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Review

Importance of Noise Hygiene in Dairy Cattle Farming—A Review

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Abstract: Noise is defined as unwanted sound, whether chronic or periodic, and can be described in a variety of terms, including its frequency, intensity, frequency spectrum, and sound pressure shape over time. The sources of noise can be technical devices, various hydraulic systems, the engines of various machines, routine work (opening and closing doors, repairing stalls, talking of workers, feeding), mechanical ventilators, animal activities, including climbing barriers, chewing barriers, vocalizations of cows. Good farms in terms of noise level are considered to be those with a noise level up to 70 dB, while farms with a noise level above 70 dB are problematic. Noise levels above 70 dB also have a detrimental effect on cow welfare, and this is associated with a high number of somatic cells in milk. When milking dairy cows, the noise level should not exceed 65–70 dB, or if it exceeds this value, it should be for a short time, as this can lead to health disorders in humans and animals in the medium term.

Keywords: noise level; dairy cows; milking parlor; hygienic importance

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1. Introduction

Anthropogenic noise has increased unprecedentedly over the past century both on land and underwater. Noise has been considered a global environmental pollutant in international legislation [1,2]. Noise pollution originates mostly from traffic, industry, resource extraction, construction and recreational activities and extends over time and space, with subsequent negative impacts on human health and wildlife [3,4]. Besides a considerably increase in overall sound levels, anthropogenic noise sources add new sounds to the environment that differ substantially in spectrum, composition, and operating cycle from the natural sounds of nature [5,6].

The main reason for determining the impact of noise on animals is the increase in technological and technical equipment in commercial farms. Increasing noise levels are expected to have a negative impact on farmed animals, their productivity and behavior [7]. In nowadays livestock farming, noise has become a rising but not enough discussed problem. Noise in premises for highly productive livestock created by the ventilation system, feeding and manure cleaning lines and by the animals is a potential stress factor and influences both the animals the staff servicing them [8].

The Interpretation of animal noise assessment is difficult because the objectives and methodology differ substantially between studies [9]. Whether a sound should be described as noise depends on subjective opinion, i.e., on whether listening leads to pleasant or unpleasant feelings [10]. The effects of noise on animal performance and behavior depend not only on its intensity or loudness (dB), its frequency (Hz) and its duration and pattern (including vibrational potential), but also on the noise perception ability of the animal species and breeds and the age and physiological state of the animals at the time of exposure. It is also important what kind of noise the animal has been exposed to during its life and the predictability of the acoustic stimuli [11].

After sight, hearing is one of the most important senses of cattle, which, depending on the surrounding conditions, interact and complement each other. This is evidenced by the position of the ears as, among other things, they indicate the direction of an animal's gaze [12]. Cattle can hear over a slightly wider frequency range than humans. Furthermore, while human hearing best receives signals in the 300–3000 Hz region, cattle are most sensitive to sounds up to 8000 Hz—with a level of best sensitivity quite similar for the two species, i.e., below 0 dB [13]. Cattle can hear high frequency sounds very well. They can hear frequencies from 23 Hz to 35 kHz, which covers the ultrasonic range of 16–35 kHz [14]. The limit of audibility of high frequencies among cattle is 37 kHz [8,15], while the most audible sound has a frequency of about 8 kHz [8,16]. Sensitivity to noise is species dependent and was found to be genetically determined [17,18]. Dairy breeds are more sensitive to noise than beef cattle breeds [18]. The authors noted sensitivity to sound in 34.9% of Holstein cows and only 27.4% of beef cattle.

With the intensification of agriculture and animal husbandry in particular, and the effects of the scientific and technical revolution into on them, has arisen (Figure 1). Noise is understood as the collection of a chaotic combination of sounds with different frequency and variable oscillation amplitude, which have a harmful effect on the bod [19].

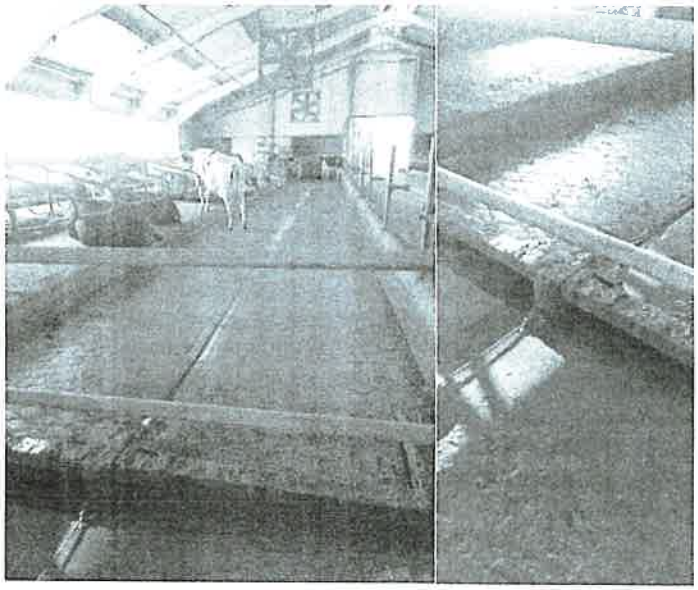

Figure 1. Manure cleaning alley Scraper.

The noise is defined as unwanted sound, whether chronic or periodic, and can be described in a variety of terms, including its frequency, intensity, frequency spectrum, and sound pressure shape over time [20]. Noise in cow farms can be continuous or with periods of interruption, depending on the size and complexity of the work processes and the time of delivery of the milk produced by the animals [21].

The aim of the present review was to study issues related to noise in dairy cattle farms and the effect of noise on both animals and workers.

2. Noise Sources in Cattle Farming

There are cases when noise is unavoidable (Figure 2). The main sources of noise in livestock premises are: milking machines and related equipment, such as vacuum pumps, the compressors of milk cooling tanks, machinery, such as tractors, wheel loaders, auger loaders, forage machines, feed mixer trailers and vehicles, machines for the cleaning of manure, water pumps; heavy transport vehicles for milk, fodder or animal transport, as well as the means of transport of the farmer's family members and of the farm workers; and

farm activities such as the separation of cows and other cattle into groups, the separation of calves from their mothers, and the separation of bulls [21].

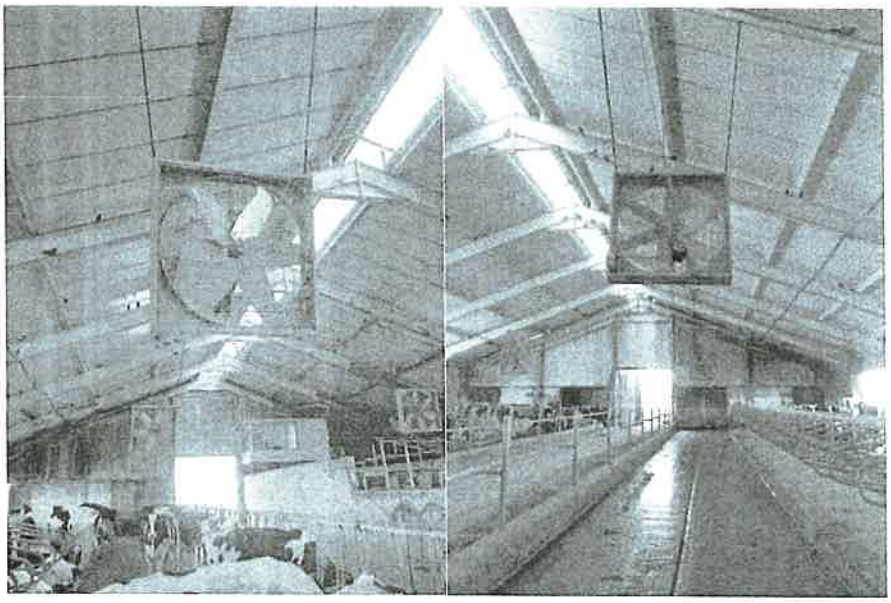

Figure 2. Ventilation fans.

In livestock buildings, sounds can be produced by a variety of sources [12]. Noise aris-ing from the rearing of farm animals can be short-term or chronic [22]. Sources of noise can be technical devices, various hydraulic systems, the engines of various machines [23], routine work (opening and closing doors, changing boxes, workers' speech, feeding), mechanical ventilators, animal activity, such as animals climbing barriers, chewing barriers, their vocalizations [24,25]. Animals are not only exposed to noise, but also produce noise (biological noise) [26,27]. The environmental noise gen-erated of various biological activities during the life of dairy cows fluctuates from 72.7 to 83.8 dB [28]. Vocalization is important for communication between animals [16]. Weeks et al. [29] reported average vocalization levels of cattle in the range from 80 to 90 dB. The same authors measured noise levels of 75–90 (average, 84) dB in a cattle building. Pursuant to Šístková et al. [28], hygiene noise thresholds are overreached when feeding and cleaning and littering of the beds, and therefore it lasts only for a short time.

There are sources of noise external to the farm. A number of studies looked at how air transport, especially helicopters, affects farm animals through the noise it produces [30]. Livestock buildings, mostly the semi-open ones, have a very noisy environment in general. They represent a good habitat for various bird species, which are also a source of noise [31].

The noise generated during the milking process depends not only on the technological equipment of the milking parlors, but also on its operational conditions. The number of animals being milked at the same time and, thus, the number of milking units are also important factors. Noise exposure directly depends on how the milkers work, especially in terms of speed of work (the faster their work, the noisier), the precision and accuracy in placing the liners (if this is done incorrectly, unpleasant noise can occur), milkers' activities such as talking and driving animals to the milking parlor, and other activities [32]. According to Kauke and Savary [33], the noise intensity is in most cases unacceptable for dairy cows and also for the milkers. Limiting excessive noise is a factor that contributes to improving welfare.

The increase in noise intensity is directly related to the number of animals in a cattle farm. A large number of animals necessitates the use of more equipment for feeding and serving them, as well as for milking and cleaning the manure. According to a study by

Deere [34], farms with a capacity of more than 100 lactating cows use at least one tractor and one feed trailer. Farms with a capacity from 200 to 400 animals use an average of 2–3 tractors and more than one feed trailer, while those with a capacity of more than 600 animals use at least four tractors and two feed trailers. Based on these data, it was concluded that the noise level increases with the increase in the capacity of the cattle farm. The various motor vehicles used to deliver the feed were found to generate noise with an intensity of 74–108 dB. Fans used in various forced ventilation systems are a source of noise from 30 to 80 dB. When jet planes fly over livestock buildings, a noise intensity of up to 95 dB is recorded [19].

The studies consider statements by farmers relating the negative impact of air-plane or helicopter sound on animals. Farmers conclude that airplane overflight may affect feed intake, growth rate or productivity performance of livestock [35]. Helicop-ters are normally used to wildlife population management, but their impact on wildlife behavior is often disregarded. The severity of the disturbance reaction can be different among different species, group size, social groups, sex, age, vegetation, season, terrain, and distance from the aircraft or helicopter [30].

Bovine vocalization studies allow the early detection of changes in animal behavior that can aid in the early detection of problems, including diseases [36]. Meen et al. [37] investi-gated the relationship between cattle voice and their behavior. They distinguished six behavioral groups of sounds classified as: "lying and ruminating", "feeding", "social interaction", "sexual behavior", "stress behavior", and "rest behavior". There was a significant difference between the maximum mean frequency (Hz) of the sounds made by cattle during lying down and rumination and that of the sounds produced by the exchange of vocalizations typical of other behaviors. The average frequency of vocalization when the animals were lying and ruminating was much lower than that of the sounds produced during various other activities. The sound made by cattle when lying down and ruminating is similar to a murmur and is an indication of the animal's welfare. Adult dairy cattle's vocalizations have a lower peak frequency than heifers' vocalizations [37].

3. Effect of Noise on Health

3.1. Effect of Noise on Health Status and Productivity in Dairy Cows

Exposing animals to unfamiliar noises can induce stress [38]. Prolonged sound can have negative effect on animals' health status. Noise directly affects the reproductive system of animals [39]. Algers and Jensen [40] reported decreased milk performance in cows for milk production exposed to 1.4 h of 80–100 dB noise two times per day. Gygax and Nosal [41] studied in 50 dairy farms the effect of vibration and noise on somatic cell counts in milk. The number of somatic cells rose with rising vibration in-tensity, but not with acoustic noise.

In essence, loud noise is a stress factor that suppresses the conditioned reflex activity of the body and negatively affects the health and productivity of animals. It was established that under the influence of constantly repeated high-intensity noise stimuli, changes occur in animals in clinical-physiological indicators and in metabolic processes. An increase in body temperature, an acceleration of the heart rate and respiratory rate, a decrease in hemoglobin, erythrocytes, total protein, and albumin levels were reported. The functioning of the forestomach and rumination are disturbed, and milk productivity decreases. Noise has a particularly strong impact on the nervous system of animals, as a result of which, stress states of varying intensity occur [19].

Noise has a direct impact on reproductive physiology and feed intake [8] and leads to a decrease in appetite and milk productivity in animals [42]. Noise induces a variety of physiological changes in the mammalian organism, such as changes in car-diovascular homeostasis and hormone secretion [43]. Additionally, excessive noise can cause fertility disorders in bulls [44].

Human-produced sounds can be stressful for livestock too. Loud shouting induces stress reactions in livestock [45]. Screaming for dairy cows is likely to be highly un-

pleasant [46]. Noise produced by people shouting and banging on metal doors and ob-jects increases the heart rate and activity in cattle [47]. Lanier et al. [18] pointed that live-stock were stressed by loud human screaming, especially when it was from a child.

Excessive noise affects the behavior and coordination of animals. In particular, mammals respond to sudden noise with higher intensity, with responses including re-action of surprise, freezing, and running away from the sound source. In comparison to constant or recurring noise, this irregular or unpredictable noise is markedly effec-tive in evoking anxiety reactions. Most animals become less sensitive to sounds gener-ated for long periods or at regular intervals [8]. The extent of an animal response varies depending on the animal species and age and on the individual. The nature of the behavioral responses to excessive noise observed in domestic animals may impair their welfare [48]. Many studies showed that sudden novel sounds affect cattle behavior more than a continuous loud noise [49,50]. An unexpected high-intensity noise, such as low-altitude aircraft overflight (above 110 dB), can induce adverse behaviors in the milking parlor, such as kicking or pushing [51]. The noise threshold expected to elicit a behavioral response from cattle is from 85 to 90 dB [52]. Noise above this threshold elicits freezing or a strong startle re-sponse [51]. Pajor et al. [46] studied the responses of dairy cows to different manipulations. Noise exposure increased restlessness and intolerance behavior, requiring an increase in manipulators' activity.

According to Waynert et al. [47], cattle respond with restlessness and increased heart rate when exposed to noise during their handling and milking. Head et al. [53] reported that a high level of farm noise adversely affects the welfare and comfort of cows, which is then reflected on their productivity and health status. Lactating cows are ex-posed to vibration and noise during milking in the milking parlor, which has a nega-tive impact on their milk yield and milk quality (increased somatic cell count) [54]. Gygax and Nosal [41] confirmed these studies regarding the relationship between vi-bration and increased somatic cell count in milk. The authors explained this relationship with a decrease in the level of oxytocin due to the stressful conditions created in the milking parlor. A study by Arnold et al. [50] showed that heifers reacted with increased heart rate and anxiety to different sounds in the farm.

Milking parlor noise directly affects work productiveness linked to betterment the behavior of cow and the interplay between human and animal. Faster locomotion in response to the noise continued for the first 4 days, with some animals showing signs of habituation by the 5th day. The responses to noise in milking parlors may be influenced by the habituation process. As dairy cows are regularly exposed to the milking environment, they become accustomed to the exposure to this type of noise [47]. A sudden noise of 105 dB could reduce the milk yield during milking. Milk letdown initiated at milking might even be interrupted [10].

When in the premise where cows are milked a loud noise is present, they become crowded, nervous and it is not possible to be completely milked due to which udder diseases occur [55].

3.2. *Effects of Noise in Cattle Farming on Humans*

The problems that noise creates are often overlooked because nowhere is the high noise level in animal houses and milking parlors assessed, nor is proper ear protection used by workers. This is mostly owing to two causes: firstly, the absence of information amid farm owners of the impairment that excessive exposure to noise can cause and secondly, the widespread but mistaken belief that noisy machines are not present in milking parlors, leading to a refusal of the use of noise protection devices by workers [11].

Raising dairy cows is hard physical work, which over time causes workers to de-velop a lot of disorders, most frequently of the locomotor apparatus, respiratory sys-tem and auditory system, particularly for employees who work for many years in this profes-sion. Noise is part of the factors of the working environment. Among the elements forming the working conditions on cattle farms, none should be underrated. [56]. Although there are differences in the perception of noise intensity, workplace noise limits have been established

for workers [57]. Workers should be provided with appropriate hearing protection and monitored health damage caused by noise impact [58]. Noise damage can have per-sonal and social consequences for affected individuals and their families [59].

Many researches have indicated serious hearing damage and even hearing loss among farmers and their relatives [60]. Hearing loss is common among older farmers, but it is also seen among young farmers and teenagers on the farm [61]. Beckett et al. [62] in a study conducted in New York found that 72% of farm workers had high frequency hear-ing loss. Factors associated with hearing loss include: age, sex, hunting and the use of grain dryers. In Ohio, reported noise sources included tractors without cabins (in almost all farms), chainsaws (80%), combine harvesters (70%), off-farm work (33%), hunt-ing (51%), and motorcycle use (21%) [63].

A South Australian study of agricultural noise exposure found that the hearing sensitivity of a 40-year-old farmer was similar to the hearing sensitivity of a 55-year-old person [64].

Noise is one of the leading harmful factors of the working environment. In many cattle farms, it may exceed the maximum permissible limit. The impact of noise on the health of workers is evident in the auditory analyzer (aural effect) and includes a transient hearing loss, a permanent chronic hearing impairment (occupational tinnitus), or an acute sound trauma. The health problems of agricultural workers are related to permanent chronic damage to the auditory analyzer and disturbances in the functional state of the nervous system (insomnia, irritability, etc.) [21]. In a study conducted by Rein [65] over five years ago, the authors found a significant difference in the auditory analyzer's health status between cattle farmers and people not exposed to elevated noise levels. According to the survey results, 30% of farmers aged 25–34 years, 40% of those aged 35–44 years, and 50% of those aged 45–54 years showed significant hearing loss as a result of their work.

According to Depczynski et al. [59] exposure to noise levels above 85 dB for more than 8 h per day (or to its sound energy equivalent) on a regular basis can cause permanent hearing damage. Hearing impairment can be engendered by protracted and additive impacts of noise for long periods, leading to metabolic impairment to the cochlea [66]. Noise helps to the occurrence of some illnesses and disturbances inflicted by stressful conditions, such as high blood pressure and other psychosomatic sickness-es [67].

People negatively influenced by noise impairment may need to watch television at turned up volume, may have problems with the telephone ringing hear, may often want for words to be to be said again, may not respond when cried out from a remote-ness, and may have troubles trying to listen a dialogue in social environment [64].The directive of the European Parliament and of the Council No. [59] specifies the limit values of noise exposure for an 8 h working day. The determination of the daily exposure to noise in a workplace for a period of time T_e up to the nominal duration of the working day of 8 h (T_o) can be obtained by normalizing the equivalent sound pressure level A in a nominal time of the working day, according to the Equation (1),

$$L_{AEX,\,8h} = L_{Aeq} + 10\,\lg\,(T_e/T_o),\,dB \quad (1)$$

The upper value requiring intervention, $L_{AEX,\,8h}$, is achieved when A = 85 dB (the peak value L_{CPk} is 137 dB for single impulses), and the lower value requiring intervention, $L_{AEX,\,8h}$, is achieved when A = 80 dB (and L_{CPk} = 135 dB for single impulses). These are workplace noise values beyond which the employer is required to take noise abatement actions. Pursuant to the Directive of the European Parliament and of the Council № 2003/10/EC, the exposure limit value $L_{AEX,\,8h}$ is 87 dB (corresponding to L_{CPk} = 140 dB for single pulses), and to this value workers cannot be exposed under any circumstances [34].

4. Disccusions about the Noise Levels in Dairy Cattle Farming

Algers et al. [10] found a noise level in a cattle building ranging from 61 to 73 dB. The noise threshold expected to elicit a behavioral response from cattle is between 85 and [52]. Ac-cording to Phillips [16], the discomfort threshold for cattle is in the range from 90 dB

to 100 dB, with physical damage to the hearing system at 110 dB. According to Nosal and Bilgery [68], good farms in terms of noise level are those with a noise level of up to 70 dB, whereas farms with a noise level above 70 dB are problematic. Noise levels exceeding 70 dB have a harmful impact on cow wellbeing too, which is related to an increase in the number of somatic cells in milk. Dimov [69] reports aver-age noise levels during the day in the buildings for free stall housing of dairy cows in the range of 52.5 to 83.0 dB. The author has pointed that the season significantly af-fected the level of noise. The noise level was highest during summer by 4–5 dB, in comparison with the other seasons. In that time, except the residual noise from the various machinery and equipment, that from the fans for cooling the premises is also added. There is an increase in the noise level at 4–6 p.m. in all three studied farms. This is related to the noise caused by the mechanization of placing the feed and also the preparation for the start of milking. Although with small differences, a higher noise level was reported in buildings with a larger capacity and more frequent and more ac-tivities during the day, such as cleaning, milking and feeding. Farms with larger ca-pacity and more and more frequently applied service processes (three times milking, cleaning, greater number of v entilation units, etc.) also point an increase in level of noise pursuant to the author. Šistkova et al. [70] in one-year study reported a level of noise of 69.2 dB in a herringbone type parlor with reached a maximum value of 82 dB. In Baumgarten's [71] definition is indicated that the noise level in the milking parlor at values ranging from 71 to 75 dB, can be assessed as 'moderate'. The noise level during milking should not be higher than 65–70 dB, and if it goes over these values it should be just for a while, because the result in medium term can be health disruptions for both humans and animals [55,72]. Dimov et al. [73] found mean noise levels in a milking parlor for one year to be 69 to 76 dB. From the analysis, the authors found that mainly the season had a statistically significant effect on the noise level. Variations in noise levels depending on the consecutive milking of the day and during the milking itself are also reported, although they do not have a significant effect.

According to Regulation No. 44 of the Bulgarian legislation, the permissible noise level in the premises where cows are kept is 75 dB [74], while according to Anonymous [75], the noise level in a cattle building can vary from 72 to 85 dB.

To reduce the noise in livestock premises, special attention should be paid to the correct installation and maintenance of the ventilation system. It is essential to ensure the spatial isolation of livestock farms from highways, airports and other sources of noise, as well as the use of silent means of transport in livestock farming. The creation of green spaces around farms and buildings is a highly effective measure to combat noise in intensive animal husbandry [19].

5. Conclusions

Noise pollution is a very modern, topical, and insufficiently considered and discussed issue. Noise in animal farms, in particular, in dairy cattle farms, is an often-overlooked problem. The modernization of intensive dairy cattle farming with various increasingly modern machines and devices for the performance of daily activities on farms (such as cleaning, feeding, milking, etc.), with the aim of greatly facilitating human labor and improve production efficiency as well as to ensure better animal welfare, is leading to increased farm noise levels (noise pollution).

In order to reduce the adverse impact of noise on dairy cows, it would be useful to replace old and amortized ventilation systems and milking equipment, which over time start to generate higher and higher noise levels.

As prevention against hearing damage when working with various machines and performing routine activities on a dairy cattle farm, workers should wear hearing protection devices, such as earmuffs and earplugs.

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Data Availability Statement: All data presented in this study are available on request from the corresponding author.

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