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Characterization of equine vocalization

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Abstract Bioacoustics is the study of sound in animals and includes, but is not limited to, animal communication with associated behavior, sound production anatomy and neurophysiology, auditory capacities and auditory mechanisms, and animal welfare. The present research investigates the vocalizations of horses during stressful situations. Stress can be positive or negative. Distress is anything that affects the animal in a negative way, such as in mare and foal separation. Eustress is anything that affects the animal in a positive way, such as morning feeding time in a horse barn. The purpose of the current research is to find spectral differences in the recorded vocalizations of stalled horses that indicate both distress and eustress using the Hidden Markov Model (HMM). Greenwood Function Cepstral Coefficient values suggest that there are spectral differences between vocalizations in a distress and eustress situation. These consistent results indicate that further research to obtain and evaluate vocalizations of horses may provide a productive tool in understanding equine welfare.

Introduction

Bioacoustics is the study of sound in animals and includes, but is not limited to, animal communication with associated behavior (Waring, 1975; Bradbury and Verencamp, 1998; Mulligan et al., 1994), sound production anatomy and neurophysiology, auditory capacities and auditory mechanisms, and animal welfare (Manteuffel, 2004). Bioacoustics is extremely important to animal welfare and potentially may be used to monitor and boost livestock and other agricultural productivity (Dantzer and Mormede, 1983; Morton and Page, 1992). Human activity has led to an increase in deafness in domestic animals (Cattanach, 1999). Examples of human activities include, but are not limited to: poor breeding/inbreeding practices, animals housed with constant machinery noise, and animals exposed to loud noises. For example, if there is a sudden loud noise, dairy cows will not let their milk down, thus interrupting milk production. Gygax and Nosal (1993) investigated the affects of vibration and noise on somatic cell counts of milk in dairy cattle. They found that reducing both vibration and noise reduced somatic cell count in cattle.

The hearing range of the horse is 55 Hz-33.5 kHz, with a best sensitivity range of 1 kHz-16 kHz at 60dB SPL (Heffner and Heffner, 1983b). This finding would imply that most of the vocalizations (Blake, 1975) that horses make are within this range; otherwise, they would not be able

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to communicate with each other. Horses are more sensitive in their low-frequency hearing ability and less sensitive to high frequencies than most other mammals (Heffner and Heffner, 1983a; Heffner, 1998). Horses may also be able to feel low-frequency vibrations and react to them, but they do not necessarily hear them.

The present research investigates the vocalizations, specifically the whinny of horses during stressful situations (Heffner and Heffner, 1983b; McDonnell, 1999). Stress can be positive or negative (Broom and Johnson, 1993). Distress is anything that affects the animal in a negative way, such as in mare and foal separation (Malinowski et al., 1990). Eustress is anything that affects the animal in a positive way, such as morning feeding time in a horse barn. From an analysis of sonograms, Browning and Scheifele (2005, 2007), showed that whinnies had a frequency-varying component—termed the “expressive component”—that appeared to change under various behavioral situations.

The total number of vocalizations recorded for the morning feeding time and mare and foal separation (indoor and outdoor) is summarized in Table 1. The independent variable for the experiment was the situation the horses experienced. The 2 situations were morning feeding time and mare and foal separation. The environment was controlled as much as possible while the horses were in their stalls. Outside distractions were minimized to the extent possible so the experimenter could determine what the horse was most likely focusing on. The vocalizations produced by the horses were the dependent variables for the experiment. To determine whether there were environmental factors to consider, vocalizations from a small number of horses outside in a small corral during morning feeding time and mare and foal separation were recorded. The objective of the outdoor vocalizations was to show a difference in the vocalizations where the environment of the horse was not controlled compared to the indoor vocalizations, where outside factors such as weather, pedestrians, and other phenomena were not present.

The purpose of the current research is to determine, using a standard analysis technique—the Hidden Markov Model (HMM) (Rabiner, 1989)—whether there is a significant spectral difference between 2 behavioral situations, 1 associated with offspring separation (distress), and 1 with food anticipation (eustress).

Methods

The vocalizations were recorded from the horses at the University of Connecticut horse barns, including the horses in the lesson barn and the horses in the polo barn, which are connected by a common walkway. The breeds of the horses were mostly Morgans and thoroughbreds. The study looked at 2 different situations: morning feeding and mare and foal separation. Both of these situations are potentially stressful situations. Feeding time is an excitable, apparently positive time, or eustress situation, for the horses. Mare and foal separation is an unpleasant, negative time, or distress situation (Malinowski et. al., 1990).

The vocalizations were recorded from horses in box stalls or outside in a small sand turnout pen using a Sony TCD-D8 digital audio tape (DAT) recorder with 48 kHz sampling frequency and 16-bit linear quantization and microphone. The experimenter carried the recorder and microphone during vocalizations. The Sony TCD-D8 DAT recorder had a flat frequency response from 20 Hz-20 kHz. The microphone was an ATR20 and had a frequency response of 80 Hz-12 kHz. The behavior, sex, and breed of the horse were also recorded. It should be noted that during the time of recording, the barn was relatively quiet.

When the horses were confined to box stalls during the 2 situations of feeding time and mare and foal separation, it was permissible to correlate the vocalization with the observed behavior. It should be noted that only the vocalizations of the mares were recorded for the mare and foal separation situation. If the vocalizations recorded were found to be spectrally similar according to the Hidden Markov Model, it was acceptable to assume that the vocalization and observed behavior were correlated.

To determine whether there were environmental factors involved with the vocalizations recorded during the morning feeding time and mare and foal separation situations, outdoor recordings were performed. The mare and foal

Table 1 Total number of horses and vocalizations

	Total horses	Total vocalizations	Total whinnies	Total nickers
Eustress (inside)	25	311	233	78
Distress (inside)	6	201	199	2
Eustress (outside)	3	51	51	0
Distress (outside)	1	16	16	0
Overall	27	582	499	80

Note: The 2 main breeds of horses that were used in the research were Morgans and thoroughbreds. There were a total of 27 horses used for the morning feeding situation and mare and foal separation. Only the mare vocalizations were recorded during the mare and foal separation. From the 27 horses, 499 whinnies were collected and analyzed using the Hidden Markov Model (HMM).