A note on acoustic analysis of dairy calves’ vocalizations at 1 day after separation from dam

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ABSTRACT

The vocalizations of animals are very useful in assessing an emotional state and welfare because they involve information about various emotions. Hence, the findings of the acoustic features of vocalization can be used to improve the productivity and welfare of animals. This study was conducted to analyse the vocalizations of dairy calves separated from the dam. At 6 days after birth, 12 dairy calves were moved into an individual calf pen (3.0m×2.0m) bedded with sawdust and straw. One and a half litres of whole milk were fed twice daily and free access to water was allowed. The calves’ vocalizations were divided into humming vocalizations (HVs: low continuous calls without tone changed), semi-humming vocalizations (SHVs: low continuous calls with tone changed), and general vocalizations (GVs). These vocalizations were classified, based on the shapes of waveforms and spectrograms. Differences in the duration, fundamental frequency, intensity, and formants among the classified vocalizations were found (P<0.0001). Acoustic parameters except intensity and 3rd formant were not different between HVs and SHVs. These results suggest that vocalization analysis could be a useful tool in assessing the emotions of calves. Acoustic parameters are also useful in classifying vocalizations. Also, intensity and 3rd formant are advantageous in distinguishing HVs and SHVs.

Key words: Vocalization, Dairy calf, Separation, Acoustic parameters.

RIASSUNTO

NOTA SULL’ANALISI ACUSTICA DI VOCALIZZAZIONI DEI VITELLI IL GIORNO DOPO LA SEPARAZIONE DALLA MADRE

Le vocalizzazioni risultano particolarmente utili per accertare le condizioni emotive e di benessere degli animali, poiché includono informazioni su diversi stati emozionali. I risultati dell’analisi acustica sulle vocalizzazioni possono quindi essere usati per migliorare la produttività e il benessere animale. Il presente...
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study è stato condotto per analizzare le vocalizzazioni di vitelli di allevamento da latte separati dalla madre. Al sesto giorno dalla nascita 12 vitelli sono stati spostati in box individuali (m 3,0×m 2,0) con lettiera composta da segatura e paglia. I vitelli sono stati alimentati con latte (1,5 l/die) e disponevano di accesso libero all’acqua. Le vocalizzazioni dei vitelli sono state suddivise in vocalizzazioni a bocca chiusa o humming (HVs: richiami bassi e continui senza cambiamenti di tono), semi-humming (SHVs: richiami bassi e continui con cambiamenti di tono) e generali (GVs). Le vocalizzazioni sono state classificate sulla base delle tipologie di forme d’onda e spettrogrammi. Le vocalizzazioni rilevate hanno evidenziato differenze significative (P<0,0001) per quanto concerne durata, frequenza fondamentale, intensità e formanti. Non sono state rilevate differenze significative dei parametri acustici tra le vocalizzazioni HVs e SHVs eccetto l’intensità e il 3° formante. I risultati suggeriscono che l’analisi acustica delle vocalizzazioni potrebbe essere uno strumento utile per comprendere le emozioni degli animali. I parametri acustici si sono rilevati adeguati per classificare le vocalizzazioni, inoltre l’intensità e il 3° formante sono risultati idonei per distinguere HVs da SHVs.

Parole chiave: Vocalizzazioni, Vitelli, Separazione, Parametri acustici.

Introduction

The vocalizations of animals have been discussed a long while (Castren et al., 1989; Watts and Stookey, 2000; Thomas et al., 2001; Marchant-Forde et al., 2002) because an animal’s vocalization involves information regarding various emotions. The information presented by vocalizations can be used to improve the productivity and welfare of animals. Playing artificial nursing and suckling sounds effectively induced nursing behaviour in sows and suckling behaviour in piglets (Jeon et al., 2003). Several studies (Kältwasser. 1990; Jourdan et al., 1995; Calvino et al., 1996) have indicated that 22 kHz calls of a rat’s vocalization are associated with pain. Vocal behaviour may be useful in developing methods of separation and weaning (Thomas et al., 2001).

Domestic mammals are separated from the dam and then face a new social environment in animal husbandry (henceforth weaning). The young mammals experience a new diet and new environment with weaning, which causes weaning stress and many other problems such as digestive trouble, thereby decreasing food intake and daily gain. Actually, weaning distress in calves was aggravated by simultaneous disruption of nutrition and social aspects (Haley et al., 2005).

It was assumed that calves’ vocalization characters during post-separation would be very useful in assessing their emotions or welfare. The objective of this study was to analyse dairy calves’ vocalizations after separation from the dam.

Material and methods

This study was conducted with 12 Holstein dairy calves (7 males and 5 females). Two weeks prior to the calving date, the cows were moved to an individual pen (4.0m×3.0m). Cows had free access to water, total mixed grain ration, and hay. The pen had concrete floor bedded with sawdust and straw. After calving, cows and calves were kept together in the pen until the separation day (6 days after calving). At 6 days after birth, calves were moved into individual calf pens (3.0m×2.0m) bedded with sawdust and straw. This building was isolated from any contact (visual or auditory) with dams. Calves were artificially fed 1.5 L milk twice a day and water was freely accessible.

Camcorders (JVC, GR-HD1KR) with microphones (Sennheizer, ME 66) were hung 2m above the floor of each pen. Calves’ vo-
Acoustic analysis of calves’ vocalizations were recorded for 120 min (06:00 to 07:00 and 12:00 to 13:00) on 1 day after separation because the most suitable time to record calves’ vocalizations was between 18 to 24 h after separation and before the morning feeding (Flower and Weary, 2001). The calves’ vocalizations were divided into humming vocalizations (HV: low continuous calls without tones changed; n=33), semi-humming vocalizations (SHV: low continuous calls with tones changed; n=28), and general vocalizations (GV; n=233). These vocalizations were classified, based on the waveform and spectrogram display (Figure 1 next page). These amplitude changes are easily classified according to waveform or spectrogram because cow and calf vocalizations have harmonics similar to the human voice (Kiley, 1972; Weary and Chua, 2000). The recorded vocalizations were digitised at a sample rate of 44 kHz and at 16-bit resolution using Cool Edit 2000 (Syntrillium, USA). Praat (P. Boersma & D. Weenink, Netherlands) was used to detect acoustic parameters. Call duration (second, s) was measured using the waveform. Intensity (dB), fundamental frequency (Hz), first formant (Hz), second formant (Hz), third formant (Hz), and forth formant (Hz) were measured with the spectrogram, and the definitions of parameters were described as shown in Table 1.

Table 1. Description of parameters used for acoustic analysis.

| Parameter         | Description                                      |
|-------------------|--------------------------------------------------|
| Duration          | The duration of the vocalization                 |
| Intensity         | The degree of strength of the vocalization       |
| Fundamental frequency | Auditory feature of sound aiming the high and the low of the sound |
| 1st formant       | The first harmonic of resonance                  |
| 2nd formant       | The second harmonic of resonance                 |
| 3rd formant       | The third harmonic of resonance                  |
| 4th formant       | The fourth harmonic of resonance                 |

Three hundred eleven calls were collected from 12 dairy calves. Seventeen calls, however, were excluded because these included environmental noise (e.g., drinking sound, feeding sound). The acoustic parameters had approximately normal distributions, so that no transformation was needed. In order to compare acoustic characters of classified calls, parameters were statistically analysed using analysis of variance in the GLM (general linear models) procedure (SAS, 2000). The effect of sex was included in the GLM model, but it was not significant (P>0.05). Also, the discriminant function was used to derive the discriminant criterion (SPSS, 1998). Discriminant analysis was processed using the method of pairwise comparison. Parameters were expressed as means and standard deviation.

Results and discussion

HV (n=33) and SHV (n=28) were investigated in 294 calls in this study and those were especially emitted with their mouths closed. These observations were most likely due to feelings of uneasiness by separation from the dam, which was comparable to that of Hopster et al. (1995). They reported that cows vocalized at low amplitude with their mouths closed when the calf was separated from the dam.
Figure 1. Waveforms and spectrograms of dairy calves’ vocalizations.

a) Humming vocalizations (HVs)

b) Semi-humming vocalizations (SHVs)

c) General vocalizations (GVs)
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In addition, Kiley (1972) reported that ‘mm’ call could be interpreted as a recognition signal between cows and calves. Therefore, we suggest that HVs and SHVs be closely connected with weaning or separation stress.

We observed differences in the duration, fundamental frequency, intensity, and formants among the vocalizations by the shape (Table 2; P<0.0001). Acoustic parameters except intensity and 3rd formant had no difference between HVs and SHVs. The intensity of the HVs (64.9±3.7 dB) was the lowest, while that of the GVs was the highest (75.2±3.0 dB). The 3rd formant of the GVs was the lowest (2242.0±57.4 Hz) whereas that of the HVs was the highest (2368.0±95.0 Hz) (Table 2; P<0.0001). These results showed that duration, fundamental frequency, intensity, and formants were useful to classify vocalizations. Intensity and 3rd formant was advantageous to distinguish HVs and SHVs. Yeon et al (2006) reported that there were differences in intensity and formants between estrus and feed anticipating vocalizations. Intensity, 2nd formant, and 4th formant were useful parameters for discrimination of estrus-related vocalizations in sows (Jeon et al., 2005a). This result also showed that these parameters were useful in classifying calf vocalizations by the shape although peak frequency and duration were advantageous to assess emotions in laboratory rats (Sales, 1972; Burman et al., 2006). Maximum frequency and minimum frequency were used to characterize the individual nursing sounds in sows (Blackshaw et al., 1996).

Duration, fundamental frequency, and intensity of the GVs were higher than those of HVs and SHVs, whereas formants of the GVs were particularly lower compared to others. Our findings suggested that fundamental frequency of the GVs be 130.4±21.9 Hz and duration of the GVs be 1.489±0.395 s (Table 2). These results were different from those of Weary and Chua (2000). They reported that fundamental frequency was 103±7 Hz and duration was 0.98±0.07 s at 1 day after separation. These differences would be due to character of the calls because they did not classify calls into call shapes such as wave-

| Parameter                  | HVs       | SHVs      | GVs       | P-value    |
|----------------------------|-----------|-----------|-----------|------------|
| No. of calls               | 33        | 28        | 233       |            |
| Duration                   | 1.100 ± 0.437b | 1.068 ± 0.348b | 1.489 ± 0.395a | < 0.0001  |
| Fundamental frequency      | 96.0 ± 21.9b | 104.3 ± 20.0b | 130.4 ± 21.9a | < 0.0001  |
| Intensity                  | 64.9 ± 3.7c | 66.5 ± 3.1b | 75.2 ± 3.0a | < 0.0001  |
| 1st formant                | 784.7 ± 87.0a | 760.0 ± 76.7a | 726.0 ± 64.4b | < 0.0001  |
| 2nd formant                | 1548.8 ± 74.3a | 1566.7 ± 75.6a | 1489.0 ± 78.8b | < 0.0001  |
| 3rd formant                | 2368.0 ± 95.0a | 2322.4 ± 93.6b | 2242.0 ± 57.4c | < 0.0001  |
| 4th formant                | 3036.5 ± 76.0a | 3014.5 ± 64.3a | 2929.9 ± 52.2b | < 0.0001  |

1HV: humming vocalizations, SHV: semi-humming vocalizations, GV: general vocalizations.

a,b,c: Means with different superscripts in the same rows are significantly different.
form and spectrogram. After discrimination analysis, 68.4% of vocalizations were classified to the original group.

There was a close connection between the fundamental frequency and the vocal cords. Also, formants had a close relation to the vocal tract such as the oral cavity (Jeon et al., 2005b). We therefore suggest that GVs are supported by the vocal cords, whereas the HVs and SHVs are supported by vocal organs. However, the values of acoustic parameters are not always absolute because the methods of management affect these factors. For instance, a fundamental frequency is higher when calves are fed conventionally than when fed more milk (Thomas et al., 2001).

In this study, we did not consider analysis of a call frequency because all calves were moved at 6 days after birth. However, several studies showed that behavioural responses of both cow and calf increased in relation to calf age at separation (Lidfors, 1996; Weary and Chua, 2000; Flower and Weary, 2001). According to Marchant-Forde et al. (2002), cows and calves responded more frequently to calls of their own calves and cows than those of other groups. These results indicated that individual recognition in calves was formed at an early age. Hence, the call frequency might be a useful parameter to evaluate emotions. This assumption was similar to data reported by Thomas et al. (2001) who showed that vocal behaviour might be useful in developing methods of separation and weaning.

Conclusions

The vocalizations of dairy calves could be classified into HVs, SHVs, and GVs. We suggest that HVs and SHVs are closely connected with weaning or separation stress. There were significant differences in duration, fundamental frequency, intensity, and formants among the classified vocalizations with ANOVA. Our results supported characters of calves’ vocalizations during post-separation. Therefore, we suggest that vocalization analysis might be possible in assessing the emotion and welfare of calves, and that stress related call (HV and SHV) frequency could be a useful indicator in assessing emotions or welfare. However, further study is necessary in order to use this method as a standard for emotion or welfare assessment.

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REFERENCES

Blackshaw, J.K, Jones, D.N., Thomas, F.J., 1996. Vocal individuality during suckling in the intensively housed domestic pig. Appl. Anim. Behav. Sci. 50:33-41.

Burman, O.H.P., Ilyat, A., Jones, G., Mendl, M., 2007. Ultrasonic vocalizations as indicators of welfare for laboratory rats (Rattus norvegicus). Appl. Anim. Behav. Sci. 104:116-129.

Calvino, B., Besson, J.M., Boehrer, A., Depaulis, A., 1996. Ultrasonic vocalization (22-28 kHz) in a model of chronic pain, the arthritic rat: effects of analgesic drugs. Neuroreport 7:581-584.

Castren, H., Algers, B., Jensen, P., Saloniemi, H., 1989. Suckling behaviour and milk consumption in newborn piglets as a response to sow grunting. Appl. Anim. Behav. Sci. 23:227-238.

Flower, F.C., Weary, D.M., 2001. Effects of early separation on the dairy cow and calf. Separation at 1 day and 2 weeks after birth. Appl. Anim. Behav. Sci. 70:275-284.

Haley, D.B., Bailey, D.W., Stookey, J.M., 2005. The effects
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of weaning beef calves in two stages on their behavior and growth rate. J. Anim. Sci. 83:2205-2214.
Hopster, H.J., O’Connell, M., Blokhuis, H.J., 1995. Acute effects of cow-calf separation on heart rate, plasma cortisol and behaviour in multiparous dairy cows. Appl. Anim. Behav. Sci. 44:1-8.
Kaltwasser, M.T., 1990. Startle-inducing acoustic stimuli evoke ultrasonic vocalization in the rat. Physiol. Behav. 48:13-17.
Kiley, M., 1972. The vocalizations of ungulates, their causation and function. Z. Tierpsychol. 31:171-222.
Jeon, J.H., Yeon, S.C., Chang, H.H., 2003. Selecting an effective sound for inducing sows and their piglets to nurse and suckle. Korean J. Anim. Sci. Tech. 45:627-632.
Jeon, J.H., Yeon, S.C., Chang, H.H., 2005a. Comparative analysis for general and estrus-related vocalizations in sows. Korean J. Anim. Sci. Tech. 47:133-140.
Jeon, J.H., Yeon, S.C., Ha, J.K., Lee, S.J., Chang, H.H., 2005b. Acoustic analysis for thermal environment-related vocalizations in laying hens. Korean J. Anim. Sci. Tech. 47:1-6.
Jourdan, D., Ardid, D., Chapuy, E., Eschalier, A., Le Bars, D., 1995. Audible and ultrasonic vocalization elicited by single electrical nociceptive stimuli to the tail in the rat. Pain 63:237-249.
Lidfors, L.M., 1996. Behavioural effects of separating the dairy calf immediately or 4 days post-partum. Appl. Anim. Behav. Sci. 49:269-283.
Marchant-Forde, J.N., Marchant-Forde, R.M., Weary, D.M., 2002. Responses of dairy cows and calves to each other’s vocalizations after early separation. Appl. Anim. Behav. Sci. 78:19-28.
Sales, G.D., 1972. Ultrasound and aggressive behaviour in rats and other small mammals. Anim. Behav. 20:88-100.
Thomas, T.J., Weary, D.M., Appleby, M.C., 2001. Newborn and 5-week-old calves vocalize in response to milk deprivation. Appl. Anim. Behav. Sci. 74:165-173.
Watts, J.M., Stookey, J.M., 2000. Vocal behaviour in cattle: the animal’s commentary on its biological processes and welfare. Appl. Anim. Behav. Sci. 67:15-33.
Weary, D.M., Chua, B., 2000. Effects of early separation on the dairy cow and calf. 1. Separation at 6 h, 1 day and 4 days after birth. Appl. Anim. Behav. Sci. 69:177-188.
Yeon, S.C., Jeon, J.H., Houpt, K.A., Chang, H.H., Lee, H.C., Lee, H.J., 2006. Acoustic features of vocalization of Korean native cow (Bos taurus coreana) in two different conditions. Appl. Anim. Behav. Sci. 101:1-9.