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Listening to Farm Animals: How Sound Analysis Could Revolutionize Livestock Welfare Monitoring

*Shruti Gupta and Sanchit Pal Singh
ICAR-Indian Veterinary Research Institute, Izatnagar, India
*Corresponding Author's email: shruti.gupta0202@gmail.com

Farm animal welfare is increasingly recognized as critical to sustainable agriculture, yet monitoring it remains challenging. Bioacoustics is the analysis of animal vocalizations and sounds that offers a promising non-invasive approach to assess multiple welfare dimensions in livestock. This emerging field can detect physical characteristics, health conditions, behavioral patterns, and emotional states in pigs, cattle, poultry, and other farm animals. Recent technological advances in machine learning and sound recording have accelerated research demonstrating that acoustic parameters can identify diseases like respiratory infections, heat stress, pain, and reproductive states. However, significant barriers limit practical implementation: most studies remain in experimental phases, methodological approaches lack standardization, and few commercial applications exist beyond pig cough monitoring systems. This article synthesizes current research on bioacoustics applications in farm animal welfare, highlighting both the technology's transformative potential and the critical need for standardized validation before widespread farm deployment.

Keywords: animal welfare, bioacoustics, farm management, machine learning, precision livestock farming

Introduction

Imagine a barn equipped with microphones that continuously listen to your animals, automatically detecting early signs of illness or distress before visible symptoms appear. This scenario is no longer pure fiction. Scientists across Europe and beyond are developing sophisticated systems that analyze farm animal sounds to monitor welfare in ways previously thought impossible, all without handling stressed animals or requiring veterinary visits. This emerging field, called bioacoustics, represents one of the most promising intersections of animal science, technology, and welfare. Recording and analyzing animal sounds, including vocal and non-vocal cues, provides a relevant tool to access and monitor different aspects of animal physiology, behavior, and general welfare in a remote, non-invasive, and continuous fashion (Coutant et al., 2024). For farmers managing large herds or flocks, this technology could fundamentally change how they detect problems and maintain animal health. According to animal welfare science, welfare describes a measurable quality of a living animal at a particular time and context and may be considered as an integrative view of both physiological and mental health (Broom, 2011).

Understanding Animal Sounds as Welfare Indicators

When we think of farm animals, we might remember cows lowing, pigs grunting, or chickens clucking. But most farmers don't realize how much information these sounds contain. Animal vocalizations have long been recognized as a biologically relevant tool to access information regarding the status of animals, including their emotions (Briefer, 2012). Beyond emotions, animal sounds reveal physical characteristics, age, sex, and health status.

The science underlying this is elegant. Animal emotional states influence the structures involved in sound production and, therefore, the sound structure itself (Coutant et al., 2024). The respiratory system determines the duration, rate, and amplitude of the voice, while the phonatory system, including the larynx, defines the sound source. The vocal tract acts as a filter and shapes the source signal by selectively amplifying certain frequencies (Coutant et al., 2024). When an animal is stressed, sick, or in pain, these physical processes change, and so do their vocalizations in measurable ways.

Researchers can extract dozens of acoustic parameters from animal calls: fundamental frequency (the lowest pitch), formant frequencies (which shape the quality of sound), duration, amplitude (loudness), and various measures of how the sound changes over time. A large number of acoustic features may be extracted from a sound wave, from the temporal analysis of vocal sequences to the fine analysis of each vocalization structure in the time, frequency, and amplitude domains (Coutant et al., 2024).

From Detection to Automatic Recognition

The journey from identifying acoustic markers to creating practical farm management tools involves several stages. A scheme to classify the status of development of a bioacoustics tool progresses from the detection of the acoustic marker of a certain condition to the production of an available device to record this condition (Coutant et al., 2024). Early-stage research explores whether a condition actually affects animal sounds. Subsequent phases develop algorithms to automatically classify these sounds, test them in realistic farm conditions, and finally, create implementable devices. Most current research sits in the middle phases. Most studies reporting the development of a method to monitor a certain parameter or behaviour are currently presenting methods to classify calls as being produced by animals presenting a certain disease versus a control group, or to discriminate among different call types (Coutant et al., 2024).

Health Monitoring: From Disease Detection to Early Warning

One of the most mature applications involves detecting respiratory disease. Coughing, one of the clinical symptoms of bovine respiratory disease, has been automatically recorded in groups of calves on farm using algorithms based on supervised learning (Carpentier et al., 2018; Vandermeulen et al., 2016). In one influential study, researchers found that increases in coughing detected by algorithms coincided with disease development in 80% of cases, suggesting potential for early intervention (Vandermeulen et al., 2016).

In poultry, different types of respiratory diseases can be detected in acoustic signals. Using an unsupervised method of machine learning based on gurgling noises, researchers classified audio recordings as produced by healthy chickens or chickens infected with infectious bronchitis with an accuracy close to 98% (Whitaker et al., 2014).

In pigs, perhaps the most heavily researched species, scientists have developed systems to detect multiple respiratory diseases. A sound-based pig anomaly detection system capable of automatically detecting pig vocalization and classifying them as normal grunts, healthy cough, or signs of specific diseases showed good detection performance close to 0.95 on small-scale farms, even in noisy barn environments, and could be used in real-time (Hong et al., 2020). This system has even reached commercialization: the SoundTalks monitoring system, first launched in 2013, is now deployed in over 20 countries. Early systems for pig cough detection showed 82% correct identification in laboratory settings, with field conditions reaching 85% accuracy in the detection of cough sounds (Exadaktylos et al., 2008).

Heat stress, another critical welfare concern, also leaves acoustic signatures. Clear differences exist between the calls of piglets subjected to heat stress as compared to the calls of their peers housed under conventional temperatures (Ferrari et al., 2013), providing another avenue for automated monitoring.

Behavioral Monitoring and Feeding

Beyond health, bioacoustics can monitor important behaviors. Monitoring feeding behaviour may be crucial to ensure the health and welfare of farm animals. In grazing ruminants, ingestive behaviour has been recorded based on biting and chewing with high accuracy levels when ambient noise is controlled (Coutant et al., 2024).

In poultry systems, an algorithm was developed to automatically record pecking sounds in broiler chickens with 93% correct identification, and showed a 99% correlation between the detected number of pecking and the feed intake of the group. Follow-up work using automatically-recorded pecking sounds determined meal size, meal duration, number of meals per day, and feeding rate, with estimates averaging 90% accuracy (Aydin & Berckmans, 2016).

Beyond Health: Behavior and Emotion

Increasingly, researchers explore whether acoustic analysis can reveal what animals are actually thinking and feeling. Affective state is a critical component of animal welfare, and assessing the emotions of animals throughout different stages of their life is crucial to monitor their well-being and evaluate the impact of husbandry practices (Coutant et al., 2024).

Studies suggest that high-arousal emotional states, particularly acute pain, fear, or frustration, produce the most distinctive and detectable acoustic signatures. A supervised learning model was developed to automatically detect states of cold/heat, pain, hunger, and thirst in piglets, showing moderate efficacy to classify some states but high accuracy of 93% to detect pain (Da Silva et al., 2019).

More encouragingly, research demonstrates that animals produce distinctly different sounds in positive versus negative contexts. A recent study using over 7400 calls from more than 400 pigs showed that the valence can be accurately automatically classified based on pig calls (Briefer et al., 2022a). In pigs, anticipation of social reunion was associated with short and higher-pitched grunts, compared to frustration of not being reunited as expected.

Identifying Individual Animals

A particularly exciting application involves animal identification and individual monitoring. Models based on the analysis of spectral and temporal acoustic features have been able to classify vocalizations according to the individual who produced them in goat kids, ewes, and lambs, as well as cows and calves (Green et al., 2019). If perfected, this could enable farmers to track welfare parameters for specific animals within large groups, identifying sick individuals without separating them from their herd mates.

The Commercial Reality: Why is progress slower than expected?

Despite decades of research demonstrating the potential of bioacoustics, widespread farm implementation remains limited. Only one specific application, i.e., pig cough monitoring, has achieved commercialization. Why? Several interconnected barriers explain this gap. These are:

1. Algorithms developed using vocalizations from a handful of animals or using the same calls to train and test models may easily result in artificially high model robustness, which may not be practically applicable (Coutant et al., 2024). A system that works perfectly in controlled experimental conditions often fails when deployed in noisy, complex farm environments with diverse animals.
2. Methodological inconsistency hampers progress. Authors use a variety of complex analysis methods and approaches to develop bioacoustics detection, and while the general method of analysis is usually explained in detail, many aspects often remain unavailable (Coutant et al., 2024). This lack of standardization means each research team essentially reinvents the wheel, wasting resources and making it difficult to build upon prior work.
3. The creation of publicly available databases would significantly improve the study of animal sounds for welfare assessment by providing a sufficient variety of inputs to

develop robust, deep-learning-based algorithms. Yet although databases exist for wild species, this is not the case for domestic animals (Mcloughlin et al., 2019).

Biological and Practical Challenges

Even when acoustic markers are identified, important biological questions remain unanswered. The same vocal parameters are often affected by multiple factors simultaneously. Body size, age, health status, and emotional state all influence sound production. Automated systems are thus likely to work more efficiently within groups of homogenous animals, such as similar body size, age, and sex, or when tracking within individual changes (Coutant et al., 2024).

Future Directions and Scope

Despite these challenges, the field continues advancing. Machine learning algorithms are becoming more sophisticated, recording equipment is improving and becoming more affordable, and researchers are increasingly collaborating across disciplines. Understanding animal communication, and more precisely farm animal communication, deserves more focus to ensure a valid use of these tools for monitoring and improving animal welfare in practice (Coutant et al., 2024).

Precision livestock farming tools, including bioacoustics analyses, have the potential to save on veterinary costs and improve livestock welfare by detecting early signs of disease or injury (Banhazi & Black, 2009). For farmers, the practical implications could be transformative. Continuous, non-invasive monitoring could identify health problems days before visible symptoms emerge, reducing antibiotic use and improving animal welfare simultaneously.

Conclusion

Bioacoustics represents a frontier in animal welfare science, offering sophisticated tools to monitor livestock health, behavior, and emotions in real time. The science is sound; the technology works. What remains is the hard work of standardization, validation, and translation from research laboratories to working farms. The barn of the future may indeed be filled with listening ears, not to spy on farmers, but to give voice to animals who cannot speak for themselves, ensuring they receive the care they deserve.

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