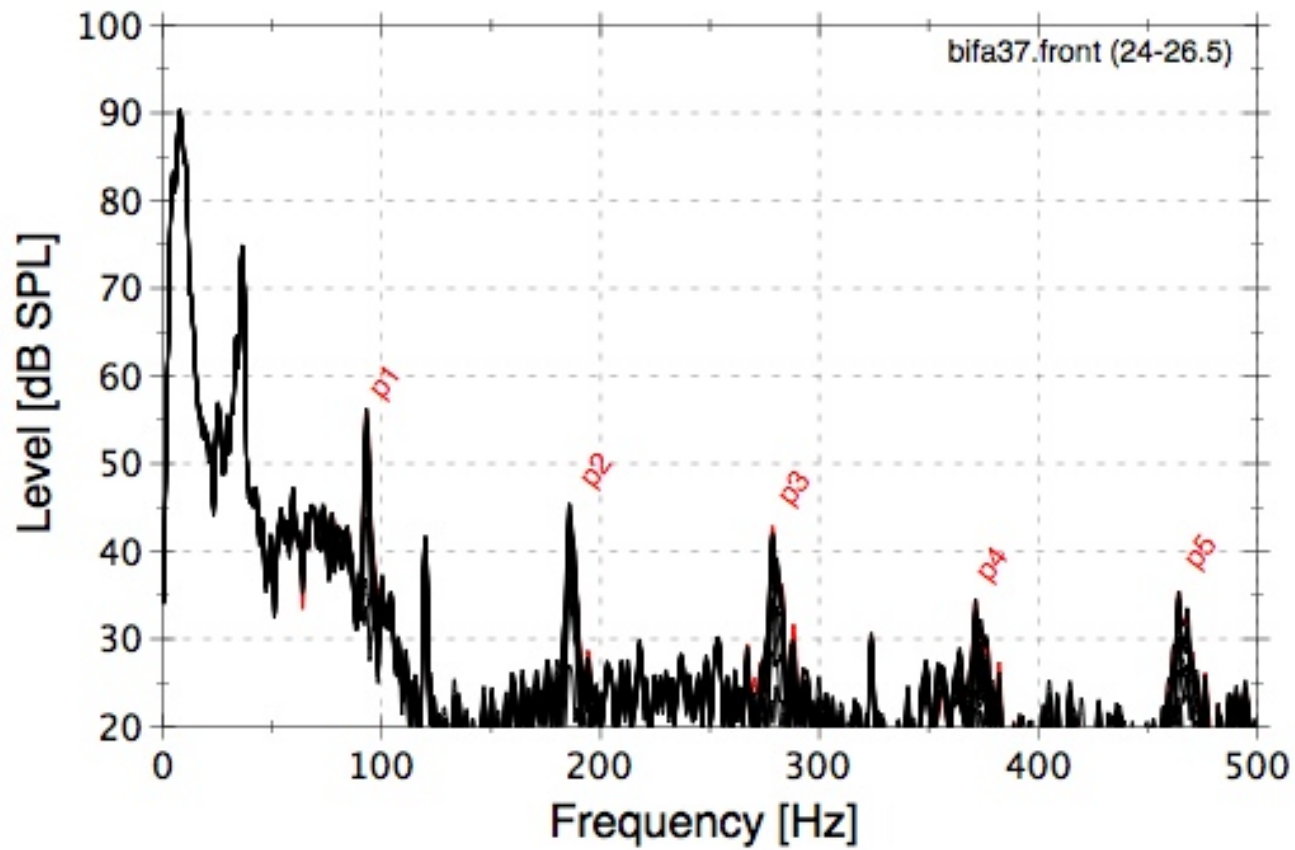
Note that acoustic energy is clearly observable to at least 40 kHz.



The University of Mississippi

National Center for Physical Acoustics





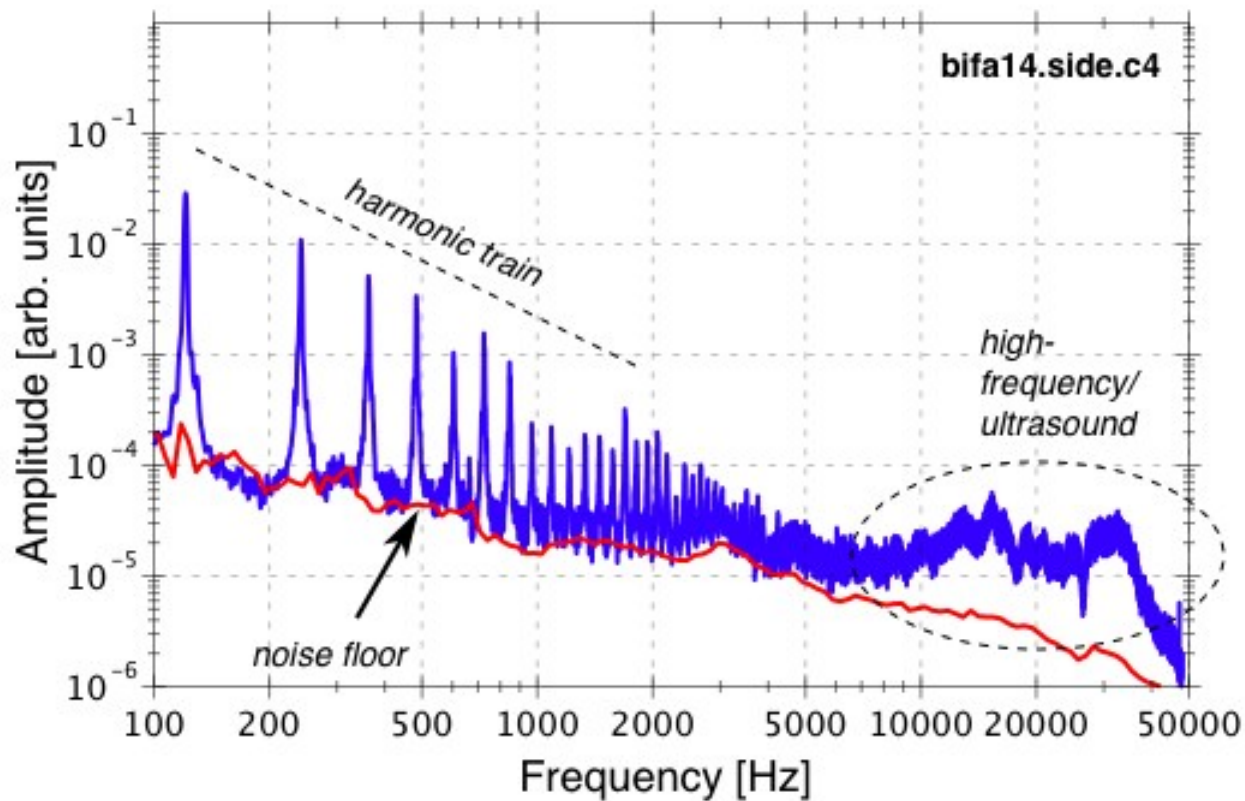
The University of Mississippi

National Center for Physical Acoustics



Pressure Spectrum from Flying Alate

Main Spectral Features Observed for BIFA Data

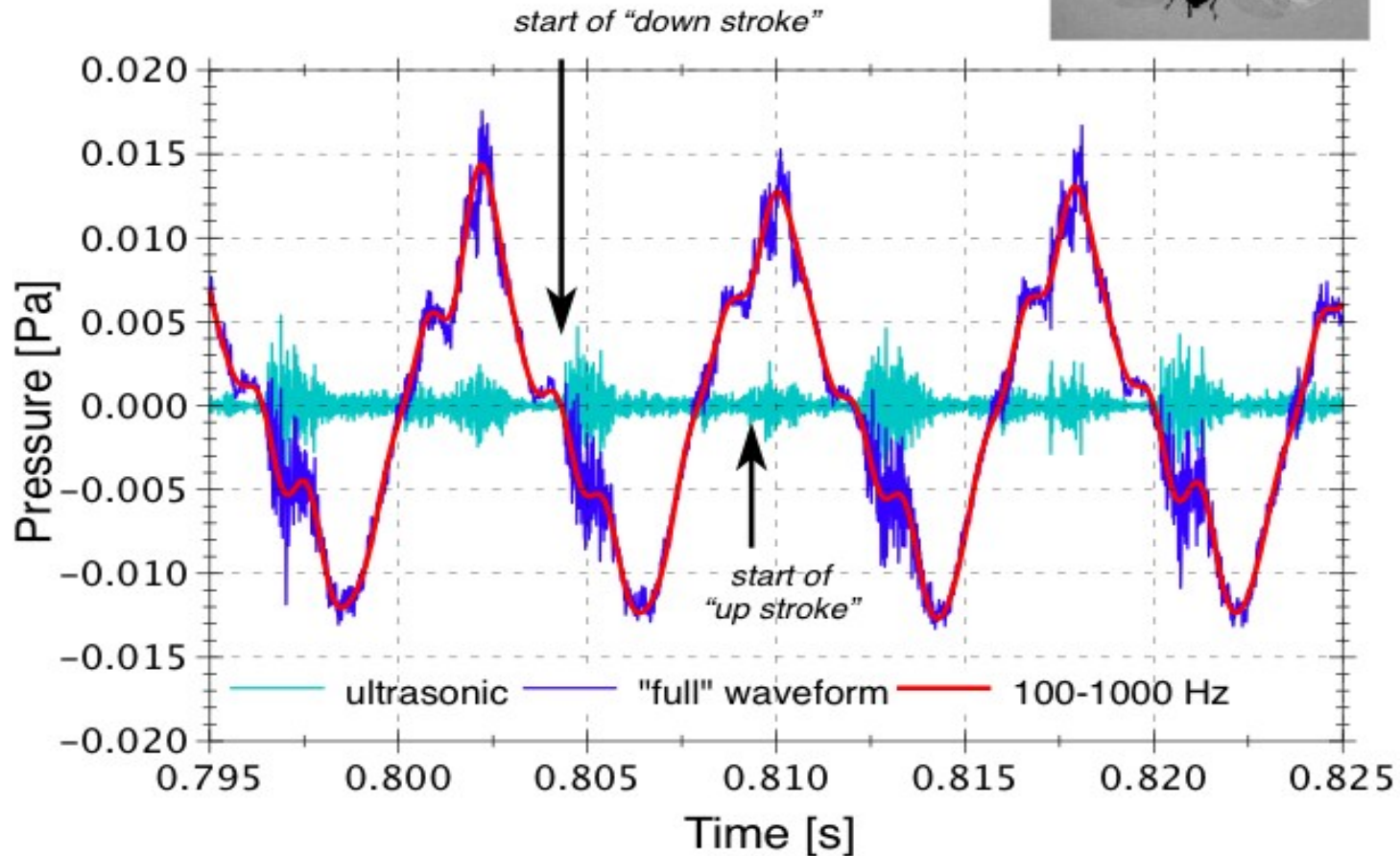
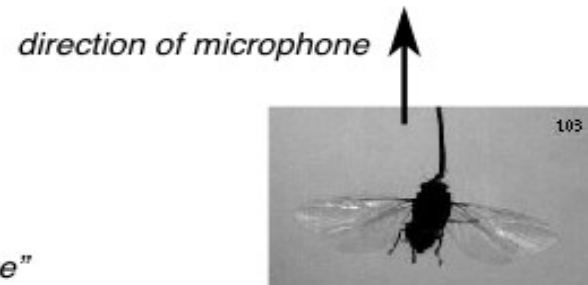


The University of Mississippi

National Center for Physical Acoustics



Time Waveform generated from a flying BIFA Alate

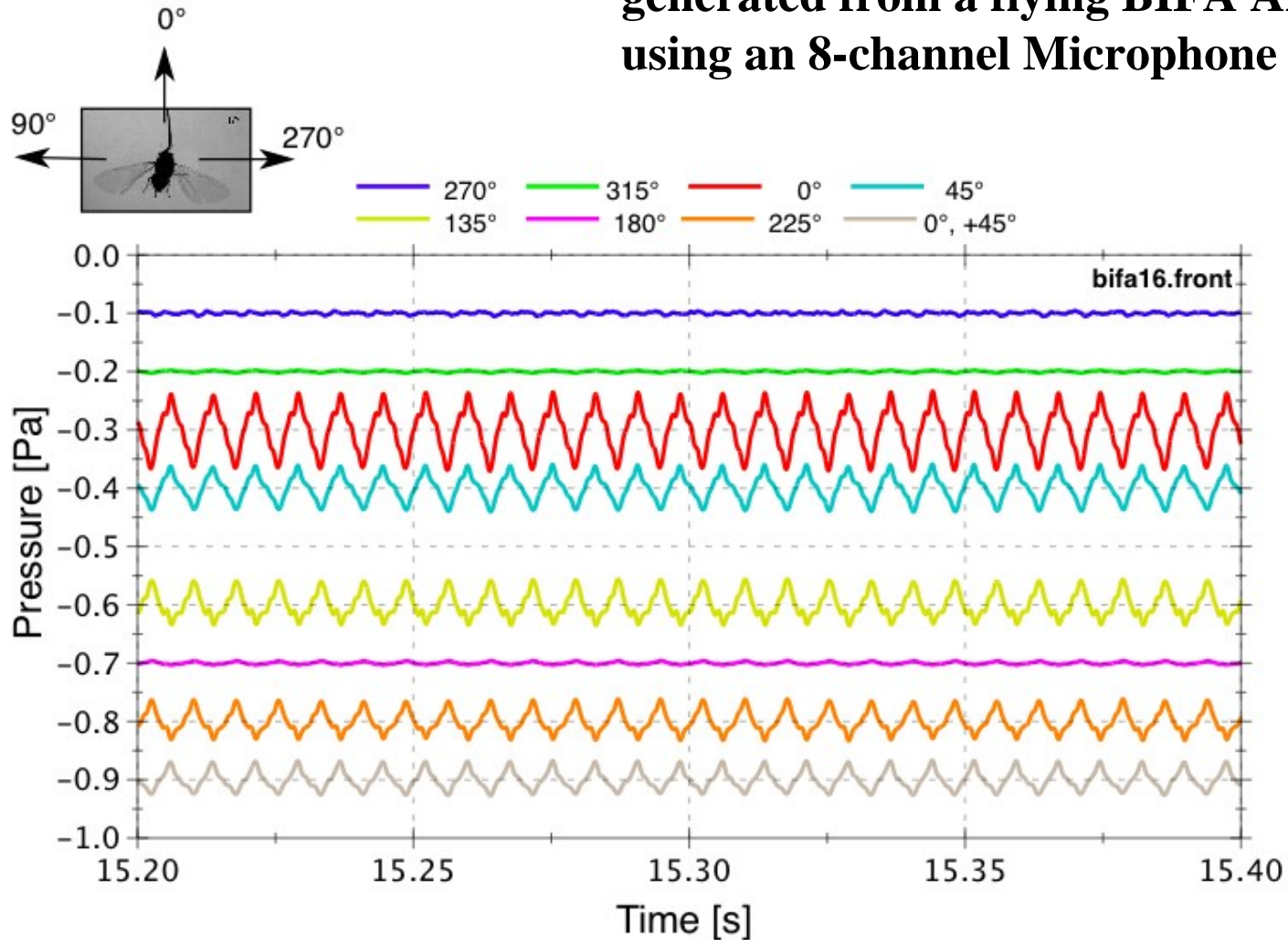


The University of Mississippi

National Center for Physical Acoustics



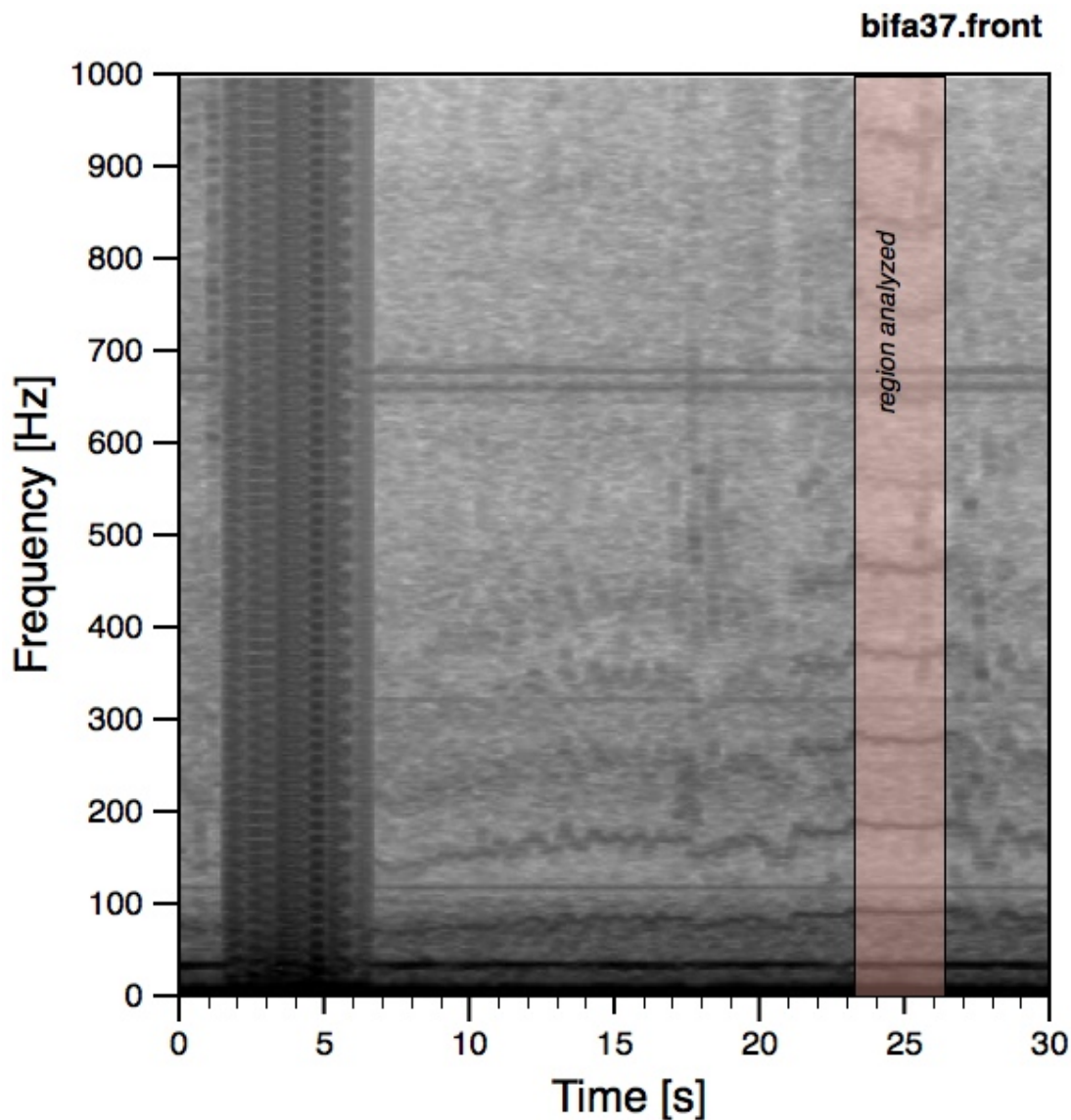
Waterfall Plot of Time Waveforms generated from a flying BIFA Alate using an 8-channel Microphone Array



The University of Mississippi

National Center for Physical Acoustics





The appearance of higher order harmonics was taken as evidence for fully developed flight: For some recordings, this only occurred sporadically.

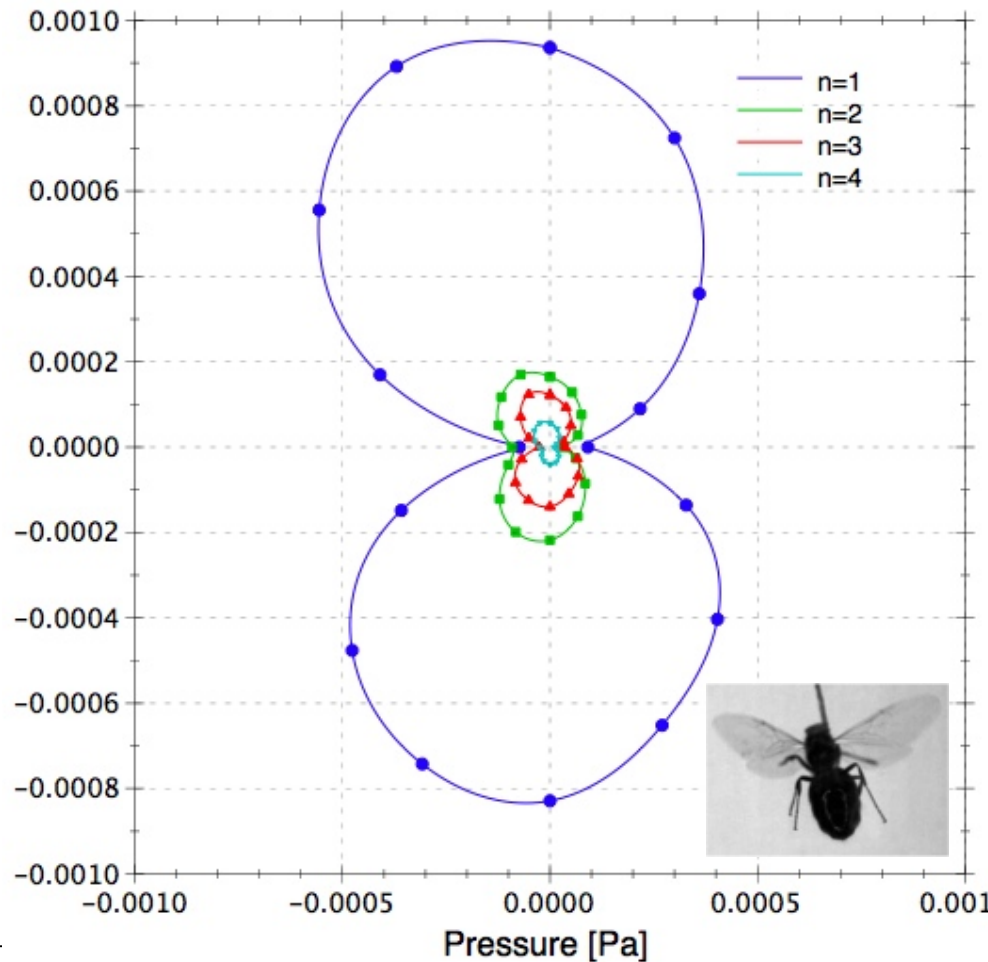


The University of Mississippi

National Center for Physical Acoustics



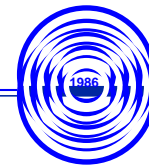
Radiation Patterns vs Harmonic Number (Front View)



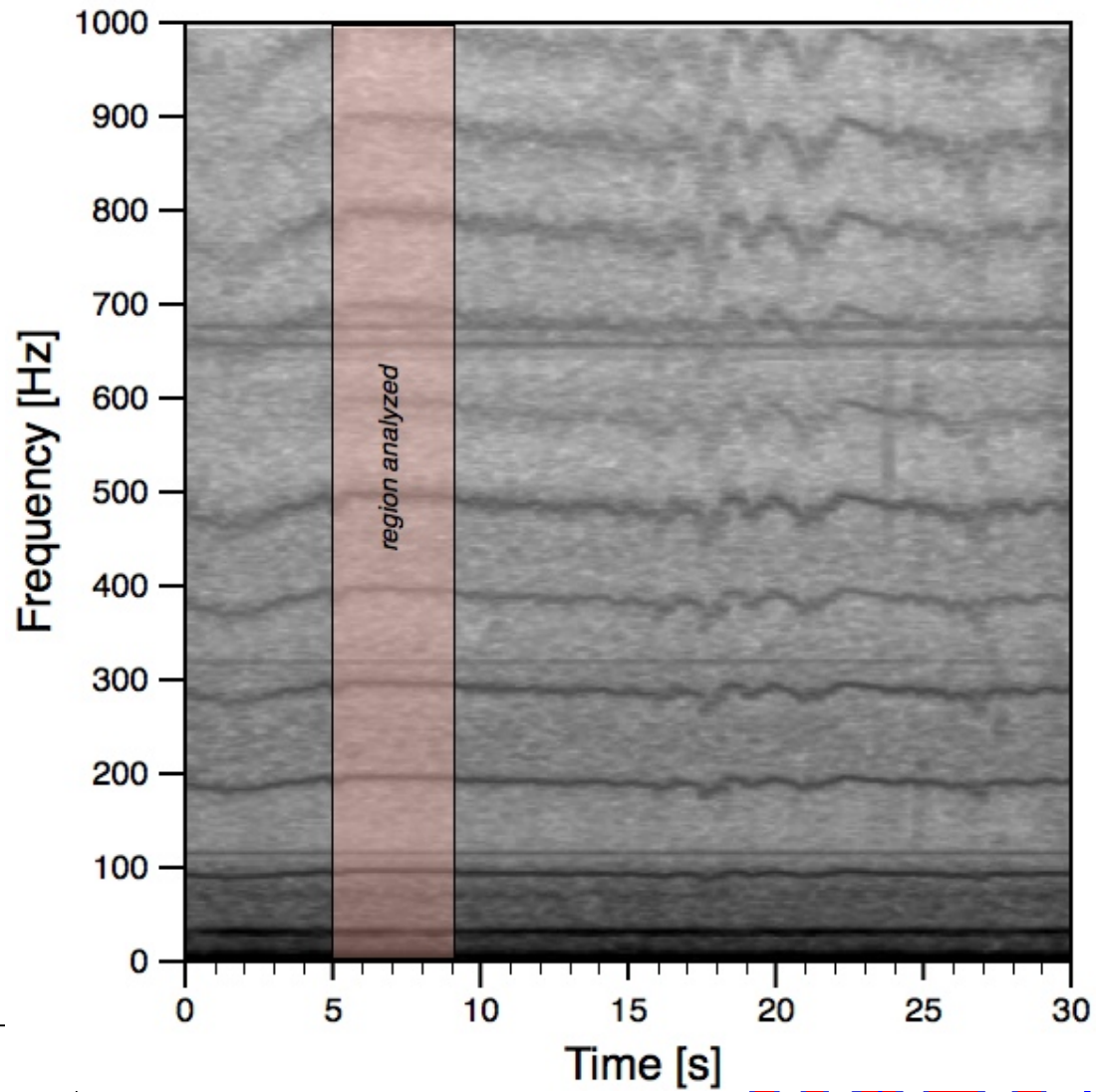
The University of Mississippi

National Center for Physical Acoustics

NCPA



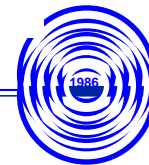
bifa37.side



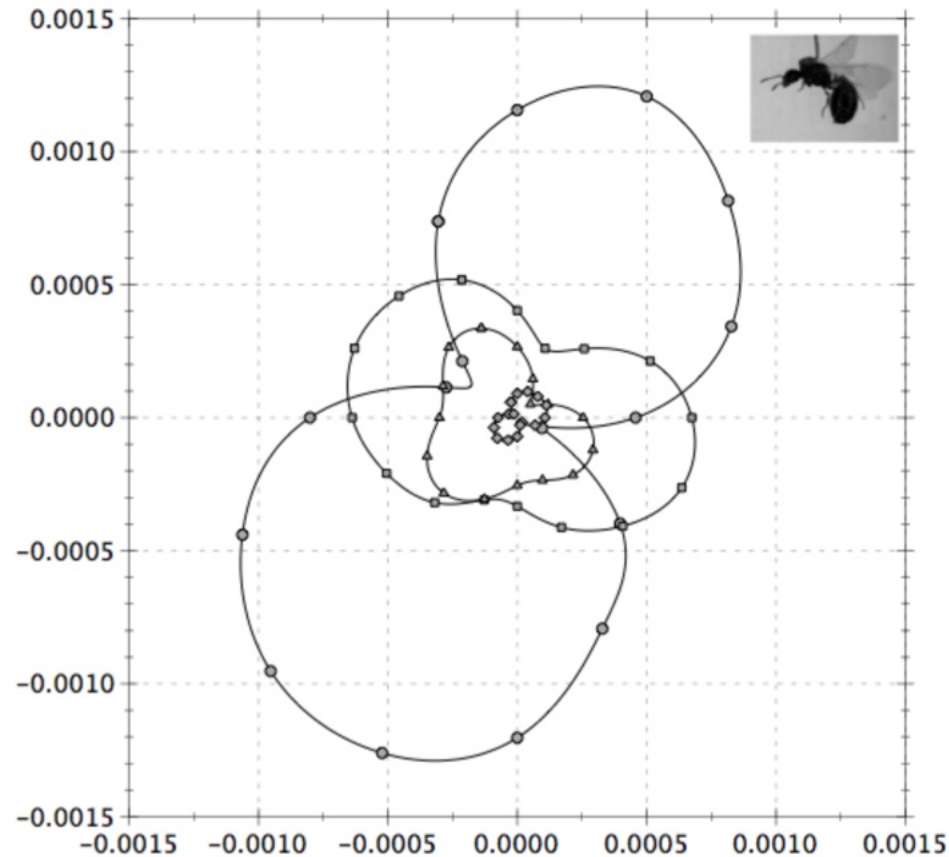
The University of Mississippi

National Center for Physical Acoustics

NCPA



Radiation Patterns vs Harmonic Number (Side View)



The University of Mississippi

National Center for Physical Acoustics



Conclusions

- Wing beats from flying alates produces audible sound, with a fundamental associated with wing beat frequency, multiple harmonics.
- Vortex shedding from wings (essential for insect flight) produces measurable ultrasound.
- It is unclear if either of these sound sources are utilized by the alates. Because the alates lack a tympanic mechanism or similar hearing organ, sound would have to be coupled to the body or antenna of the insect in order for detection (associated frequencies approximately 35-50 kHz).
- Sound patterns are generally dipolar, with some difference in the pattern between order of harmonic. If the insect can perceive sound at these frequencies, this changing pattern could be used as a cue for the relative orientation of another flying alate. Systematic differences in wingbeat frequencies for males vs. females could also be used as a cue for the sex of the other flying alate.

