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NOISE AS A FACTOR OF ENVIRONMENTAL STRESS FOR CATTLE – A REVIEW

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Abstract

One of the minor studied stress factors in cattle breeding is noise. Noise is any unwanted chronic or intermittent sound and the amount and type of noise sources are related to the cattle production system. The aim of the review was to highlight the literature regarding noise as a robust environmental stressor and the following impact on the behavioural, physiological and performance reactions of cattle. In addition, it was shown how often this problem is discussed in the scientific literature. Review was conducted with a search strategy of peer-reviewed articles written in English before June 2022. The systematic searches were performed using the Web of Science and Scopus databases with the integration of Boolean operators to string together words or phrases. It is recommended to create an environment around cows in which the acoustic stimuli affecting the animals are under their control. Therefore, if the sound source cannot be eliminated, animals should be able to choose places with a lower sound intensity appropriate for the perceptual abilities of cattle. On the other hand, attention is paid to the positive aspects of some groups of sound signals i.e. positive nature of music for cows and people during milking. The scientific publications analysed by the methodology drew attention to the repeatability of the discussed results. Further research on this subject should be considered because developing farms use modern solutions in barns which can negatively affect the acoustic comfort of cows, and their impact has yet to be determined.

Key words: environmental stressor, noise, dairy cattle, behaviour, freestall barns

Environmental stress is a well-known concept and may be caused by changes in the physical conditions of the livestock environment. This state depends on the biological properties of the species, individual characteristics, type, duration, and intensity of the stressor. The animals' adaptation strategy to environmental changes occurring in the production system promotes physiological and production changes, but also behavioural reactions, which together constitute a defensive reaction of the body. These strategies mainly involve attempts by the animal to reduce the stressor by tolerating it, assimilating to it or buffering the stressor (Brouček, 2014). The failure of these mechanisms leads to an impairment of animal welfare and the associated stress responses. Understanding the behavioural changes in cows to the most common environmental stressors (i.e. heat stress) allows them to ensure appropriate environmental conditions (Herbut et al., 2021).

Cattle breeders are increasingly aware of the relationship between animal welfare, health, behaviour, and productivity. The welfare-based approach includes the identification of animal behaviour in neutral environments and their variability when the lower or upper thresholds of the optimal value characteristic of the cattle are exceeded (Grandin, 2003, 2014).

One of the minor studied stress factors in cattle breeding is noise. Noise is any unwanted chronic or intermittent sound (Brouček, 2014). It is characterized by its intensity (dB) and frequency, i.e., the pitch of the sound, which means the number of air vibrations per second (Hz) (Brouček, 2014) and its intensity also depends on the distance and the source of the generated sound (Šístková et al., 2016 a). The amount and type of noise sources are related to the animal production system (Weeks, 2008). In pasture systems, there is generally no problem with noise. However, the rise of car traffic, railways and air transport routes generate noise that can result in unfavourable responses in dairy cattle. In modern farms (with high-tech machinery), the noise of varying intensity degrees is unavoidable. The sources of sounds include biological noise (e.g., animals), as described by Pšenka et al. (2016), and mechanical noise, such as the passage of feed wagons, the passage of machines for manure removal and cleaning of manure corridors, mechanical ventilation

(e.g., air mixers), and milking parlours of various designs (Gaworski et al., 2018; Dimov et al., 2022).

The development of increasingly advanced techniques for recording, analysing, and interpreting the vocalisation of cattle and sound signals coming from their surroundings (Milone et al., 2012) allows for the full use of sounds in the assessment of animal welfare (Watts and Stookey, 2000; Manteuffel et al., 2004; Meen et al., 2015). According to Umstatter et al. (2013), sound signalling with parameters safe for cows can be used as virtual fencing in the pasture, at least as a supplementation of electric fence to conventional grazing animals. The observed possibility of the animal becoming accustomed to repetitively occurring, even harmful sounds, may eliminate or reduce stress reactions in cows over time.

In this review, we aimed to highlight the literature regarding noise as a robust environmental stressor and the following impact on the behavioural, physiological and performance reactions of lactating cows in dairy barns. In addition, we showed how often this problem is discussed in the scientific literature and what recommendations are proposed for dairy farmers to tackle this stressor.

Methodology

This review was conducted with a search strategy of peer-reviewed articles written in English before June 2022. The systematic searches were performed using the Web of Science and Scopus databases with the integration of Boolean operators (i.e., AND, OR, NOT) to string together words or phrases, as well as wildcard truncations (denoted as " ") to designate a range of possible word forms. The "*" symbol was employed to account for alternate spellings. First, keywords were defined that relate to the research problem, such as: cattle, noise, cow, vocalization. Both in the Scopus and Web of Science databases, articles were searched by the above-mentioned criteria. Only publications containing key terms in the publication title, abstract or keywords were included. Searches in the Scopus database resulted in 1,037 publications, including 996 articles. In the case of the Web of Science database, 1,152 publications were found, including 1,045 articles. We selected experimental studies that related the effects of different noise sources on dairy cattle's behavioural and physiological responses. The results from the search of both databases were automatically checked for duplicates. All duplicates and publications written in a language other than English were excluded. The articles were also scanned to filter out different results from such sources as reports with technical recommendations. This part resembled the snowball method. In the next step, the titles and abstracts were evaluated to identify and remove additional articles not relevant to the topic or out of the scope of interest. To provide a comprehensive literature overview, no additional restrictions were placed upon publication year, sample size, journal, or overall quality. Finally, data from 88 articles and 5 books from 1978–2022 were selected for closer revision for purposes of this review. All exclusion and inclusion criteria for the review were developed a priori and agreed upon by all co-authors.

Sources and intensity of sound in cattle barn/facilities

The sources of sounds in the barn may be of biological (animal) and mechanical origin. While the natural sounds are related to the animals, mechanical ones come from devices installed inside the barn or periodically pass through the building or its surroundings. One example of a permanent noise source is mechanical ventilation, which depends on the structure of barns (Herbut and Angrecka, 2015; Kic, 2017, 2022). The selection of the type of fans and air mixers is based on technical specifications which determine, among others, the power, efficiency, and volume of the operating equipment. For most fans, the sound intensity ranges between 55 and 67 dB. Therefore, according to the noise threshold (65 dB) established by Romaniuk et al. (2005), this range is considered acoustic comfort for cows. However, incorrect assembly and wear of the elements of the fan structure can increase the intensity of noise and threaten the acoustic comfort of cattle. Another permanent noise source is related to one of the essential elements of dairy farms which is the milking parlour (Dimov et al., 2020). The construction of milking parlour fences, fan structure but also very often workers and cattle handling generate noise at specific intervals, depending on the milking hours. Pšenka et al. (2016) investigated which conditions occurred in the process of cow milking. According to these authors, while the noise level during milking should not be higher than 85 dB, in practice, there may be problems with compliance with this requirement regardless of the milking system. These results were confirmed by Šístková et al. (2016 b). Irrespective of the type of milking parlour, the generated noise exceeded the permissible values, of which the most negative was noise caused by metal parts and barriers hitting each other and values were in the range of 76 dB to 91 dB. It corresponded to the value from Algers et al. (1978), which detected noise levels in milking parlours in range from 75 dB to 90 dB. Furthermore, the barn has a non-permanent noise source. Grandin (1999) recommends that pad gates with rubber stops to prevent clanging and banging, and also hydraulic equipment should be engineered for low noise. However, the generalisation of the expected sound intensity values should be considered for specific solutions. Farms have many possibilities in this area, i.e., the cleaning can be done using a tractor or specialised equipment (Gaworski and Boćkowski, 2022).

After sight, hearing is one of the cattle's most essential senses, which, depending on the surrounding conditions, interact and complement each other. This is evidenced by the position of the ears, among other things, which indicates the direction of the animal's gaze (Phillips, 2002; Beaver and Höglund, 2016). Cattle may hear in a slightly more comprehensive frequency range than humans. In addition, while the human sense of hearing best receives signals in the field of 300–3000 Hz, cattle

are the most sensitive to sounds with a frequency of 8000 Hz – with a level of best sensitivity quite similar for both species, below 0 dB (Heffner, 1998; Ekesbo and Gunnarsson, 2018). Cattle can hear high-frequency sounds very well. They can hear frequencies from 23 Hz to 35 kHz, which covers the ultrasound range of 16–35 kHz (Heffner and Heffner, 1983, 1992; Lemcke et al., 2021). The audibility limit for high frequencies among cattle is 37 kHz (Heffner, 1998; Brouček, 2014), while the most audible sound has a frequency of about 8 kHz (Phillips, 2009; Brouček, 2014). Cattle experience discomfort at 90–100 dB, but ear damage occurs at 110 dB (Phillips, 2009; Brouček, 2014).

In the research on cattle's reactions to sound signals, the most significant attention has been paid to the negative impact of noise on animals (Brouček, 2014). Differentiation in acoustic sensitivity was demonstrated in different breeds, sexes, and individual animals (Watts et al., 2001; Slabbekoorn and Bouton, 2008; Yoshihara and Oya, 2021). According to Lanier et al. (2000), cattle of beef breeds are more sensitive to sounds, compared to Holstein-Friesian cattle, which is closely related, among others, to the temperament and excitability of the animals. The habituation of cattle towards increasing sound intensity may occur in the range of 60–90 dB. After exceeding this limit, physiological processes are usually disrupted (e.g., disorders of the secretory activity of the adrenal cortex, adverse changes in the metabolism of polyunsaturated fatty acids, and reduction of the immune response), which in turn negatively affects the animals' behaviour (mainly feeding behaviour) and – in the case of dairy cows – causes a decrease in their milk yield, an increase in the number of somatic cells in milk, and reproductive problems (Johns et al., 2015; Esmail, 2017). Exposure of dairy cattle to 80–100 dB of noise twice a day reduces milk yield and may even result in breaks in milk discharge (Algers et al., 1978; Algers and Jensen, 1991). Loud noise, such as the crying of a child, shouting, or the clanging of metal elements, causes stress reactions in cattle and negatively affects their behaviour, coordination, milk yield, and fertility (Waynert et al., 1999; Pajor et al., 2000; Hemsworth et al., 2003). Moreover, excessive noise can cause fertility disorders in bulls (Yadav et al., 2018).

Cattle vocalisation as a reaction to stress

A critical area of research in the field of cattle's response to sound signals is the issue of intraspecies communication and shaping bonds in social relations (Phillips, 2002). In this context, particular attention was paid to the behavioural and emotional problems of animals subjected to sudden early separation, pointing to the critical role of both sight and hearing in shaping the cow-calf relationship (Weary and Chua, 2000; Marchant-Forde et al., 2002; Johnsen et al., 2015; Padilla de la Torre et al., 2016). Based on the vocalisation of animals in different physiological states, attention was paid to the individual nature of these relationships (Hopster et al., 1995; Padilla de la Torre et al., 2015; Yoshihara and Oya, 2021). On the other hand, recording calf vocalisation during cow milking was suggested as a kind of additional stimulation of animals for milk production (Pollock and Hurnik, 1978; McCowan et al., 2002). However, in practice, in the face of research on the formation of an emotional bond between a cow and a calf, this type of action is not a humane way of dealing with animals.

The tendency of cows to make sounds in response to pain and acute stress varies greatly. When analysing the sounds emitted by cows, it is possible to interpret the behaviour of individual animals, their health and welfare (Manteuffel et al., 2004). Studies of cattle vocalisation allow for the early detection of behavioural changes, which may help in the early detection of problems, including disease (Banhazi and Black, 2009). Meen et al. (2015) researched a correlation between the vocalisation of cattle and their behaviour. They distinguished six behavioural groups: 'lying and ruminating', 'feeding related', 'social interaction', 'sexual behaviour', 'stress-related behaviour' and 'remaining behaviour'. There was a significant difference between the maximum average frequency (Hz) of sounds emitted by cattle during lying and ruminating and exchanges of vocalisations during other behaviours. The average frequency of calls when lying down and ruminating was much lower than during different activities. The sound emitted by cattle when ruminating lying down sounded like a murmur and was an indication of the animal's welfare. The sounds of adult dairy cattle had a lower maximum frequency than heifer sounds (Meen et al., 2015).

In dairy cows, differences in vocalisation can also be observed over time after parturition. These are associated with maternal behaviour and stress. There are disturbances in the mother's reactions, when calves are separated. Behavioural and vocal patterns vary depending on the cows' emotional states and the calf's proximity (Green et al., 2021). Therefore they may show subjective experiences of animals, including their emotional states (Briefer, 2012; Baciadonna et al., 2019; Green et al., 2021). During the interaction with the calf and after the separation of the calves, dairy cows show a high frequency of vocalisation (Lidfors, 1996; Weary and Chua, 2000; Flower and Weary, 2001; Stěhulová et al., 2008). Separating calves is stressful for cows (Lidfors, 1996; Flower and Weary, 2001). This leads to the dominance of high-frequency sounds, a more significant share of mixed and open calls, a greater share of vocal sequences, more voice units per sequence, and shorter sequence spacing (Green et al., 2021). When interacting with the calf, the cows emit more isolated exclamations. These are low-frequency sounds with closed mouths with a longer time between sequences, indicating positive reactions (Ede et al., 2019; Meagher et al., 2019, Green et al., 2021). Separation also causes acute stress among calves, visible, among others, by the high volume of their voices (Lidfors, 1996; Flower and Weary, 2001; Stěhulová et al., 2008). Broadly understood, social isolation also af-

fects vocalisation. Cattle isolated from the herd show increased vocal responses related to perceived anxiety (Müller and Schrader, 2005; Færevik et al., 2006). In addition, food quality and hunger may influence vocalisation (Valizaheh et al., 2008). Additionally, in the case of stressful and painful husbandry procedures, a higher noise index and a higher number of animal sounds were observed (Watts and Stookey, 1999; Green et al., 2018).

The behaviour of cattle regarding sound stimuli

Noise

Cattle react differently depending on the stimulus's nature and the animal's condition (Grandin, 1998). At the behavioural level, one can talk about the occurrence of unconditioned and conditional reflexes. This raises issues related to instinctive (innate) and learned (acquired) reactions acquired via the "self-learning" of the animal (as a reaction to the stimulus without direct, intentional human action), as well as via training (as a reaction to the stimulus induced by deliberate human activity). Among the methods of animal learning/training, the most important include habituation (getting used to environmental conditions), instrumental conditioning (e.g., learning to use automatic drinking machines, feed wagons), and classical contitioning; i.e., the secretion of oxytocin by an animal in response to stimuli associated with the approaching time of milking or feeding (Hurnik et al., 1999; Mandel et al., 2016; Houpt, 2018). In addition, modern knowledge suggests the high cognitive abilities of cattle, which proves the complexity of these animals' interpretation of environmental stimuli and their way of reacting in the form of specific behaviours (Marino and Allen, 2017). This is so, among others, in the case of changes in light and sound signals coming from the animals' environment. In barn conditions (especially in free-standing barns), the daily rhythm of animal activity depends mainly on routine activities such as milking or feeding, which take place throughout the day (Adamczyk et al., 2011). That is why it is so important that sudden environmental stimuli are eliminated, as they can negatively affect cattle accustomed to the noise of circadian rhythm.

The fright reaction in cattle is most often caused by sudden, high, intermittent sounds, while animals can gradually get used to them as part of the background of noise and with a gradual change in the intensity of sound signals (Waynert et al., 1999). Research by Arnold et al. (2007, 2008) shows that heifers reacted with increased heart rate and anxiety to sounds recorded on a dairy cow farm. When given the appropriate opportunity, animals learned to avoid these noises. Further, regarding the individual animal activities (e.g. escape, retreat, freezing, kicking), Esmail (2017) lists the following cattle behaviour prompted by sudden noise with an intensity above 110 dB: animals may jump, reduce activity and stay huddled together for up to 30 minutes afterwards; animals may freeze into a motionless stance, but may later become aggressive; animals may increase defecation and reduce both social and non-social activities (sniffing, grooming, crawling).

Music as sound

It was found that music's influence on animals depends on the species and may be positive, negative, or not deliver any effect (Dhungana et al., 2018). Some studies show that music can calm and positively affect breeding animals; however, these effects have been explored in a few studies (Uetake et al., 1997; Kıyıcı et al., 2013; Mandel et al., 2016; Ciborowska et al., 2021). The impact of different types of music on dairy cows was investigated. Music genres such as country, rock, opera, reggae, pop, lullabies, classics, rap, heavy metal and hip-hop were played. The music differed in rhythm, pace, amplitude and frequency, which allowed researchers to check what aspects of the cow would react to (Kemp, 2020). These studies showed that each cow had its musical preferences, and music affects the level of stress in cattle. Cows were most relaxed when listening to lullabies, but this was not reflected in greater productivity. Data on the impact of music on milk production were ambiguous, and the most significant amount of milk was collected during the period when no music was played (Kemp, 2020).

Greater efficiency in milk production when music was played during milking was observed by Evans and Albright (1989) (classical music), Moregaonkar et al. (2006) (instrumental music), Liu et al. (2017) (classical and entertainment music), and Zhao (2020) (classical, rock, pop music). Nevertheless, other studies have not shown the impact of classical and rock music on milk production (Evans and Albright, 1989; Kıyıcı et al., 2013; Li et al., 2017). Some authors have even observed a decrease in productivity (North and MacKenzie, 2001; Donghai et al., 2018; Kemp, 2020). The observed ambiguities result from additional factors that may affect cows' milk yield, complicating the study of music's influence on lactation. The milk yield of cows depends on such factors as breed, age, milking technique, mood, weather, feed, lactation cycle period, and disease etc. These factors may hinder the interpretation of the obtained data (Kenison, 2016; Lemcke et al., 2021). It is anticipated that the long-term playing of slow music at intervals during milkings, such as lullabies, classical music, opera or reggae, may increase cow welfare and productivity by reducing stress over time. Study done by Ciborowska et al. (2021) includes an analysis of the effects of many different types of music on cattle. The cattle showed limited motility while playing classical music. In addition, the herd was more likely to engage in positive social interactions. The animals turned out to be more relaxed, spending more time resting and chewing. Similar reactions were recorded by Crouch et al. (2019) while playing audiobooks. Ciborowska et al. (2021) notes that Indian instrumental music can increase milk yield by up to 12.64%. Among the types of music that negatively affected milk yield (and often also increased plasma LDH

levels) were rock music, African percussion music, Latin American music, and Chinese folk music. Based on these examples, it can be concluded that music genres with a subdued, natural sound are the best choice for both cattle and humans. Fast, heavy and rhythmic music causes a negative reaction of the cattle. Ciborowska et al. (2021) also highlighted that loud music above 90 dB disturbed glucose metabolism and insulin secretion. Much depends on the duration and volume of the music as well as the place where the speaker is placed (Kemp, 2020; Lemcke et al., 2021).

Implications and conclusions

It is recommended to create an environment around cows in which the acoustic stimuli affecting the animals are under allowable sound intensity values. Sudden sounds, especially high-pitched ones, with a high level of intensity should be eliminated from the vicinity of the cattle. This can be achieved by equipping buildings for cattle with installations that do not generate much noise, e.g. silent air mixers. At the level of production of milking parlour equipment, attention should be paid to securing metal parts that hit each other, e.g. quick exit gates. This would reduce the level of sound, which is said to be one of the loudest noises in the milking parlour.

However, if the sound source cannot be eliminated, animals should be able to choose places with a lower sound intensity appropriate for the perceptual abilities of cattle. This can mainly be achieved by giving cattle the opportunity to move away from the source of the sound. However, in the building, such a possibility is limited by the area designated for technological groups.

Attention is paid to the positive aspects of some groups of sound signals. The positive nature of music (mainly classical and country music) for cows and people during milking, shown based on examples, may, in this case, constitute a valuable enrichment of the environment.

The scientific publications analysed by the methodology drew attention to the repeatability of the discussed results. It is challenging to find recent results or recommendations that would characterise the problem of noise as an environmental stressor. It is often possible to find information about the situation as a solution to this problem. However, further research on this subject should be considered. This is especially true since developing farms use modern solutions in barns which can negatively affect the acoustic comfort of cows, and their impact has yet to be determined.

Vocalization in cattle is a complex issue and remains in the phase of recognition and analysis. Many researchers emphasize that the recognition of vocalizations should take place at the level of a given herd of cattle (Green et al., 2018). The high or low frequency, sound intensity level and duration of cattle noises depend, among other things, on individual characteristics. Further and more accurate characterization of cattle vocalization is needed to determine the animals' response in positive and negative situations (Green et al., 2019). Research was also conducted to determine the possibility of using vocalization as an indicator of cattle welfare (Meen et al., 2015). On this basis, we can conclude that a multivariate sound analysis carried out within the barn and/or herd of cows will enable a realistic assessment of the impact of noise on cattle and the possibility of reducing it to acceptable levels.

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