Silent owl flight: setup for flyover noise measurements

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Introduction

It is common knowledge that most genera of owls fly silently in order to be able to catch their prey. To investigate the mechanisms leading to that quiet flight, several studies were made and basic flyover measurements were carried out by biologists in the past. For example GRAHAM [1] described the peculiar properties of owls' feathers in 1934. These are the leading edge comb (comb-like fringe), the trailing edge fringe and the downy upper surface. In 1971 GRUSCHKA et al. [2] measured the sound pressure level emitted by a gliding Barn Owl in the laboratory. They also investigated the effect of modifications to the wing leading edge, the trailing edge and the surface of the wings on the sound pressure level, but made no measurements on non silent flying birds. A summary of this works is given by LILLEY [3]. In 1973 NEUHAUS et al. [4] compared the flight of owls to the flight of ducks. Because they did the measurements outdoors with a single microphone, they had considerable difficulties to get reliable results. So far, no direct comparisons have been made between the noise generated by a gliding owl to that generated by other raptors.

Due to the progress of the measurement and analysis technology it should be possible to do acoustic measurements on flying birds in nature, although the very low noise level that is produced when the owls are in gliding flight requires special care in regard to the measurement setup.

One possibility is the application of microphone array measurement techniques. In the past, such techniques were successfully applied to flyover noise measurements on aircraft and passing train measurements (e.g. [5, 6]).

This article describes an attempt to do flyover noise measurements of trained birds under natural conditions. It is focused on the measurement setup. Preliminary results are presented for two raptor genera, including one owl.

The experiments were to be carried out in order to get quantitative prove that owls fly significantly more silent than other birds of prey. Therefore, the radiated sound pressure level and spectra for the gliding flight of various owls and non–silent flying birds had to be detected and compared, taking into account the flight speed, trajectory and flight phase as well as the size and weight of the animals.

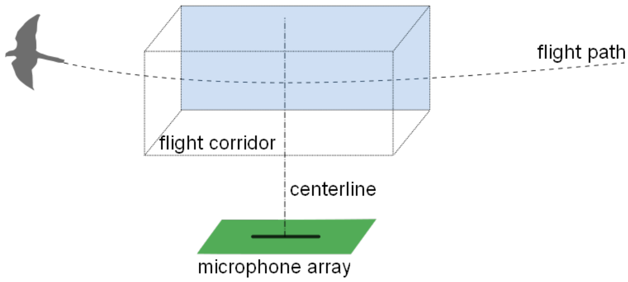

Figure 1: Measurement setup, the bird is gliding over the microphone array through a flight corridor

Measurement Setup

The flyover experiments were conducted outdoors. Educated falconers made the different birds glide through a certain flight corridor, which is the area of maximum sensitivity of a microphone array (Figure 1). During the acoustic measurements the flights were recorded at the same time using two video cameras to determine the flyover time, the flight speed and the trajectory. Both the videos and the acoustic measurements were synchronized. The wind speed, the wind direction and the temperature were recorded every five minutes.

Eight microphones were used for the tested measurement setup. A signal to noise ratio as high as possible and a low sensitivity to deviations of the actual trajectory from the ideal one are important design criteria for the microphone array. One possible solution is a linear array design with equidistant microphones. It offers a narrow main lobe in the direction of the flight and has no angular dependence in the direction orthogonal to the direction of flight. This leads to a high tolerance towards a possible lateral deviation of the trajectory.

The most advantageous spacing of these eight microphones was identified in a numerical simulation. A moving dipole–source as well as a great number of unidirectional radiating disturbance noise sources, evenly distributed along a horizontal ring, were modeled. For the most interesting cases (octave bands with center frequencies from 1 kHz to 4 kHz and a flight altitude of more than 2 m) an arrangement with uniform spacing of the microphones of 8 cm proved to be favorable (Figure 2). The microphone array was mounted on a ground plate to increase the sensitivity of the microphones and to reduce wind noise.

Experiments

The tests were conducted in the wildlife park *Wildpark Johannismühle* (near Berlin) with the following birds (Figure 3):

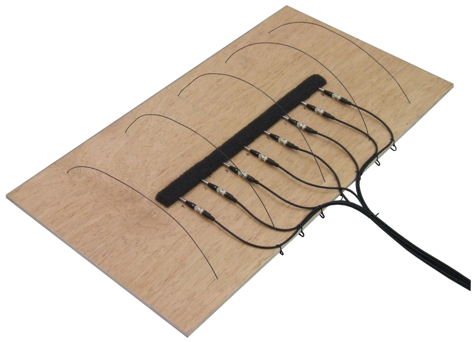

Figure 2: 8 channel microphone array, board with wire bows to apply a camouflage cover

- Harris Hawk (*Parabuteo unicinctus*), no feasible data collected
- Common Kestrel (*Falco tinnunculus*), weight: ca. 200 g, 99 flights (8 suitable)
- Barn Owl (*Tyto alba*), weight: ca. 350 g, 21 flights (2 suitable)
- Eurasian Eagle Owl (*Bubo bubo bubo*), no feasible data collected
- Siberian Eagle Owl (*Bubo bubo sibiricus*), weight: ca. 2500 g, 4 flights (1 suitable)

Figure 3: Test subjects from *Wildpark Johannismühle*, from left: Common Kestrel, Barn Owl, Eagle Owl

The realization of the flyover measurements was fairly difficult since the birds do often exhibit an unpredictable behavior. Moreover, they generally do fly only when hungry and need to be rewarded with food. Other problems include a wrong trajectory, wrong flight conditions (flapping) and shouting (e.g. a young Harris Hawk shouted during each flight, resulting in not a single usable measurement). Some of the birds even are a risk for the measurement equipment, because they might mistake the microphone array for a thread or a toy.

Analysis

The post processing had to be carried out in the time domain because the interesting noise source is moving. A simple time domain delay and sum beamforming algorithm was used [7]. The data were resampled and de–dopplerized and the focus was swept according to the flight path of the bird [8]. The trajectory, the flight speed and the flyover time were gained from the video recordings. The calculated sound pressure levels were normalized to a flight altitude of 1 m.

Preliminary Results

We obtained reliable results of the flight noise as described above for three birds only. The results from two flights are given as an example and are shown in the Figures 4 and 5 as octave and third octave band sound pressure level measured in the center of the microphone array. For the first plot (Figure 4), the array is focused to a region from 1 m in front to 1 m behind of the assumed moving source coordinate. This region is swept with the flying bird and the result is plotted along the time axis top down. Note the very low sound pressure level of the radiated noise. In the 2000 Hz plot of the flight of the Barn Owl there are disturbances from another source (shout from another bird), but the vertical line of the flight noise in the center is just visible.

The second plot (Figure 5) gives the comparison of the third octave band flyover sound pressure levels. For the example above, the flight velocities are 5.5 m/s and 5.7 m/s for the Common Kestrel and the Barn Owl, respectively.

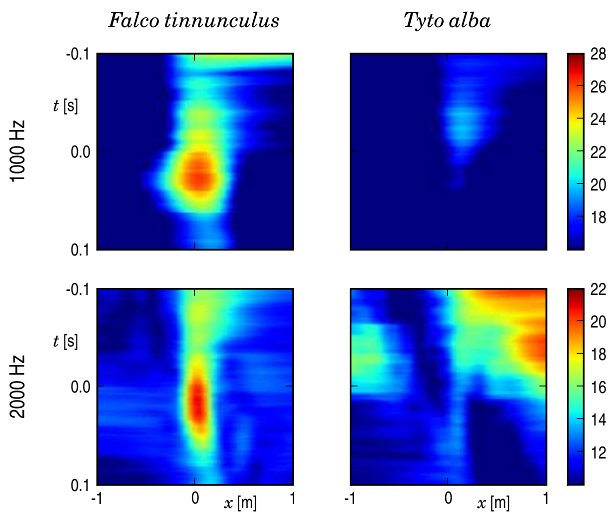

Figure 4: Preliminary results: octave band sound pressure level as a function of time (vertically) and position relative to the bird (horizontally), left: Common Kestrel, right: Barn Owl

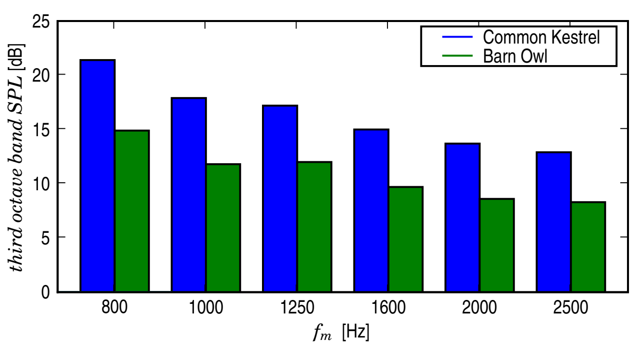

Figure 5: Preliminary results: comparison of third octave band sound pressure levels at the moment of flyover, Common Kestrel and Barn Owl

Outlook

Further measurements are planned using a greater number of microphones and an optimized array layout. It is necessary to improve the flight conditions so that the birds fly at an adapted altitude and that their gliding–flight phase lasts as long as possible. The number of flyover attempts of owls and other birds should be increased to obtain more reliable results for various flight speeds. It is also intended to apply more sophisticated signal processing algorithms.

Acknowledgments

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References

[1] Graham, R.R.: The silent flight of owls. In: *Journal of the Royal Aeronautical Society* 286 (1934), S. 837–843

[2] Gruschka, H.D. ; Borchers, I.U. ; Coble, J.G.: Aerodynamic Noise produced by a Gliding Owl. In: *Nature* 233 (1971), Nr. 5319, S. 409–411

[3] Lilley, G.M.: A study of the silent flight of the owl. In: *4th AIAA/CEAS Aeroacoustics Conference, June2-4, 1998/ Toulouse, France* (1998)

[4] Neuhaus, W. ; Bretting, H. ; Schweizer, B.: Morphologische und funktionelle Untersuchungen über den 'lautlosen' Flug der Eulen (Strix aluco) im Vergleich zum Flug der Enten (Anas platyrhynchos). In: *Biologisches Zentralblatt* 92 (1973), S. 495–512

[5] Brühl, S. ; Röder, A.: Acoustic Noise Source Modelling Based on Microphone Array Measurements. In: *Journal of Sound and Vibration* 231 (2000), Nr. 3, S. 611–617

[6] Sijtsma, P. ; Stoker, R.W.: Determination of Absolute Contributions of Aircraft Noise Components using Fly-Over Array Measurements. In: *NLR-TP-2004-167* (2004)

[7] Johnson, D.H. ; Dudgeon, D.E.: *Array signal processing: concepts and techniques*. PTR Prentice Hall, Englewood Cliffs, New Jersey, 1993

[8] Zechel, G. ; Zeibig, A. ; Beitelschmidt, M.: Beamforming an bewegten Objekten im Zeitbereich. In: *DAGA 2008, Dresden* (2008)