SPECTRAL ANALYSIS OF THE AVIAN HEART VALVE SOUNDS

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12th Annual International Conference of the IEEE EMBS, 1990
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ABSTRACT

Recent studies have demonstrated that the electrocardiogram (ECG) provides the information about heart abnormalities in broiler chickens; however, no study has been done on data acquisition and/or analysis for acoustic properties of the avian heart which may provide valuable information to treat and prognosticate. The objectives of this experiment are to develop a noninvasive technique for recording avian heart valve sounds (HVS) using a tracheal microphone and to establish a relationship between the HVS frequency distribution and the ECG recordings. HVS data were collected from 16 7-week-old broilers. ECG recorded from the same 16 broilers were divided into 3 categories based on R-S wave complex. The results show that the distribution of the HVS frequency spectrum can discriminate the heart condition of the broilers.

INTRODUCTION

Ascites refers to fluid accumulation in the abdominal cavity, and it can occur as young as 1 week of age. Observations in the United States and Mexico have shown that right ventricle dilatation can be found in 10-50% of 1 day old broiler chicks [1]. This may suggest that there is a population of chicks that begin their life with a high potential to develop ascites.

ECG techniques have been used previously to study the development of round heart disease (RH) in turkey pouls. Because the right ventricle is grossly dilated, the electrical waves recorded in the ECG show abnormalities [2]. The disadvantages in current methods of diagnosing ascites syndrome include technical problems in placement of electrodes and in interpretation of the ECG data qualitatively.

The objectives of this experiment are to develop a noninvasive technique for recording avian HVS using a tracheal microphone and to establish a relationship between HVS frequency contents and ECG recordings. Lessard et al. [3] have demonstrated a system to monitor heart rate and respiratory rate using a microphone placed at the trachea. Im et al. [4] utilized the spectral analyses of the HVS to provide an insight into the relationship between respiratory static volumes and HVS. If a relationship between HVS frequency characteristics and the condition of broilers is established, early detection of ascites syndrome could reduce losses to the broiler industry and help in providing appropriate treatment for abnormal broilers as early as possible. The transducer (microphone) will provide a quick and easy way of accessing information from broilers.

EXPERIMENTAL DESIGN AND METHODS

Data were obtained from 16 7-week-old broilers with 3 trials per broiler. Two signals, ECG and HVS, were obtained from the subjects. The ECG were acquired using a standard unipolar, augmented and orthogonal limb-lead recordings system. The use of a portable battery powered physiograph allowed the recording procedure to be carried out inside the poultry house. The HVS at the trachea were acquired with a microphone embedded in an resonant housing. The signals from the microphone were conditioned through filter stages. The first stage was a high-pass filter with a cutoff of 8 Hz and the second stage, a low-pass filtered with a cutoff of 500 Hz. The HVS were input to a 12-bit analog-to-digital converter (A/D). The signals were digitized at a sampling rate of 1024 samples per second. This sampling rate was chosen to avoid "aliasing" of the heart sounds spectra. Two seconds of data were collected for each trial. After each trial, the data were transferred to an IBM AT and stored for future processing. The overall equipment for data collection is shown in Fig. 1.

DATA PROCESSING AND ANALYSIS

Data were analyzed in several off-line processes, which include data collection, selection of data segment, and spectral analysis. Sample plot of the HVS raw data is given in Fig. 2.

After the data were collected, the 3 best segments of the HVS were selected. Each segment of HVS was divided into the first heart valve sounds (HVS1) and the second heart valve
sounds (HVS2). The fast Fourier transform (FFT) was used to transform the heart sounds data from the time domain to the frequency domain. The averaged spectral estimate for HVS1 and HVS2 were calculated within each subject.

![Diagram](image1)

**Figure 1.** Overall equipment setup for data collection.

![Diagram](image2)

**Figure 2.** Sample plot of the raw data for the HVS.

ECG was recorded for the same 16 broilers. All strip chart recordings were analyzed by quantifying the amplitude of the R and S-wave in each of the recordings. Once all of the ECG recordings had been measured, broilers were divided into 3 groups (supernormal, normal, and abnormal) based on vectoriographoelectrocardiographic techniques [2]. This procedure allowed the determination of the mean electrical axis in degrees and the magnitude of the resultant vector in millivolts for each bird in the study.

**RESULTS AND DISCUSSIONS**

Sixteen broilers were divided into 3 categories based on the ECG analysis. Supernormal group and normal group consisted of 3 and 11 broilers, respectively. Two broilers were categorized as an abnormal group. The frequency spectrum of the HVS within each group were averaged. Fig. 3 and Fig. 4 represent the averaged spectral plots of each group for the HVS1 and the HVS2, respectively.

As can be seen from Fig. 3, an increase in the peak values of the spectral distribution is observed as the broilers group becomes abnormal. Fig. 4 showed that the HVS2 has a similar frequency spectrum as the HVS1 except that one of the major energy contents of the abnormal group appeared at 28 Hz.

In conclusion, HVS1 can be used to discriminate the condition of broilers by frequency analysis. The supernormal group and the normal group have the predominant energy concentrated at the frequency band 20-30 Hz and 45-60 Hz, respectively. The abnormal group has the most energy concentrated at the high frequency band, 80-160 Hz. This study will be continued with a larger number of sample size. The meaningful spectral indices such as peak frequency, mean power frequency, and bandwidth will be extracted from the frequency data and used to determine the condition of the broilers.

**REFERENCES**