euronoise 2021
25th to 27th of October
Madeira, Portugal - online

Dairy Cattle Welfare through Acoustic Analysis: preliminary results of acoustic environment description

Rosa M Alsina-Pagès[1], Pol Llonch[2], Gerardo José Ginovart-Panisello[1], Raúl Guevara[3], Marc Freixes[1], Muriel Castro[2], Leticia Duboc[1], Eva Mainau[3]

[1] GTM – Grup de Recerca en Tecnologies Mèdia, La Salle – URL, c/Quatre Camins, 30, 08022 Barcelona (Spain)

[2] Department of Animal and Food Science, Universitat Autònoma de Barcelona, 08193, Cerdanyola del Vallès (Spain)

[3] AWEC Advisors S.L. Parc de Recerca de la UAB, Av. Can Domènech S/N, 08193 Cerdanyola del Vallès (Spain)

Abstract

Animal welfare has become a fundamental concern for western society. Studies show that animal welfare is associated to growth and reproductive potential, as well as the production efficiency. However, the assessment of animal welfare normally relies on momentary recordings of environmental and animal-based indicators. Tools available for this purpose are costly, time consuming and sometimes invasive. Livestock vocalizations can inform about their welfare in a real time and continuous manner. This contribution shows the preliminary results of an acoustic environmental analysis conducted in a real-operation environment, in a dairy cattle farm, to assess cow's vocalizations. The main parameters analyzed correspond to the vocalizations, their peak frequency and their repetitiveness, in the framework of their daily life. In this work we describe the acoustic characterization of vocalizations and their similarities and differences, depending on factors known to affect negatively the welfare of the cows such as feed availability (hunger), parturition (pain), among others. These preliminary results reveal that some audio descriptors are able to inform about the welfare of cows through a non-invasive and continuous system that can be used throughout the lifespan of the cows.

Keywords: acoustic signal processing, cow, vocalization, bioacoustics, animal welfare

1 Introduction

Dairy cattle are one of the livestock systems with the highest production shares in Europe. Over the last decades, animal welfare has become a fundamental concern for this industry. Studies show that the welfare of cows may adversely affect their growth and reproductive potential, as well as the quantity and the quality of the milk they produce [1]. Furthermore, society has become increasingly aware of animal welfare, demanding transparency and better treatment of farmed animals [2].

Demand for animal-based products is expected to increase in the next years [3]. Meeting demand depends on the sector's competitiveness against world exporters and improvements on quality standards compared to Europe's main competitors. Competitiveness can be boosted by increasing the production efficiency and

aligning with the demands of consumers. Animal welfare addresses both strategies as it affects production efficiency and consumer acceptability [4]. Studies showed that many animal welfare problems generate a stress response, reducing feed intake and efficiency in transforming it into food products and making them more susceptible to diseases [5]. Also, consumers are increasingly concerned with the welfare of animals in the food production system, demanding transparency and proactive ways to ensure the welfare of animals [6]. Thus, if animal welfare can be monitored constantly, this will allow for the implementation of relevant corrective measures for efficiency and to provide consumers the information they demand.

The acoustic characteristics of cattle vocalizations varies according to their welfare [7]. However, despite the efforts made in investigating the association between vocalizations and welfare, this research has never been translated successfully into a tool available to farmers and producers. In this paper, we detail the first steps to develop a tool to monitor vocalizations of cows for automatically detecting changes in their levels of stress or pain and their resulting welfare status. The advantages of the future implementation of this proposal are that it (1) offers a continuous 24x7 monitoring of the wellbeing of cows (technological advantage); (2) does not require human effort to measure it (economic advantage); and (3) it monitors the welfare on cows throughout their lifetime using automatic methods, giving consumers a more realistic view of animal welfare (social advantage).

In this work we detail the interdisciplinary work in signal processing and animal welfare to carry out recording campaigns in a real-environment of a commercial cattle farm and we describe the first approximation to labelling of cow vocalizations, that will lead in the future to the design of a complete acoustic corpus to train a machine learning algorithm to automatically detect the acoustic description and characterisation of the cattle in a farm.

2 The Acoustic System

Figure 1 – Acoustical deployment in farm (left), the recording box (centre) and the recording hardware (right) microphone position

In order to collect raw cow vocalization in farm without distorting the farmer's management routine, we have deployed an acoustic system in a commercial dairy farm (Malla, Barcelona). This system consists of a professional handheld recorder (zoom H5 [8]) sampling at 44,100 Hz and 16 bits resolution connected to a directional microphone Behringer ultravoice XM1800S [9] placed in the centre of the calving cow beds. Raw recording data is continuously collected for 5 days, as longer recording was not possible due to the capacity of the equipment limited to 32 Gb of data.

In order to gather vocalisations from a specific individual, a recording system integrated in a collar has been designed. The core of the system is the spy recorder SOROKA 15E [10]. This recorder allows to record uncompressed PCM audio at a different sampling rates and resolutions. Moreover, it offers a much greater autonomy than handheld recorders. The recorder is elastically suspended inside a collar through a 3D printed structure specially designed for this purpose (see Fig. 2).

Figure 2: (left) The collar with the small recorder suspended inside, to record individual vocalizations during the drying-off, and (right), the installation of the acoustic sensor next to the calving cow beds.

3 Recording campaign

The recording campaign consists in three different experiments to evaluate of the cow vocalizations: i) calving cows, ii) cows during the dry-off period, and iii) lactating cows, in the barn. These situations were chosen because they can potentially greatly affect the production and wellbeing of cows. Calving is a painful and risky process for both the cow and the new-born calf. Optimizing the calving process will reduce its negative consequences on the welfare and productivity of cows [11]. The dry-off period is critically important for the welfare of dairy cows and their production in the following lactation. The main welfare problems during the dry-off period are an increased risk of intramammary infections, pain and discomfort due to udder engorgement and aggressive interactions between cows [12]. Finally, lactating cows can suffer from pain in different situations, as for instance during lameness and mastitis. Vocalisations can be used as an indicator of pain, therefore used to monitor welfare problems associated to pain [13].

During the three trials, the team considered the environmental noise in the farm, cows' group vocalizations, and also the vocalizations of individuals animals). The following three blocks of tests were designed to ensure more reliable technical results from this proof of concept:

1. **Recording of vocalizations during calving**: the dataset gathered sums up to 135 hours and 30 minutes of calving cows, having recorded the vocalizations of several deliveries indicated by the farmer.
2. **Recording during dry-off period:** with a total of 100 hours of environmental acoustic recordings of the drying-off cows' site. Moreover, a total of 56 hours and 29 minutes were recorded from one of the three cows using the collar.
3. **Recording of regular lactating cows:** during 200 hours and 56 minutes, which were used as the reference of non-stressed group vocalizations.

4 Data Processing and Qualitative analysis

In this section, we make a brief summary of the first approach made to the recorded data, in this case, on the labelling of cows in the process of calving. In particular the analysed test dataset consists of 68 minutes of manually labelled audio containing 115 vocalizations. We first describe the taxonomy used and then discuss the manual labelling process.

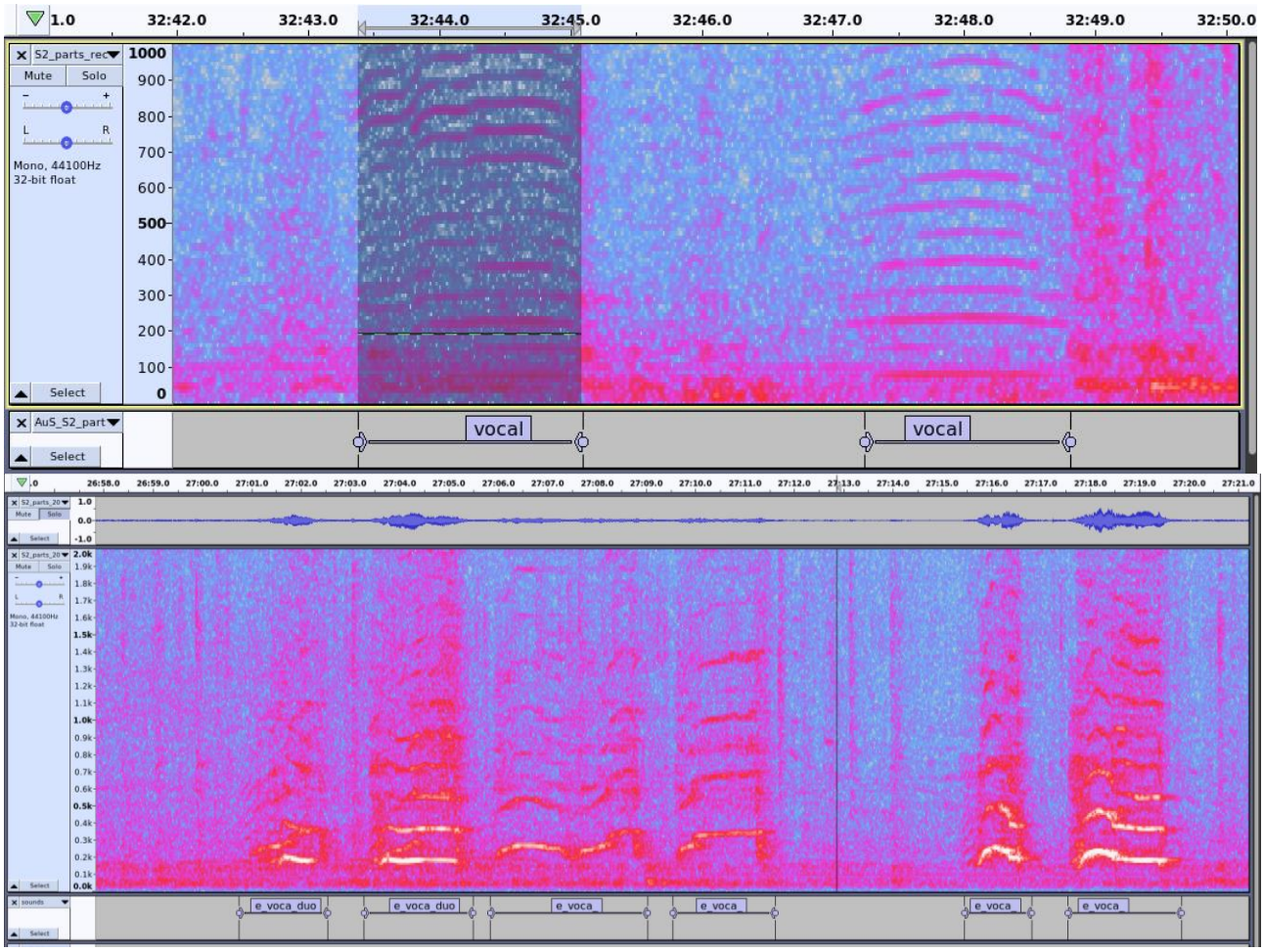

Figure 3 and 4: Vocalization labelling using Audacity. The labels can be found in the bottom of the screen. Just above, we can observe the spectrogram, and finally, in the top part is the time representation of the same raw acoustic audio.

4.1 Preliminary Labelling Procedure

The labelling process is normally manual and under the watchful eye of experts, in this case, veterinarians and acoustic signal processing engineers. We have used a free software called Audacity which allows for multiple tagging for each audio fragment recorded on the farm, see several examples in Figures 3 and 4. It also allows to extract the vocalizations once labelled, so that one can work without all the other environmental sounds recorded on the farm.

4.2 Preliminary Analysis of Vocalizations

The 115 annotated vocalisations sum up a total of 141.4 seconds, representing a 3.47 % of the duration of the whole audio file. The preliminary analysis over this data shows that the duration of the vocalisations range between 0.49 and 2.92 s, being their average duration 1.23 s. The distribution of durations is depicted in Fig. 5. Regarding the fundamental frequency f0, they range from 73.86 to 278 Hz, and the average is 156.84 Hz.

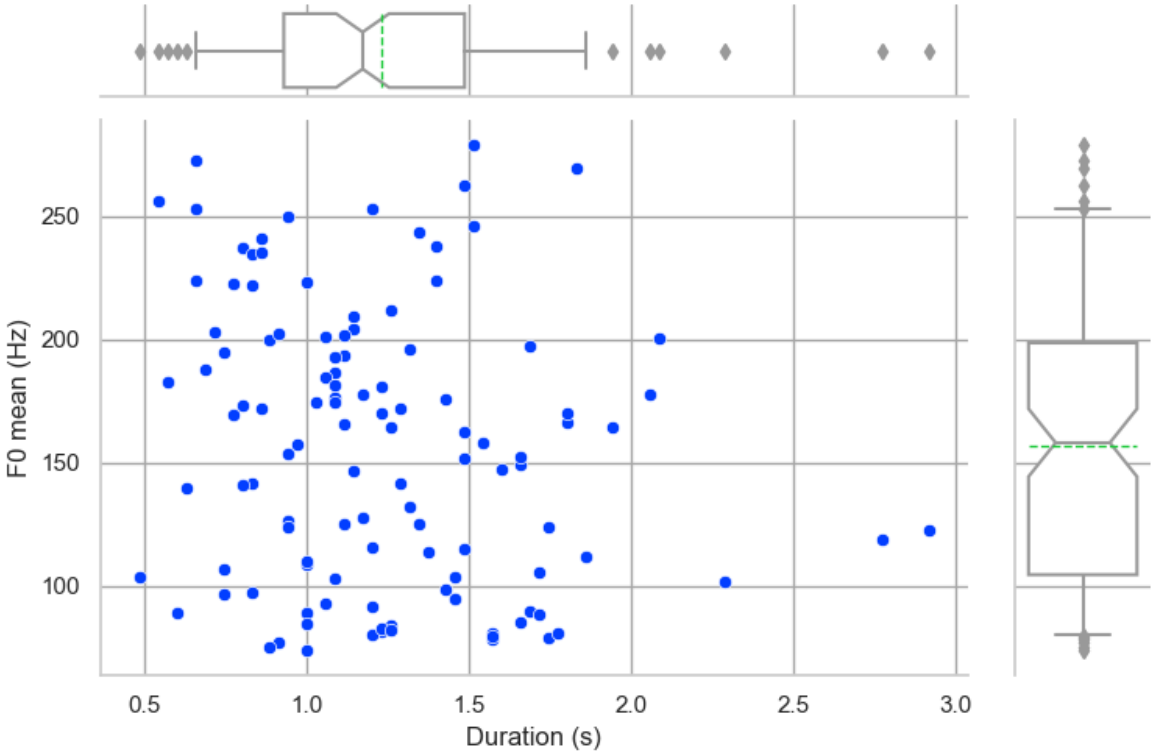

Figure 5: duration and f0 mean of the analysed vocalisations. Whiskers are set to 5th and 95th percentile.

The spectral characteristics vary between different vocalisations. Fig. 6 shows two spectrograms corresponding to a low and a high f0 vocalisations. According to the literature these would correspond to a relaxed or positive state and to a stress, pain or hunger.

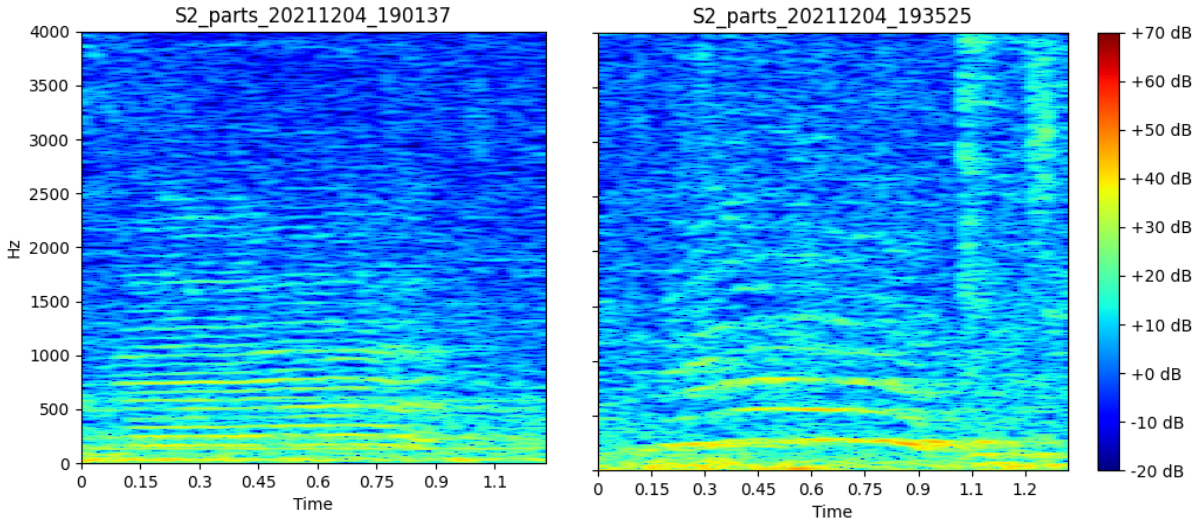

Figure.6. Spectrograms of two vocalisations. The one on the left could be associated with a relaxed cow, the other with stress or pain.

3 Discussion and Future Work

The first approximation presented in this paper has create a small corpus with high-quality recording of cows' vocalizations in a commercial farm and their respective spectrotemporal data. The preliminary labelling of vocalizations of cows in labour showed that previous to labour, cows perform vocalisations with a different acoustic profile, which could be easily identified by a trained human. This encourage us to progress with the labelling, probably creating an automatic labeller to increase the total amount of data annotated, with a posterior supervision of experts. After enlarging the dataset available, we will carry out some tests over machine learning algorithms to determine whether the different types of vocalizations can be distinguished in an automatic way, by means of a small – and probably low-cost – acoustic sensor to be deployed in different locations of a farm.

The first task focuses on working in the real-life environment of a farm, considering all the other possible noises and interferences on our system. Farms have many physical obstacles and different types of machinery that influence the quality of the collected audio. To consider those, it will be necessary a physical and acoustic analysis of the potential environments of the farms under test to ensure an adequate capture of the vocalization data. This includes a study of the coverage of the microphones and their range to determine how many animals may be under study, and if it is necessary more than one sensor in a particular environment. In this first task, we will also consider the connectivity platform of the sensor to enable the collection of the recorded data from the recording set to be able to design the datasets. In a later stage this connectivity will allow the constantly

reporting of vocalizations detected on the sensor to a central server that integrates it, analyses it over time (with the philosophy of a longitudinal study) and generates reports of events that have occurred on the farm.

The second task focuses on the testing of the sensor in a real farm environment, to ensure its correct operation and connectivity. This sensor will record fragments of raw acoustic data (RAW) to extract both the acoustic level of the farm (calculated in-situ within the sensors) and examples of vocalizations that respond to different circumstances of interest. This data will allow us to design a wider dataset, including other locations and environmental sounds. This phase has a high cost in terms of data storage, and must be limited in time but also in the amount of data that is stored.

The goal of this procedure is to enrich our knowledge of the acoustic environment of the farms, so that the team can design a reliable sensor, running real-time algorithms that are able detect instantaneously any modification in the vocalisations and monitor big data of information coming from the farms, and furthermore, are able to respect the privacy of the farm and its workers. Finally, the last contribution of this work, when the previous technical stages are complete, will be to predict particular health or wellbeing of the cows and to inform the farmers or the veterinarians of any incidence.

Acknowledgements

This work was partially funded by IdC 2019 - LLAVOR, with a project entitled “CowTalk: Automatic Classification of Cow Vocalisations to Monitor Dairy Cattle Welfare”, with code 2019-LLAV-00060, with FEDER and AGAUR funding. The authors wish to thank Josep Maria of the commercial farm in Malla.

References

[1] Bargo, F., & Tedó, M. B. E. Mainau, P. Llonch, IR Ipharraguerre, and X. Manteca. 2018. Chicken or the egg: the reciprocal association between feeding behavior and animal welfare and their impact on productivity in dairy cows. *Front. Vet. Sci*, *5*, 305-316.

[2] Gołębiewska, B., Gębska, M., & Stefańczyk, J. (2018). ANIMAL WELFARE AS ONE OF THE CRITERION DETERMINING POLISH CONSUMERS’DECISIONS REGARDING THEIR PURCHASE OF MEAT. *Acta Scientiarum Polonorum. Oeconomia*, *17*(3), 13-21.

[3] FAO, 2012. World Agriculture towards 2030/2050: The 2012 Revision. ESA Working Paper No 12-03.

[4] Buller, H., Blokhuis, H., Lokhorst, K., Silberberg, M., and Veissier, I. (2020). Animal welfare management in a digital world. *Animals* 10, 1–12. doi:10.3390/ani10101779.

[5] Morrow-Tesch JL, McGlone JJ, Salak-Johnson JL. Heat and social stress effects on pig immune measures. J Anim Sci. 1994;72(10):2599–609.

[6] Font-I-Furnols M, Skrlep M, Aluwé M. Attitudes and beliefs of consumers towards pig welfare and pork quality. IOP Conf Ser Earth Environ Sci. 2019;333(1).

[7] Mainau, E., Temple, D., LLONCH, P., & MANTECA, X. UDDER PAIN AND DISCOMFORT AT DRY-OFF IN DAIRY CATTLE (II).

[8] Zoom Corporation. H5 Handy Recorder—Operation Manual; Zoom Corporation: Tokyo, Japan, 2014.

[9] Behringer. Ultravoice XM1800S Technical Specifications; Behringer: Willich, Germany, 2011.

[10] https://ts-market.com/products/models/19058/ [last access 25/07/2021]

[11] Mainau E, Manteca X (2011). Pain and discomfort caused by parturition in cows and sows. Applied Animal Behaviour Science 135: 241-251.

[12] Vilar MJ, Rajala-Schultz PJ (2020). Dry-off and dairy cow udder health and welfare: Effects of different milk cessation methods. The Veterinary Journal 262: 105503 http://dx.doi.org/10.1016/j.tvjl.2020.105503

[13] Green, A. C., Johnston, I. N., & Clark, C. E. F. (2018). Invited review: The evolution of cattle bioacoustics and application for advanced dairy systems. animal, 12(6), 1250-1259.