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# Pig Vocalizations Under Selected Husbandry Practices

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## ABSTRACT

Acoustical characteristics of vocalizations of sows, piglets, and nursery pigs under selected husbandry practices were analyzed with a digital signal processing system. The duration (D) and major energy-resonance frequency ( $f^*$ ) for each call were determined as follows: a) processing of piglets (D = 0.81 s and  $f^*$  = 3 700 Hz); b) food anticipation of breeding-gestation sows (2.50 s and 3 000 Hz); c) isolation of piglet (0.34 s and 500, 3 500 Hz); d) startling of nursery pigs (0.29 s and 900 Hz); e) sows in heat (3.07 s and 1 375 Hz); f) farrowing (0.10 s and 3 000 Hz); g) sow nursing (0.15 s and 1 000 Hz); and h) mate greeting of sow (0.13 s and 1 000 Hz). Calls a) to d) are responses to human generated stressors, and calls e) through h) responses to social and physiological states of the pigs. Thus, vocalizations can be segmented for different pig production situations.

## INTRODUCTION

Changes in livestock husbandry practices have led to a growing concern by both livestock producers and consumers about the well-being of animals. Well-being can be defined in physiological or mental terms. The mental well-being can be measured by behavioral or other outward responses. Vocalization, an outward response of the animal, could allow the herdsman to evaluate if management problems exist.

The relationship between physical activity, e.g., peck, threat, step and push, and vocalization has been shown to exist for hens (Stone et al., 1984). Vocalizations of dogs have been identified as bark, whine, howl, and growl (Haupt, 1982). These vocalizations signified various states of the animal, with bark being related to territory marking or various wants or approaching danger; whine being care requesting; and growling being aggression. Relationships between vocalizations and different states of well-being for cats were also reported (Haupt, 1982).

Examples of vocalization of swine related to fear, isolation, pain, greeting, anticipating, and frustration

have been presented by Wood-Gush (1983). These vocalizations were categorized by types of calls, e.g., bark, grunt, squeal, and scream. This simple analysis indicated that these emotions of swine could be identified by combinations of the related vocalizations.

Kiley (1972), as reported by Wood-Gush (1983), developed a series of sonographs for 15 different calls of adult pigs. From these sonographs, differences in frequency pattern and duration of the calls were observed. Jensen and Algers (1984) categorized piglet vocalizations during suckling into five classes: croaking, deep grunt, high grunt, scream, and squeak. Each of the five class calls showed a unique "pattern diagram". The duration of the calls varied from 0.2 s to 0.6 s, and the frequency from 500 Hz to 4 000 Hz, depending upon the type of call. Hence, it appears that vocalization may be used as a global means of evaluating animal welfare and can be combined with physiological measurements to indicate the overall welfare of the animal.

A study of behavioral audiograms on swine (Heffner and Heffner, 1987) indicated that the hearing frequency for pigs has an upper limit of 45 KHz, which is significantly higher than the limit of 17 KHz for humans. This information implies that swine "communication" in a mechanically equipped facility may be interfered with by the existence of ultrasounds which are not "heard" by the people who work there. Thus, "communication" frequencies of swine under various conditions ought to be investigated in order to provide basic knowledge for such a "communication"-interference study.

Experienced herdsman may identify problems through animal vocalization. However, the herdsman cannot be in the livestock facility for 24 h/day. An electronic system that would analyze vocalizations of animals on a 24-h basis might provide a management tool for the stockman. This system could identify the state of the pigs, e.g., farrowing, heat, and hunger. However, the basic premise is that pig vocalizations in different husbandry situations can be segmented to evaluate the state of the animal. The objective of this study was to determine the possibility of such segmentation through electronic acoustical analysis.

## MATERIALS AND METHODS

Pigs used in this study included one-week-old piglets (Whiteline x Duroc breed); nursery pigs (six to seven weeks of age); and breeding-gestation, farrowing and nursing sows (Whiteline breed). These animals were housed in the Integrated Energy Farm facilities at Agricultural Research and Development Center of the University of Nebraska.

Vocalizations of the pigs were recorded with an Uher

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4200 monitor report reel-to-reel recorder† at the highest recording speed of 19 cm/s and frequency response of 20 to 25 000 Hz in association with an MKH 416 Tu3 directional studio microphone (Saul Mineroff Electronics, Inc., Valley Stream, NY). The microphone, with a frequency response of 20 to 20 000 Hz, was held or placed 0.3 m to 1 m away from the animal, except for the recording of the startled vocalizations. Sound recording level was adjusted so the maximum sound signal would not overload the db capacity of the recorder. When necessary, time delay in recording was allowed for the animals to adjust to the presence of experimenter. Mechanical noise in the facility was reduced to minimum during recordings. Vocalizations presented in this report were related to the following husbandry situations.

1. Food anticipation. Prior to once-a-day feeding of breeding-gestation (B-G) sows housed in the 60 sows' B-G room.
2. In-heat. Breeding sows in heat, housed in the B-G room.
3. Mate greeting. Greeting response of breeding sow to boar in the breeding pen.
4. Farrowing. Sow farrowing in a farrowing room.
5. Nursing. Sow response to piglets suckling in a farrowing room.
6. Processing. Castration, teeth clipping, ear notching, and piglet tail removals performed in a farrowing room. (The piglets were cradled between the herdsman's thighs. Insertion was made and the testicles removed with a scalpel. Iodine was then applied to the cut.)
7. Isolation. Separation of a piglet from the sow and other piglets with recording person being present.
8. Startled. Alarm response of nursery pigs to sudden entering of people into a nursery room.

The recorded vocalizations, with at least five animals involved in each category, were digitized and analyzed using a Personal Acoustics Laboratory (PAL) digital signal processing system (Spectrum Engineering, Fairfield, CA) at digitizing rates of 10 KHz to 20 KHz depending upon the type of call being digitized. Analog signals of each call were first digitized at sampling frequency of 20 kHz (capacity of the PAL system) without limiting any signal frequencies. The digitizing rate at 20 kHz allows the analysis of vocalization frequency to 10 kHz. However, when signal frequencies are below 10 kHz, lower digitizing rate can be used thus allowing a longer analog signal record to be digitized. After examination of the digitized signals, they were redigitized with frequencies below and above certain levels filtered. In addition, magnitude of the signals was squared and a percent of the squared magnitude was taken in the three dimensional (frequency, time, and magnitude) (3-D) sonographs. Such a procedure was used to eliminate the unwanted noises, to protect against aliasing, and to maintain the completeness of the signals. Although the actual decibel magnitude was not retained,

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it would not affect the general profile characteristics of the sound. Fast Fourier transformation was used in generation of the 3-D sonographs.

Vocalizations were then categorized according to acoustical characteristics of duration, fundamental frequency ( $f_0$ ), major sound energy-resonance frequency ( $f^*$ ), and tone spectral profile of the vocalization. The duration of each call was measured with the PAL system by the product of time taken per frame of digitized signal and the total number of frames in each call. The  $f_0$  was measured by manually counting the number of signal cycles associated with approximately 0.2 to 0.1 of the call duration. The use of 0.20 to 0.1 of a call to determine its  $f_0$  was because of the similarity among the signals within each cell. With the knowledge of  $f_0$ ,  $f^*$  and other harmonics could be estimated from the 3-D sonographs of the call since harmonics are multiples of  $f_0$ . Tone spectral profiles were also obtained by inspecting the 3-D sonographs. The terms amplitude modulation (AM) (jagged or smooth) and frequency modulation (FM) were used to describe the spectral profiles. A sonograph with basically single-frequency tone but variation in amplitude was referred to having an AM profile. Depending on the appearance, AM profiles were further classified to be either smooth or jagged. Similarly, a sonograph with multi-frequency tones was called an FM profile.

## RESULTS AND DISCUSSION

Representative 3-D sonographs for the selected vocalizations are presented in Figs. 1 and 2. The vocalizations were grouped in terms of responses to human generated stressors (Fig. 1) and response to social and physiological states of the pigs (Fig. 2). The scales of time and amplitude axes in the 3-D sonographs were not shown by the PAL processing programs. Generally, one call was covered on the time span. Since these sonographs were presented mainly for representative illustrations of the vocalization profiles, they were not affected by the unspecified time span and amplitude of the graphs. A summary of the acoustical characteristics of these vocalizations is given in Table 1.

### Food Anticipation

The hungry breeding-gestation sows, while anticipating being fed, produced vocalizations which had an average duration of 2.5 s. The frequency spectrum of the call was characterized by an  $f_0$  of 750 Hz and an  $f^*$  of 2 250 Hz and 3 000 Hz, with jagged AM profiles (Fig. 1). It appeared that once one sow started to vocalize for food, the rest followed, indicating the social nature of pigs in response to an act. The onset of such vocalization seemed to be easily aroused when the animals heard or observed a person. Sows were rather quiet during and after feeding.

### In-heat

Sows in estrus were found vocalizing in their own pens. They were climbing on each other and showed a physical state of being restless. The calls had a duration of 3.1 s,  $f_0$  and  $f^*$  of 1 375 Hz, and contained jagged peak AM profiles (Fig. 2). The in-heat call had the longest duration among all the situation-related vocalizations.

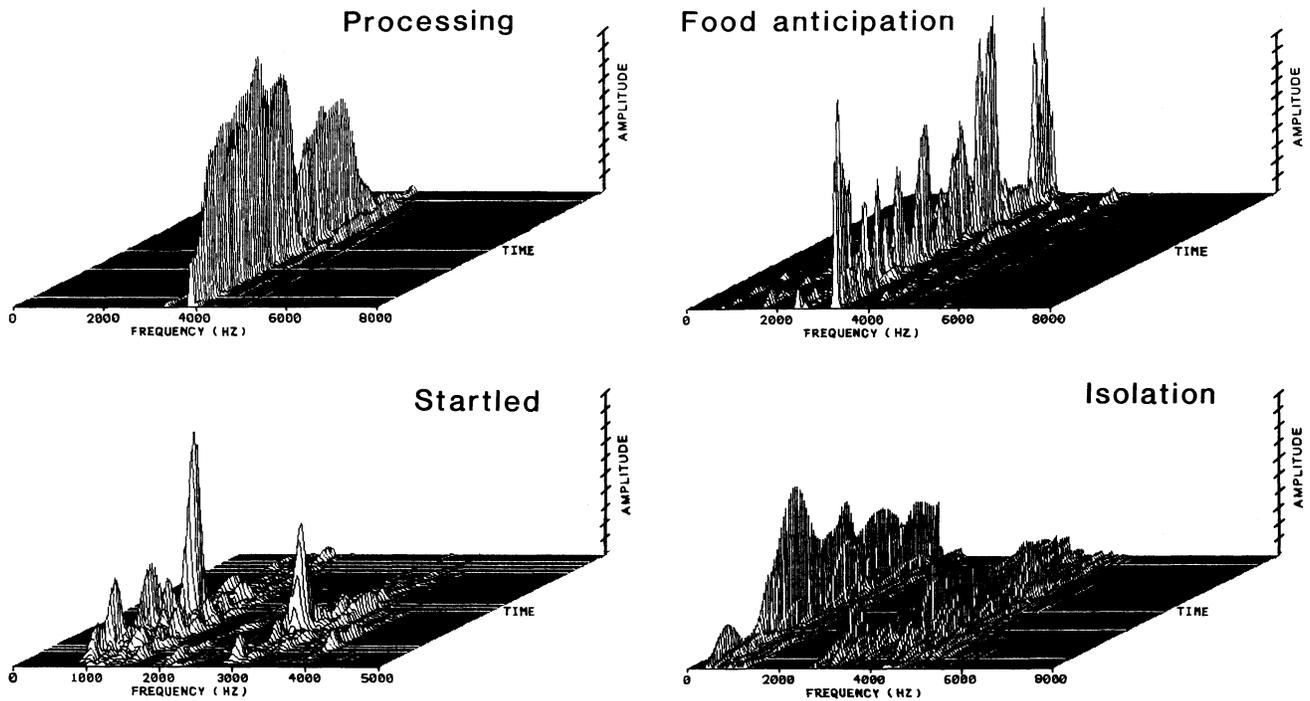


Fig. 1—Sonographs of pig vocalizations to human generated stressors.

### Mate Greeting

As soon as the in-heat sow was placed with the boar, the in-heat calls became greeting grunts. The greeting grunts had a duration of 0.13 s,  $f_0$  of 500 Hz,  $f^*$  of 1 000 Hz and a smooth AM tone spectral profile (Fig. 2). Vocalization was not detected during copulation except toward the end of copulation when the sow started vocalizing, which could result from being tired. The greeting response clearly differed from the food anticipation or the in-heat response.

### Farrowing

The farrowing sow started with deep breathing, followed by unevenly spaced grunts. Such grunts had smooth FM tone profiles, with an  $f_0$  of 750 Hz and an  $f^*$  of 3 000 Hz (Fig. 2). Each grunt lasted for only 0.1 s.

### Nursing

The suckling grunts of a nursing sow shared similar acoustical characteristics with the mate greeting responses, and therefore might be considered as a kind

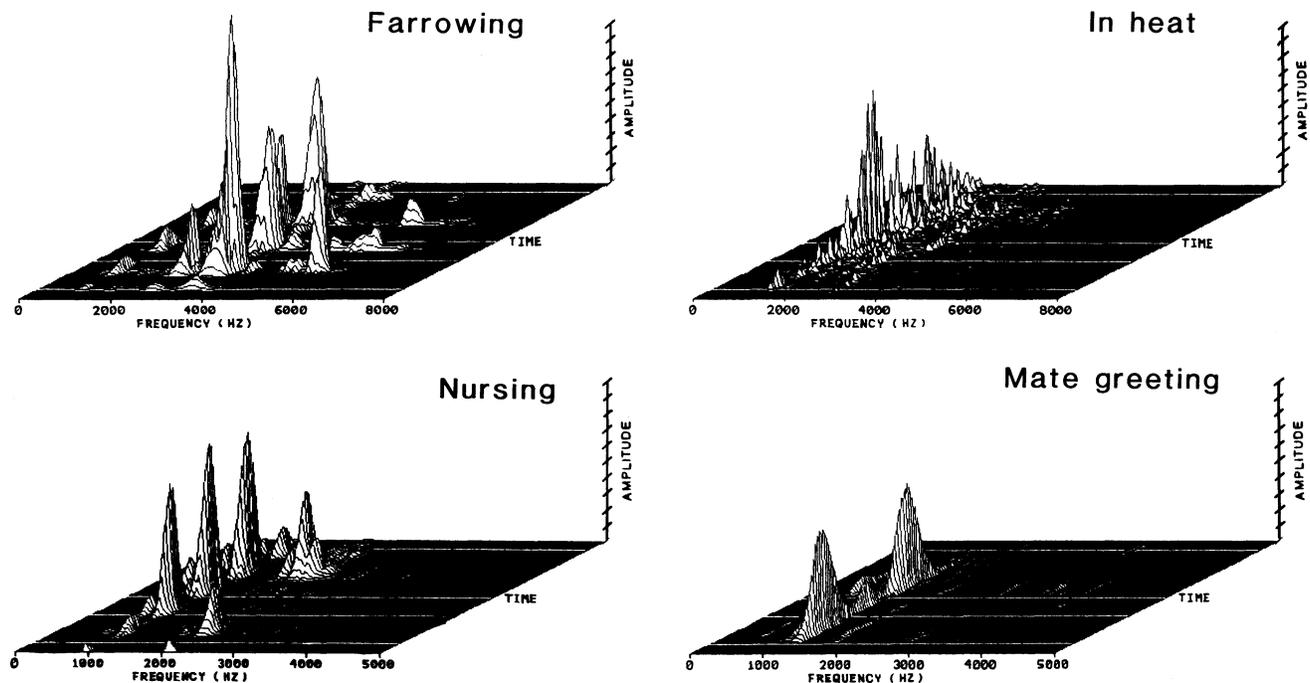


Fig. 2—Sonographs of pig vocalizations to social and physiological states of the pigs.

**TABLE 1. Summary of acoustical characteristics of pig vocalizations under the selected husbandry situations**

Type of calls <sup>1</sup>	Duration(s) ± S.D.	Harmonics (Hz) <sup>2</sup>	Stress Ranking <sup>3</sup>	Tone profile
<b>SOW</b>				
Food anticipation (5)	2.50±1.3	750, 1500, 2250**, 3000*, 3750, 4500	1	jagged AM
In heat (5)	3.07±1.5	1375*, 2750	2	jagged AM
Mate greeting (20)	0.13±0.02	500, 1000*, 1500	6	smooth AM
Farrowing (18)	0.10±0.02	750***, 1500, 2250**, 3000*, 4500	5	smooth FM
Nursing (20)	0.15±0.02	1000*, 2000	6	smooth AM
<b>PIGLET</b>				
Processing (13)	0.81±0.15	3700* (or 3000)	1	pure AM
Isolation (17)	0.34±0.10	500*, 3000, 3500*, 4000, 4500	3	AM & FM
<b>NURSERY</b>				
Startled (7)	0.29±0.10	900*, 1800, 2700	4	AM & FM

<sup>1</sup> Numbers in the parentheses following each type of call are the number of vocalizations involved in the analysis

<sup>2</sup> The first harmonic in each category is defined as the fundamental frequency ( $f_0$ ) of the vocalization. Harmonics with superscripts are the major energy-resonance frequencies where the majority of the acoustical energy is observed. For a given vocalization, the major frequency with the lower number of superscripts occurred more often than the frequency with the higher number of superscripts. Harmonics without superscripts contained much lower energy

<sup>3</sup> The degree of stress would become less severe, based on characteristics of vocalization, as the ranking number becomes larger. Validations of such a ranking based on physiological measurements are suggested

of greeting response. The suckling grunts had a duration of 0.15 s,  $f_0$  of 1 000 Hz, with smooth AM profiles (Fig. 2).

### Processing

Piglets being processed (i.e., when being castrated, ear-notched, teeth-clipped, and tail-removed) produced squeals that had a duration of 0.81 s,  $f_0$  and  $f^*$  of 3 000 or 3 700 Hz, and a clear pure AM tone (Fig. 1). The squeals shared somewhat similar characteristics to the food anticipation sound of sows in that both sounds tended to possess high  $f^*$  and longer duration. The processing squeals, on the other hand, differed from the food anticipation calls in that the squeals had less magnitude variations. Such squeals would be a reflection of restraint or physical pain. The acoustic characteristics noticed here were similar to those for screams of piglets during suckling as reported Jensen and Algers (1984). This information may be helpful in designing a sound detector placed in the farrowing room to monitor piglet well-being.

### Isolation

Vocalizations with a duration of 0.34 s,  $f_0$  of 500 Hz, and  $f^*$  of 500 and 3 500 Hz were found typical for the isolated piglets. The sound appeared to be a mixture of AM and FM profiles, and high and low pitch tones (Fig. 1).

### Startled

The vocalization recording taken for nursery pigs was the startled response of the animals to our sudden appearance in the facility. The startled vocalizations had a duration of 0.29 s,  $f_0$  and  $f^*$  of 900 Hz, and an AM - FM mixing tone profile (Fig. 1). This mixture could represent an integration of both greeting response and alarm response of the pigs.

It appeared that both duration and frequency, at least  $f^*$ , of the vocalizations increased as stress of the animal became more severe, although no behavioral or physiological data were taken to verify this tendency. Based on such a criterion, the severity of stress might be ranked in a descending order (Table 1) as follows: piglet processing or food anticipation of B-G sows; sows in heat; isolation of piglets; startling of nursery pigs; and farrowing. Nursing and mate greeting responses were considered to be non-stressful indicating calls. Thus, a sound-sensing device might be developed to monitor the state of the pigs with the aid of an expert system.

### CONCLUSIONS

Pig vocalizations related to selected situations could be segmented from each other and possibly from background noise, e.g., farrowing from nursing. The degree of pig stress might be distinguished based on the acoustical characteristics of vocalizations in terms of duration and frequency, with more severe stress tending to result in longer duration and higher frequency calls, although such tendency needs to be further validated through physiological or behavioral means.

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