VOCAL TRACT BIOMETRY AND ACoustic Features of DAIRY COWS

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ABSTRACT
Vocalization in dairy animals is thought to be one of the best means of conversation between each other as well as with environment. The present investigation was carried out on 12 lactating crossbred Karan Fries cows. The vocal signals from these animals were recorded for sufficient time in order to receive 50 complete sound clips. The various acoustic features were extracted in order to establish the relationship between these and various vocal tract or other body related measurements. Call duration of KF crossbred cows in present investigation was found to have a significant (p< 0.05) strong negative correlation with circumference of neck. A significant direct association was observed for maximum (p< 0.05) and minimum (p< 0.01) amplitude with various biometric parameters viz. body weight, heart girth and body length. Moreover, a significant strong negative association was observed for heart girth with mean (p< 0.01) and maximum (p< 0.05) intensities. Association between 1st fundamental frequency and circumference of neck was significant (p< 0.05). Correlation between average formant dispersion and the circumference of neck was also strong, positive and highly significant (p< 0.01).

Key words: Acoustic features, KaranFries cows, Vocal signal, Vocal tract biometry.

INTRODUCTION
It is conjectured that the voice of the animals are produced for communication with the environment, other animals and the husbandry men. Like human being vocalization in of dairy animals provides a great deal of information regarding their individuality, physical-physiological condition, age, sex, dominance status (Watts and Stookey, 2000) etc. Experienced farmers may identify problems through animal vocalization. It is obvious from various research works that animals have their own feelings, desires and need which they express either through their voice or typical behavioral patterns, but human do fail to recognize them. In past decade few researchers have started decoding animal language. It is obvious now that the patterns of vocal signals of dairy animals do change during their different conditions (physical and physiological) and stage (Singh, 2011). It may also be used in effective and timed detection of heat in dairy animals. Vocal signals have been found to be efficient enough in discrimination of one individual from other at the same time it was also able to differentiate the various conditions of dairy animals. Under experimental conditions involving pain or social isolation, vocal response is useful as an indicator of welfare, if properly used (Watts and Stookey, 2000). Vocalization is the sound signal produced by the vibrations of their vocal folds and modified by the resonance of their vocal tract. The voice of animal is produced by larynx and the other voice organs such as lung, trachea, oral cavity, nasal cavity, lips etc contribute in voice production. Sound signals consist of various bioacoustics parameters viz. frequency, amplitude, intensity, resonance etc which are variable from one individual to other and also in different condition of the same animal. These bioacoustics parameters are basically dependent on the length (Fitch et al., 1997; Riede et al., 1999 and Ghazanfer et al., 2007), diameters and annular rings on wind pipe or trachea, lung volume (Fant et al., 1966), body size (Evans et al., 2006), size of vocal tract (Reby et al., 2005), body size and weight (Hauser 1993; Reby et al., 2003; Ey et al., 2007; Charlton et al., 2009 and Boyle et al., 2011) and nostril size (Sanvito et al., 2007 & 2008) etc. These
characteristic features of wind pipe may directly or indirectly be affected by the vocal tract biometry and the capacity of chest cavity. The information regarding these facts is in scarcity. Thus the target of present investigation was to find out certain relationships between acoustic features and vocal tract biometry of Karan Fries crossbred cow.

MATERIALS AND METHODS
Selection of animals: Total 12 Karan Fries Cattle were selected on the basis of Peak milk yield in their second or third parity. The KF Cows were selected to study the relationship between their acoustic features and Vocal tract biometry. Each and every recording was done by separating the animals from their herd. All the other management practices (feeding, breeding, housing etc.) were performed as per normal schedule of the farm without any interference.

Body measurements: Following body parameters were measured from adult KF cows by measuring tape
a) Neck length(cm): length from poll to joint of shoulder
b) Circumference of neck(cm): measured at middle of neck
c) Heart girth (cm): around just behind elbow
d) Width of chest (cm): between front legs
e) Width of muzzle (cm): between nostrils
f) Body length (cm): point of shoulder to pin point
g) Body weight (Kg): average body weight of the animal at the time of recording
h) Peak milk yield (Kg): from record cell of Livestock Research Centre NDRI Karnal.

Recording and editing of voice signals: The sound signals of KF cows in present investigation were recorded for a sufficient period of time so that we could get at least 50 clips (each clip including one complete vocal signal made in single attempt) from the total recordings of each animal. Sound recording was performed by using a video camera (Sony HDV FX7E, handycam) equipped with a good quality microphone (Sony ECM674, unidirectional) available at Video Lab (Communication Center), NDRI, Karnal for the better quality measures. The microphone was fixed at the front wall of fence at a height of 150cm from the floor, while the video camera was kept on a tripod at the most suitable position from where it could record every single activity of that particular cow. Environmental disturbances were not captured due to specification of unidirectional microphone. All the superimposed sounds and noise signals were detected and eliminated manually from subsequent analysis. Clips of complete voice signals were prepared from all the recordings by using Adobe Premium Pro-1.5 audio-visual editing software package.

PROCESSING OF VOICE SIGNAL AND FEATURE EXTRACTION
Resampling of sound signals was done at a sampling frequency of 48 KHz and 16 bit. To extract a given set of features, only a small window of voice signals was processed at a time because speech signals are slowly time varying signals (it is called quasi-stationary). When examined over a sufficiently short period of time (between 5 to 25 msec), its characteristics are fairly stationary. Thus the voice signals were then broken into short frames of size of 15 msec by using a hamming window. A specific shape of window (Hamming window) was used for the purpose of windowing in order to minimize the effect of abruptly chopping the signals in the window. So every single window was now having a number of sound frames of the length of 10 msec each.

Feature extraction involved generating of the best set of parameters that represented the vocal signals from all the frames of each voice clip. Following acoustic features were extracted at NDRI, Karnal with the help of PRAAT 5.1.36 software package developed by Boersma and Weenink (2010):

a) Call Duration (Sec.)
b) Amplitude (P)- Minimum and Maximum
c) Total Energy (P²s)
d) Pitch (Hz)- Q50%(Median), Minimum, Maximum, Range and Mean
e) Intensity (dB) - Minimum, Maximum and mean
f) Formants (Hz) – F1, F2, F3, F4 and F5
g) Formants dispersion (Hz): averaged difference between successive formants
h) Number of Pulse
i) Number of Periods
j) Unvoiced frame (%)
k) Mean Noise/Hormonic (%)

Statistical analysis: The statistical analysis was carried out on an HCL System IV computer available at the computer centre of the institute. The relationship between body parameter and acoustic features were analyzed by using Pearson correlation.
RESULTS AND DISCUSSION

The average call duration of KF crossbred cows in present investigation was observed to be 2.24±0.58 seconds. The waveform or oscillogram, of a vocal signal uttered by a cow has been presented in Fig. 1, in which various acoustic features like intensity, formants amplitude pulse, periodicity and Harmonicity are quite visible. Fig 2 is representing the spectral analysis window of a single vocal signal from a particular KF cow.

The results of present investigation for the relationship between various acoustic features and vocal tract biometry are presented through Table 1. Call duration of KF crossbred cows in present investigation was found to have a significant (p<0.05) strong negatively correlation with peak milk yield and circumference of neck. It implies that animals with greater circumference of neck may be good yielder of milk and high yielder will oftenly produce a short termed voice. Maximum and minimum amplitudes of call signals of KF cows reflected strong positive correlations with all vocal tract biometric parameters. The negative signs of Pearson correlations for various biometric parameters with minimum amplitude were only because these were assigned negative sign for proper representation. The peak milk yield and body weight of crossbred cows was having a significant (p<0.05) direct association with maximum amplitude while the association between minimum amplitude with various biometric parameters viz. body weight, heart girth and body length was significantly high (p<0.01). These observations gave an approval to the findings of Hauser 1993; Reby et al., 2003; Ey et al., 2007; Charlton et al., 2009 and Boyle et al., 2011 who reported that body weight and size of an animal do affect the vocal signals produced by it.

The energy peak gain of the same, in terms of both spatial and time domain has been depicted through fig 3. The total energy of vocal signals of cows was negatively associated with all biometric parameters and even with peak milk yield (Table 1). It was considered that the energy of a particular animal was constant and the more it would be utilized in milk production the least it will be available for voice production.

The median, maximum, mean pitch and range of pitch were observed to have a non significant strong and positive association with neck length and circumference of neck (Table 1). It indicated that the animals with heavier (i.e. long and wide) neck produce more shrill voice.

Table 1 revealed a significant strong negative association between mean (p<0.01) and maximum (p<0.05) intensities. The probable indication of this finding would be that the animals with higher lung capacity will oftenly produce the

FIGURE 1: Waveform and Oscillogram of a voice signal from a Karan Fries crossbred cow showing intensity (___), Formants (___), Pitch (___) and Pulses
voice of low intensity. These facts of present investigation put forth the concept generated from various workers that lung volume (Fant et al., 1966) and body size (Evans et al., 2006) affected the vocal signal production process significantly.

The spreading of tracks for various formants of a voice signal from a KF cow, in a time domain has been depicted through fig 4. Table 1 reflected a low grade, non-significant, negative correlation between different formants of voice signals from cows and their neck length but it was observed to be higher for neck circumference. Moreover, association between 1st fundamental frequency and circumference of neck was significant (p<0.05). The findings of present investigation coincided with the findings reported by Fitch et al., 1997; Riede et al., 1999 and Ghazanfer et al., 2007 that formants were negatively associated with that of vocal tract length.

The association between higher formants in present investigation was observed to be strong, positive with peak milk yield of KF crossbred cows and for 5th formant it was highly significant (p<0.01). It implied that higher are the higher formants of a cow more would be its peak yield and the cow would be a good producer. The grade of association between biometric parameters was increased with the increase in the number of resonance. There existed a strong,
positive and highly significant ($p < 0.01$) correlation between average formant dispersion with peak milk yield of cows and their circumference of neck.

**CONCLUSIONS**

Vocal tract biometry was an indirect measure of acoustic features. As various physical and physiological conditions of dairy animals are reflected in terms of acoustic features hence these could also be accessed by measuring various vocal tract related biometry. From present investigation it could be concluded that various body measurements viz. body weight, neck length, circumference of neck, heart girth, chest width, body length and width of muzzle etc contributed in the production of typical vocal signals but out of these body weight, circumference of neck, heart girth, muzzle width affected the quality of sound signals significantly.
REFERENCES