Effect of milking environment enrichment through music on production performance and behaviour in cattle

S. A. Kochewad1 · G. K. Gaur2 · V. P. Maurya2 · P. K. Bharti3 · N. R. Sahoo4 · H. O. Pandey2 · Mukesh Singh2 · M. R. Verma2

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Abstract
Enrichment of milking environment through music has been proposed to help animals to cope with divergent stressors. In sight of the above, a study was conducted to evaluate the effect of Indian instrumental music-based environmental enrichment played in yaman raga on milk production performance and behaviour in cattle. A total of 21 lactating dairy cattle (Vrindavani crossbred cows) having similar parity and stage of lactation were selected in three groups — T1, T2 and T3, each consisting of seven animals. The T1 and T2 groups were exposed to instrumental flute and sitar, respectively, 10 min prior to the start of milking and continued till completion of milking; while the T3 group served as control. Musical enrichment of the environment was done using recorded-tape of flute and sitar was played in yamen raga at 40–60 (dB) decibel intensity. The results revealed a non-significant difference in milk yield, rectal temperature, respiration rate, T3 (triiodothyronine) and T4 (thyroxine) hormones. However, there exhibited a significant ($p < 0.05$) difference in milking time, milking speed, cortisol hormones and behavioural parameters such as milk let-down in the animals exposed to music compared to the control group. Thus, the results have significant implications relating to the behavioural fitness and welfare of dairy animals and reducing residual milk.

Keywords Cortisol · Environment enrichment · Milk yield · Milk let-down · Music · Stress

Introduction
Dairy farming globally is gradually changing to intensified farming (Mandel et al. 2016) from a low input, low output-based system to a high input, high output-based system. The change towards intensive rearing system of dairy animals will have profound effects on the health, welfare and management practices (Barkema et al. 2015). In intensive dairy farming, most of the time, the animals are unable to express their natural behaviours such as grazing, breeding and socialising with restricted movement (von Keyserlingk et al. 2009). Intensive farming can achieve overall economic gains, but also incurs site-specific social and environmental costs (Clay et al. 2020). High-yielding dairy animals are often under production stress. The environment in milking barns and the experience of rough handling of animals by milkers during the milking process cause stress in animals. Due to the bad experiences faced by animals in milking parlours, the animals hesitate to enter the milking barns. The sound of human shouting and metal items slamming increases the heart rate and activity of cattle (Waynert et al. 1999).

Under increasing stress conditions, dairy cows show declined milk production. For both ethical and physiological concerns, chronic stress and anxiety are undesirable. Stress in animals produces not only immediate reactions, but it can also have long-term effects on their biology, even across generations (Ericsson et al. 2016). Stress can potentially inhibit the release of oxytocin — a key hormone responsible for releasing of milk in animals. Thus, under stress-prone environmental conditions.
circumstances, introduction of enriching amendments could induce a significant improvement in physiology of the animals (Newberry 1995). Environmental enrichment refers to changes in an animal’s biological function as a result of changes in their environment, including reproductive performance, physical fitness and overall physiology (Newberry 1995). Social, occupational, physical, sensory and nutritional enrichment are all examples of environmental enrichment. Each type of enrichment may contribute to the animal’s welfare in a different way; the mechanism and method might be complex; enrichment has short and long-term consequences, and at different life stages contributes differently to welfare; more than one mechanism can explain contribution; and certain enrichment methods are limited to a specific time window (Mandel et al. 2016). Environment enrichment has a positive effect on animal behaviour and can lower fear and stress responses in animals (Miranda-de la Lama et al., 2013). Environment enrichment also helps animals to cope up with stressors in their surroundings, reduce frustration, increase the fulfilment of behavioural needs and promote more positive affective states (Mandel et al. 2016).

An efficient management of the surrounding environment thus plays an important role towards maximising profitability, animal comfort and welfare. In this context, many farmers and dairy owners have employed various strategies and new technologies to improve milk yield and animal comfort; however, the success is limited. Music therapy, which was more widely used in people, is now being used to enrich the environment of farm animals (Ciborowska et al. 2021). Playing classical music inside the milking parlour has an indirect impact on cow welfare, because it reduces ambient noise for cows (Cloutier, 2000; Mandel et al. 2016). Music has been shown to exhibit a mood-regulatory effect (Saarikallio and Erkkila 2007). Cardona et al. (2022) reported that animals subjected to music exhibited a wide variety of emotional responses with various affective valences, depending on the harmonic structure of the stimulus. A calming music can improve milk yield, probably due to its role in decreasing the stress levels. Slow music is reported to improve daily milk yield by 3% in cows, while fast music decreases it by 2% (Nold 2007). Wells (2009) reported that classical and country music have more positive effects on behaviour than rock music as it enhances stress. Playing music might be a practical tool to reduce necessary efforts of driving cows to milking, and Lemcke et al. (2021) also reported that the music genres exhibited different responses on milk yield in different trials by various researchers, which might be due to other characteristics of the music, such as different frequencies (measured in hertz, Hz), tempi (measured in beats per minute, bpm), or amplitudes (measured in decibel, dB). Many researchers have reported that Indian classical music has positive effects on animals. In Indian classical music, ragas are specific combinations of tonic intervals capable of evoking distinct emotions that are unique to the raga; Mathur et al. (2015) also reported raga Yaman evokes emotion of being calm/happy.

In sight of the benefits of music as environment enrichment strategy, the optimization of music parameters for dairy animals is critically needed to maintain an optimal balance of the animal comfort, behavioural needs and reducing residual milk. This study typically evaluates the influence of different Indian classical instrumental music played in yaman raga on stress levels in animals, milk production and animal welfare.

Material and methods

Experimental design

The study was conducted on lactating dairy animals at the Cattle and Buffalo (C&B) Farm of Indian Veterinary Research Institute, Izatnagar, Uttar Pradesh, India. The experimental site is located at an altitude of 169 mamsl, 28.22° N latitude and 79.24° E longitude. The climate of the place touches both the extremes of hot (approx. 45 °C) and cold (approx. 5 °C) and RH ranges between 15 and 99%. The average maximum and minimum values of air temperature recorded are 38.07 °C and 7.43 °C, respectively. The mean monthly RH ranges between 45.46 and 93.93%. Average annual rainfall ranges between 90 and 120 cm, most of which is received during July to September. A total of 21 lactating dairy cattle (Vrindavani crossbred cows) having similar parity and stage of lactation were selected in three groups — T1, T2 and T3, each consisting of seven animals. Music system was installed in the milking barn. The speakers were placed at 1-m height in front of the animals, and all the (instrument) music was played in at 40–60 decibel (dB) intensity. The range of decibels of playing music was decided upon the response behaviour of the animals towards low and high intensity. The range of decibels received at the head level of animals was ensured. The instrumental music flute and sitar were played in yamern raga, which has been reported to evoke calming/happy effect (Mathur et al. 2015). The T1 and T2 groups were exposed to instrumental flute and sitar played in yaman raga, respectively 10 min prior to the start of milking and continued till completion of milking; while the T3 group served as control representing the routine milking management system at C&B farm. The experiment was conducted for a period of 105 days.
**Milk yield and animal physiology**

Machine milking method was used for milking of animals, and daily individual milk yield was recorded in kilogram animal\(^{-1}\). Individual cow milking time (min) was also recorded. Milking speed (kg min\(^{-1}\)) was calculated by using milk yield and milking time. Physiological variables such as rectal temperature and respiratory rate of animals were recorded at fortnightly intervals after milking. Rectal temperature was recorded by using a digital clinical thermometer. Respiration rate was counted from a distance by observing flank movements and expressed as counts per minute. Blood sampling was done on the 90th days during the experimental period by puncturing the jugular vein following the aseptic measures. All the samples were analysed in the Nuclear Research Laboratory (NRL), IVRI, Izatnagar for stress indicators like T\(_3\) (triiodothyronine), T\(_4\) (thyroxine) and cortisol hormone. For hormonal assay, the preserved serum was brought to the room temperature. Cortisol, T\(_3\) and T\(_4\) was estimated using standard Radio-Immuno Assay (RIA) kits (Erba Diagnostics Mannheim GmbH, Germany).

Behavioural activities of animals were recorded in evening milking hours by two observers for recording behavioural parameters of individual animals by visual observations, and the mean of the observation was taken as score for analysis. Focal sampling method (Martin and Bateson 1993) was used for recording the behavioural data. Score card was prepared for recording the behavioural parameters of individual animals. Each behavioural activity was assigned a score in the scale of 1–3; the highest the activity, the more the score was assigned. The parameters recorded were entry of animals in the milking parlour, assembling in the milking parlour, fear for milkers, feeding activity, the more the score was assigned. The parameters recorded were entry of animals in the milking parlour, assembling in the milking parlour, fear for milkers, feeding behaviour, shaking of head and body parts, feed tossing, feeding time, kicking behaviour during udder preparation, milk letting-down behaviour and abnormal behaviour such as licking and knot tying.

**Statistical analysis**

Data were analysed using Statistical package for social science program version 20 (SPSS Inc., Chicago, IL, USA). The data were expressed as mean ± standard errors of mean and tested for normality and homogeneity of variance using Shapiro–Wilk’s and Levene’s test, respectively. When both tests were satisfied, one-way ANOVA (analysis of variance) with Tukey’s multiple range test (TMRT) were applied to test the statistically significant difference at \(p < 0.05\). The Kruskal–Wallis test was used for comparing behavioural parameters in different groups.

**Results**

**Effect of music on milk parameters**

**Milk yield in Vrindavani crossbred cows**

The initial milk yield in T1, T2 and T3 groups were 14.21 ± 0.83, 13.88 ± 0.98 and 14.75 ± 0.55, respectively which exhibited a non-significant \((p > 0.05)\) difference among the groups. Throughout the experiment of 105 days, there was a non-significant \((p > 0.05)\) difference in milk yield among the groups (Table 1). The overall mean milk yield in T1, T2 and T3 were 12.59 ± 0.09, 12.85 ± 0.07 and 12.57 ± 0.05, respectively.

**Milking time in Vrindavani crossbred cows in different groups**

There was a significant difference \((p < 0.01)\) in milking time in the different groups (Table 1). The milking time in animals during the initial stage was non-significant \((p > 0.05)\). The milking time in the initial stage in T1, T2 and T3 groups was 11.96 ± 0.44, 11.96 ± 0.85 and 12.25 ± 0.62, respectively. However, during the second fortnight, T1 group showed a significant \((p < 0.05)\) reduction in milking time as compared to T3 group, whereas it appeared aligned with that in T2 group. During the fifth fortnight, T2 group showed a significantly \((p < 0.05)\) lower milking time as compared to T3 group, whereas it was comparable to T1 group. The overall milking time was significantly \((p < 0.01)\) lower in T1 (10.67 ± 0.06) and T2 (10.70 ± 0.05) over the control (10.98 ± 0.06).

**Milk flow rate in Vrindavani crossbred cow**

Milk flow rate differed significantly in the different groups (Table 1). The milk flow rate among the cows during the initial stage was non-significant \((p > 0.05)\). However, during the fifth fortnight, T2 group exhibited a significantly \((p < 0.05)\) higher milk flow rate, as compared to T1 and T3. During the sixth fortnight, T2 group had significantly \((p < 0.05)\) higher milk flow rate, as compared to T3 group. Overall, both the musical treatments (T1 and T2) were significantly \((p < 0.01)\) enhancing the milk flow rate over the control.
almost similar with no significant difference (p > 0.05). The overall respiration rate in T1, T2 and T3 groups was 22.73 ± 0.34, 22.2 ± 0.41 and 23.47 ± 0.35, respectively (Table 2). Although the respiration rate was relatively higher in T3 group compared to music exposed groups, it remained statistically non-significant (p > 0.05).

Table 2 Mean of various physiological parameters in Vrindavani crossbred cows

| Exp Gr | Initial | I   | II   | III  | IV   | V    | VI   | VII  | Overall |
|--------|---------|-----|------|------|------|------|------|------|---------|
| Respiration rate (counts/min) | | | | | | | | | |
| T1     | 23.14 ± 1.05 | 22.0 ± 1.06 | 23.14 ± 0.71 | 22.85 ± 0.85 | 21.71 ± 0.80 | 23.28 ± 0.64 | 22.73 ± 0.34 |
| T2     | 22.28 ± 0.52 | 21.71 ± 1.47 | 22.85 ± 1.14 | 22.28 ± 0.68 | 21.14 ± 1.14 | 22.28 ± 0.68 | 22.2 ± 0.41 |
| T3     | 23.28 ± 0.94 | 23.42 ± 0.94 | 24.57 ± 1.04 | 23.42 ± 1.04 | 23.0 ± 0.65 | 23.14 ± 0.73 | 23.47 ± 0.35 |
| p-Value| 0.883 | 0.683 | 0.594 | 0.822 | 0.598 | 0.377 | 0.143 |
| Rectal temperature (°F) | | | | | | | | | |
| T1     | 99.9 ± 0.34 | 99.84 ± 0.41 | 100.35 ± 0.39 | 100.2 ± 0.7 | 100.45 ± 0.23 | 99.74 ± 0.43 | 100.08 ± 0.14 |
| T2     | 99.8 ± 0.09 | 100.21 ± 0.34 | 100.21 ± 0.34 | 99.9 ± 0.40 | 100 ± 0.31 | 99.14 ± 0.41 | 99.82 ± 0.13 |
| T3     | 99.95 ± 0.26 | 100.24 ± 0.35 | 100.24 ± 0.35 | 100.78 ± 0.31 | 100.62 ± 0.37 | 99.17 ± 0.40 | 100.06 ± 0.15 |
| p-Value| 0.997 | 0.781 | 0.994 | 0.411 | 0.450 | 0.661 | 0.363 |

Means with different superscripts in column within each subhead differ significantly at (p < 0.05)* and (p < 0.01)**
Hormone profile in Vrindavani crossbred cows

Profiling of T3 (triiodothyronine) and T4 (thyroxine) hormones revealed a statistically non-significant \((p > 0.05)\) influence of musical enrichment of milking environment. However, cortisol hormone found to be significantly \((p < 0.05)\) higher in T3 group over the T2 and T1 groups (Table 3). Thus, the results established an important positive interaction of musical enrichment on lowering the cortisol levels in dairy cows.

Effect of music on milking behaviour

Measured behavioural characteristics such as entry of animals in milking shed, assembling in milking parlour, fear for milkers, feeding behaviour, feed tossing, feeding time, kicking behaviour, abnormal behaviour and behaviour during knot tying appeared almost similar in all the three groups; there was non-significant \((p > 0.05)\) difference in these parameters (Table 4). However, a significant effect of musical enrichment was evident on calmly assembling in milking parlour, which was significantly \((p < 0.05)\) higher in T1 and T2 groups. The shaking of head and movements of head and body parts was significantly \((p < 0.05)\) higher in T3 group and recorded lower in T2 and T1 groups. Milk-letting down behaviour was significantly \((p < 0.05)\) lower in T2 and T3 groups.
behaviour score was significantly ($p < 0.01$) higher in T2 (74.81) and T1 groups (72.89), while the least score was seen in T3 group (48.96).

**Discussion**

Milk production in dairy animals is an interactive effect of both the genetic and environmental factors (Kunaka and Makuza 2005). Adverse environmental factors hinder the animal’s real genetic ability of production (Missanjo et al. 2011). Environmental enrichment increases animals’ physical activity and also fulfils their psychological and behaviour needs. Enrichment reduces stress and increases animal welfare, animal health and productivity. Here, we used sensory method of environment enrichment through Indian instrumental music played in yaman raga to enrich the milking environment and investigate the influence on various production performances and behaviour in cattle. Valla et al. (2017) reported that ragas are musical compositions capable of creating distinct moods or feelings and are the core concept in this system of Indian music. We used different Indian instrumental music played in yaman raga; Mathur et al. (2015) reported that yaman raga has a calming/relaxing effect on the individual. The results revealed that the effect of environmental enrichment through music had a non-significant effect on milk yield. The milk yield is influenced by various factors, and the effect of music might be far lower, as compared to the other factors that ultimately reflected a non-significant interaction. Although the present study revealed a trend, the results indicated a need of a precise experiment with a larger number of animals that could yield sound outcomes. The animals exposed to music were observed to have a significantly lower milking time as compared to the control group. Abuzead and Khalil (2007) found that the milk cortisol of animals in the slow music group was significantly lower than that in the fast music and control groups. A calming effect of music was evident on animals which might have helped in reducing the stress hormone that ultimately affected the milk let-down and its effect on milking behaviour. Similar findings were also reported by Roy et al. (2018), where lowering of stress was observed by a reduced cortisol level when music was played, as compared to the control group. Fadlelmoula and Kaskous (2020) also reported a negative correlation between milk yield and concentration of cortisol in milking animals. Kıyıcı et al. (2013) used music as a measure to reduce stress levels in dairy cows during milking and found that cows subjected to classical music for a period of 28 weeks, compared to no music, had higher milk let-down speed ($6.27 \pm 0.12$ min vs. $6.68 \pm 0.13$ min, respectively. Bobic et al. (2011) reported that the onset of stress condition activates the sympathetic nervous system and hypothalamic–pituitary–adrenal axis, causing a hormonal change in the blood (increased levels of βendorphin, cortisol, ACTH and catecholamines) that leads to disturbances in the release of milk, decreased productivity and decreased immunity. Furthermore, removal of the music enrichment in animals has been linked to a significant increase in faecal cortisol and the heterophil:lymphocyte ratio, suggesting an increased level of stress (Peveler and Hickman 2018). Domestic animals react to stress by an alteration of behavioural and physiological responses (Deiss et al. 2009), which includes activation of the central nervous system, endocrine and immune systems that can ultimately influence the animal’s production performance (Caroprese et al. 2010). This study also proved a marked effect of music on behavioural characteristics of milking cows such as shaking of head and body parts during milking. These results corroborate the findings of Wells and Irwin (2008) that reported a beneficial impact of auditory stimulation through classical music on reducing stereotypic behaviour in animals. Similarly, the use of auditory stimuli was also known to reduce abnormal behaviours such as tongue rolling which is indicative of reduced stress and increased welfare and positive social interactions (Crouch et al. 2019). The amplitude of music also influences the milk ejection. Algers and Jensen (1991) reported that dairy cows exposed to 80–100 dB of sound for 1.4-h duration twice daily resulted in reduced milk yield in dairy cows. Similarly, Algers et al. (1978) reported that it causes interrupted ejection. A stimulatory effect of music on calm behaviour and readiness of cows to access the milking compartments were also reported (Uetake et al. 1995; Moregaonkar et al. 2006) that further signify beneficial interactions of musical enrichment in dairy cows.
Conclusion
The results endorse beneficial effects of slow instrumental music played in yaman raga towards improving the behaviour and welfare of dairy animals. Furthermore, a smooth movement of animals through the music barn could be useful to regulate the stress levels in animals and promote easy milk let-down. Musical enrichment is a relatively easily accessible, user-friendly, economic technique with no environmental consequences. Thus, these findings have significant implications in the area of animal behaviour and welfare. Further precise studies with larger groups of animals are needed to reveal the underlying mechanisms of action of environmental enrichment through music in dairy animals.

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Author contribution Conceptualization: GKG, SAK; methodology: SAK, PKB; formal analysis: MK, HOP; supervision: GKV, VPM and SAK; statistical analysis: MRV; literature collection: NRS, SAK; writing and original draft preparation: SAK, PKB and NRS; writing, review and editing: PKB, NRS, MS and GKV. All the authors have read and approved the manuscript.

Data availability The datasets generated during the current study are not publicly available as it will compromise the privacy of research but are available from the corresponding author on reasonable request.

Declarations

Statement of animal ethics Institutional Guidelines of Indian Council of Agricultural Research-Indian Veterinary Research Institute (ICAR-IVRI) as per the Institute Research Council has followed experimenting.

Conflict of interest The authors declare no competing interests.

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