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RESEARCH ARTICLE

Environmental and Management Factors Associated with Cutaneous Lupus Erythematosus Occurrence in Horses of Ajmer District, Rajasthan, India

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ABSTRACT

Cutaneous Lupus Erythematosus (CLE) is a photosensitive autoimmune dermatological disorder influenced by interactions between immune dysregulation, genetic susceptibility, and environmental triggers. Although CLE has been described in horses, population-level information regarding climatic, environmental, and management factors associated with disease occurrence remains limited. The present study was conducted to evaluate the association of climatic conditions, environmental exposure, and management practices with CLE occurrence among horses in Ajmer district, Rajasthan, India. A two-year cross-sectional epidemiological study was conducted during 2024–2025 involving 360 horses examined from farms, stables, equine establishments, and rural locations. Clinical and dermatological examinations were performed, and suspected cases were confirmed through histopathological evaluation. Climatic variables including daily maximum temperature and relative humidity, along with environmental and management factors such as sunlight exposure, housing system, shade availability, outdoor exposure, and protective management practices were assessed. Among the examined horses, 27 were classified as CLE-positive, resulting in an overall prevalence of 7.5%. Higher CLE prevalence was observed among horses exposed to prolonged sunlight (10.0%), high maximum temperature conditions (>40°C; 9.3%), and low relative humidity (<30%; 9.3%). Similarly, open housing systems, inadequate shade availability, continuous outdoor exposure, and poor protective management were associated with increased CLE occurrence. One-way ANOVA revealed significant effects of sunlight exposure, housing system, shade availability, outdoor exposure, management practices, and temperature, whereas relative humidity showed a marginal association with CLE occurrence. The findings indicate that climatic and environmental conditions may act as important modifiers of equine CLE expression. Improved environmental management, including shade provision, controlled outdoor exposure, and reduction of excessive solar stress, may help reduce the risk and severity of CLE in horses maintained under semi-arid climatic conditions.

Keywords: *Cutaneous Lupus Erythematosus; horse; ultraviolet radiation; temperature; relative humidity; environmental exposure; management practices; Rajasthan*

INTRODUCTION

Cutaneous Lupus Erythematosus (CLE) is a chronic autoimmune dermatological disorder characterized by immune-mediated inflammation involving the epidermis, dermoepidermal junction, and superficial dermal tissues. The disease commonly presents with alopecia, erythema, scaling, crusting, pigmentary alterations, and inflammatory lesions, particularly on sun-exposed body regions. Although CLE has been extensively studied in humans and reported in several animal species, epidemiological information regarding environmental factors associated with equine CLE remains limited. Disease development involves complex interactions

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among genetic susceptibility, immune dysregulation, and environmental triggers. Ultraviolet (UV) radiation is considered one of the major environmental factors involved in disease initiation and exacerbation. UV exposure induces keratinocyte apoptosis, increases nuclear antigen availability, stimulates inflammatory cytokine production, and promotes autoimmune responses in susceptible individuals (Jessop & Whitelaw, 2014; Walling & Sontheimer, 2009; Grönhagen & Nyberg, 2014). Abnormal UV responses have also been recognized as important mechanisms contributing to lupus-associated skin inflammation (Corbin et al., 2023; Klein & Kunz, 2022).

In horses, prolonged sunlight exposure may increase the risk of photosensitive skin disorders because animals are frequently maintained under outdoor or semi-open management systems. The semi-arid climate of Rajasthan, characterized by intense solar radiation, prolonged sunshine duration, elevated summer temperature, and variable humidity conditions, may influence the expression of immune-mediated dermatological diseases. Apart from UV radiation, climatic factors such as temperature and relative humidity may modify disease severity. Elevated temperature can increase thermal stress, oxidative imbalance, and inflammatory responses, whereas low humidity may reduce skin hydration, impair epidermal barrier function, and increase susceptibility to environmental stress. Heat stress and dry climatic conditions have been reported to influence physiological responses, immune regulation, and skin barrier integrity in domestic animals (Bernabucci et al., 2010; Lacetera, 2019; Proksch et al., 2008; Elias, 2012). Environmental management practices can modify the effects of climatic exposure. Housing systems, availability of shade, duration of outdoor activity, and protective measures influence the intensity of UV exposure and thermal stress experienced by horses. Animals maintained under open housing systems or without adequate shade may experience greater cumulative solar exposure and environmental stress compared with animals maintained under protected conditions. Similar associations between environmental exposure and immune-mediated skin disorders have been reported in veterinary dermatology (Scott & Miller, 2011; Gross et al., 2005).

Recent evidence from equine cases has highlighted the importance of environmental modification in CLE management, with successful treatment reported using UV protection and topical tacrolimus (Dropsy et al., 2026). However, population-level studies evaluating climatic, environmental, and management-related factors associated with equine CLE occurrence are lacking. Ajmer district of Rajasthan provides a suitable environment for such investigation due to high solar intensity, seasonal temperature variation, and diverse horse management systems. Therefore, the present study was conducted to evaluate the association of climatic factors (daily maximum temperature and relative humidity), environmental exposure, housing practices, and management conditions with the occurrence of Cutaneous Lupus Erythematosus among horses in Ajmer district of Rajasthan, India.

MATERIALS AND METHODS

A two-year cross-sectional epidemiological study was conducted during 2024–2025 in Ajmer district, Rajasthan, India, involving 360 horses (180 horses/year) examined from farms, stables, equine establishments, and rural locations. The study area represents a semi-arid climatic region characterized by high solar radiation, prolonged sunshine duration, elevated summer temperature, and low atmospheric humidity. Horses were selected using a stratified sampling approach considering animal availability, owner consent, and representation of different management conditions. All animals underwent detailed clinical and dermatological examination, and suspected CLE cases were confirmed through histopathological evaluation of skin biopsy samples. Environmental, climatic, and management variables, including sunlight exposure duration, daily maximum temperature, relative humidity, housing system, shade availability, outdoor exposure, and protective management practices, were recorded through direct observation, owner interviews, and available meteorological records. Sunlight exposure was categorized as low (<4 hours/day), moderate (4–8 hours/day), and high (>8 hours/day). Daily maximum temperature was grouped into <35°C, 35–40°C, and >40°C categories, whereas relative humidity was classified as low (<30%), moderate (30–50%), and high (>50%). Housing system, shade availability, outdoor exposure, and management practices were categorized according to their level of environmental protection. CLE status was coded as 1 for positive cases and 0 for negative cases. Prevalence was calculated as the percentage of CLE-positive horses among the total examined population. One-way analysis of variance (ANOVA) with eta squared (η^2) was performed to evaluate differences in CLE occurrence among climatic, environmental, and management categories. Spearman correlation analysis was used to assess associations between environmental exposure scores and CLE status. Statistical significance was considered at $p < 0.05$. All procedures were performed according to standard veterinary ethical guidelines, and owner consent was obtained before examination and sample collection.

RESULTS

Clinical Identification and Overall Prevalence of CLE

A total of 360 horses were examined during the study period (2024–2025) through detailed clinical and dermatological evaluation. Suspected cases exhibited characteristic dermatological manifestations, including alopecia, erythema, scaling, crusting, depigmentation, and epidermal erosion. The lesions were predominantly observed on sun-exposed anatomical regions, particularly the muzzle, eyelids, periocular region, and ear margins. Following clinical examination, differential diagnosis, and histopathological confirmation in selected cases, 27 horses were classified as CLE-positive. The overall prevalence of Cutaneous Lupus Erythematosus in the studied population was calculated as 7.5%, indicating the occurrence of CLE among horses examined in Ajmer district during the study period.

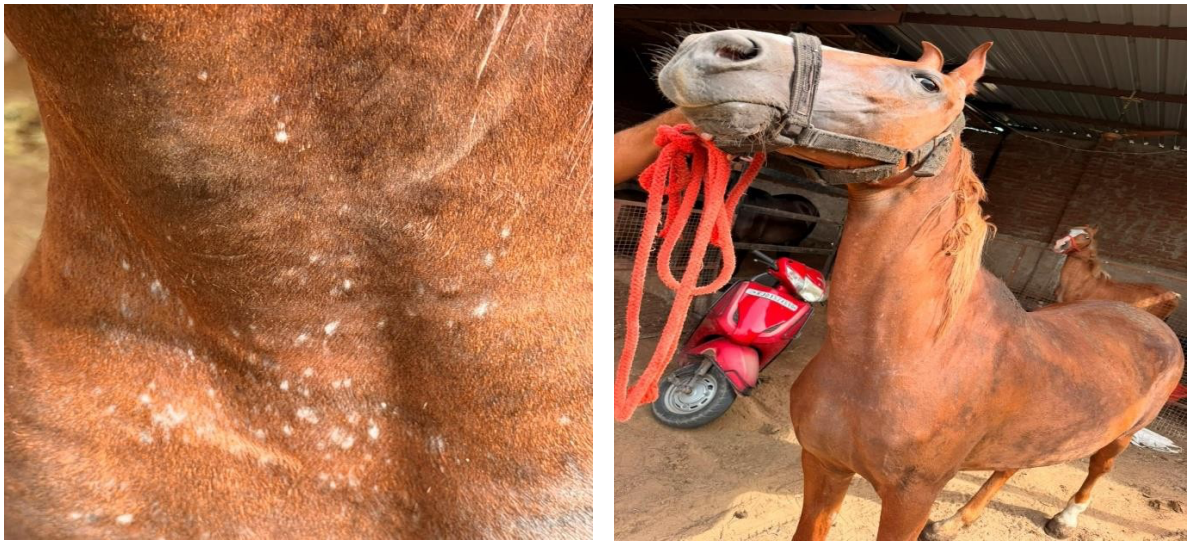


Figure 1: Disease symptoms among the horses.

Climatic Factors Associated with CLE Occurrence

Association Between daily Maximum Temperature and CLE Occurrence

The occurrence of CLE was evaluated in relation to the daily maximum ambient temperature recorded during the 14 days preceding clinical examination. Variation in CLE prevalence was observed among different temperature exposure categories. Horses examined during periods with higher maximum temperatures showed comparatively greater prevalence of CLE. The lowest prevalence was recorded when the daily maximum temperature was below 35°C (4.4%), whereas higher prevalence was observed during periods with temperatures ranging from 35–40°C (8.0%) and above 40°C (9.3%).

The increasing trend in CLE occurrence with rising maximum temperature suggests that elevated ambient temperature may act as an environmental modifier by increasing thermal stress, enhancing outdoor exposure, and intensifying the effects of solar radiation on susceptible animals. However, because the present investigation followed a cross-sectional design, these findings indicate an association between temperature conditions and CLE occurrence rather than a direct causal relationship.

Table 1. Prevalence of CLE according to daily maximum temperature

Daily maximum temperature	**Number of horses examined**	**Number of CLE cases**	**Prevalence (%)**
<35°C	90	4	4.4
35–40°C	162	13	8.0
>40°C	108	10	9.3
Total	**360**	**27**	**7.5**

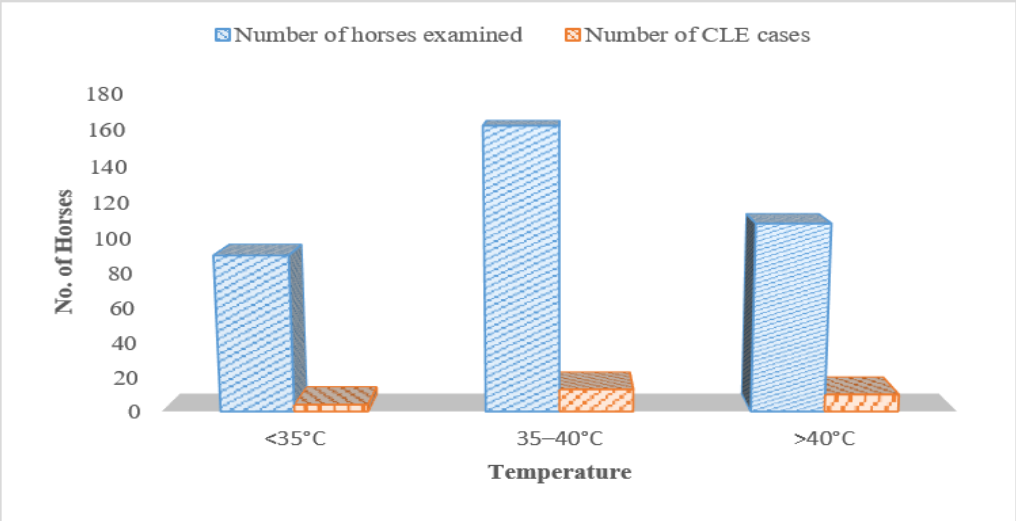


Figure 2. Prevalence of Cutaneous Lupus Erythematosus according to daily maximum temperature conditions.

Association between Relative Humidity and CLE Occurrence

The relationship between relative humidity conditions and CLE occurrence was evaluated to determine the influence of atmospheric moisture conditions on disease distribution. Horses exposed to lower relative humidity showed comparatively higher prevalence of CLE than those maintained under moderate or higher humidity conditions. The highest prevalence was observed under low humidity conditions (<30%) with 9.3% occurrence, followed by moderate humidity conditions (30–50%) with 7.4% prevalence. The lowest prevalence was observed under higher humidity conditions (>50%) with 5.6% occurrence.

The increased prevalence under low humidity conditions may be associated with the semi-arid climatic characteristics of Ajmer, where dry environmental conditions may contribute to reduced skin moisture, altered skin barrier function, and increased susceptibility to solar-induced inflammatory responses. Relative humidity may therefore function as an environmental modifying factor influencing CLE expression rather than acting as an independent cause of disease development.

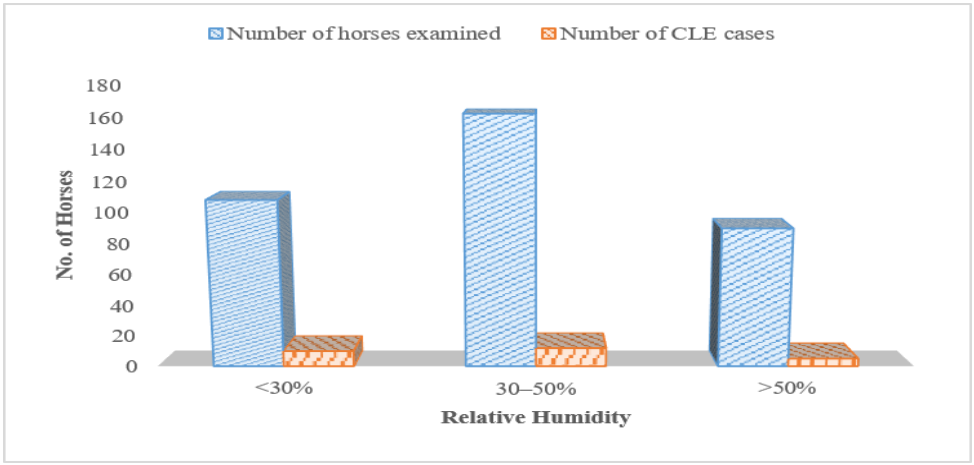


Figure 3. Prevalence of Cutaneous Lupus Erythematosus according to relative humidity conditions.

Table 2. Prevalence of CLE according to relative humidity conditions

Relative humidity	Number of horses examined	Number of CLE cases	Prevalence (%)
<30%	108	10	9.3
30–50%	162	12	7.4
>50%	90	5	5.6
Total	**360**	**27**	**7.5**

Environmental Exposure Factors Associated with CLE Occurrence

Association Between Sunlight Exposure and CLE Occurrence

Environmental exposure analysis showed variation in CLE occurrence according to daily sunlight exposure. Horses exposed to prolonged sunlight showed comparatively higher prevalence than animals maintained under restricted sunlight conditions. The highest prevalence was observed among horses with high sunlight exposure (>8 hours/day), whereas horses with limited outdoor exposure showed lower disease occurrence. The findings indicate a numerical increase in CLE prevalence with increasing duration of sunlight exposure.

Table 3. Effect of daily sunlight exposure on CLE prevalence

Sunlight exposure	Horses examined	CLE-positive horses	Prevalence (%)
Low (<4 hours/day)	90	4	4.4
Moderate (4–8 hours/day)	150	11	7.3
High (>8 hours/day)	120	12	10.0
Total	360	27	7.5

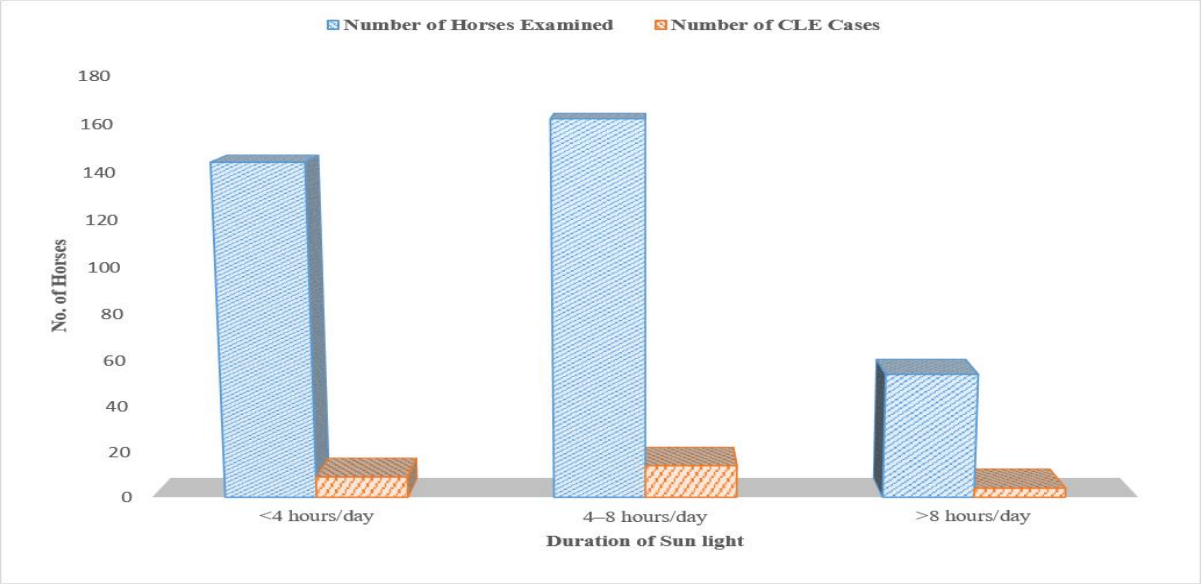


Figure 4: Environmental exposure-based prevalence of Cutaneous Lupus Erythematosus among horses according to daily sunlight exposure categories

Association Between Housing System and CLE Occurrence

Housing conditions showed variation in CLE occurrence. Horses maintained under open housing systems showed higher prevalence compared with animals maintained under indoor or semi-open housing conditions. Open housing conditions, associated with greater direct solar exposure, showed comparatively higher CLE occurrence.

Table 4. Housing system-wise prevalence of CLE

Housing system	Horses examined	CLE-positive horses	Prevalence (%)
Indoor housing	90	4	4.4
Semi-open housing	180	14	7.8
Open housing	90	9	10.0
Total	360	27	7.5

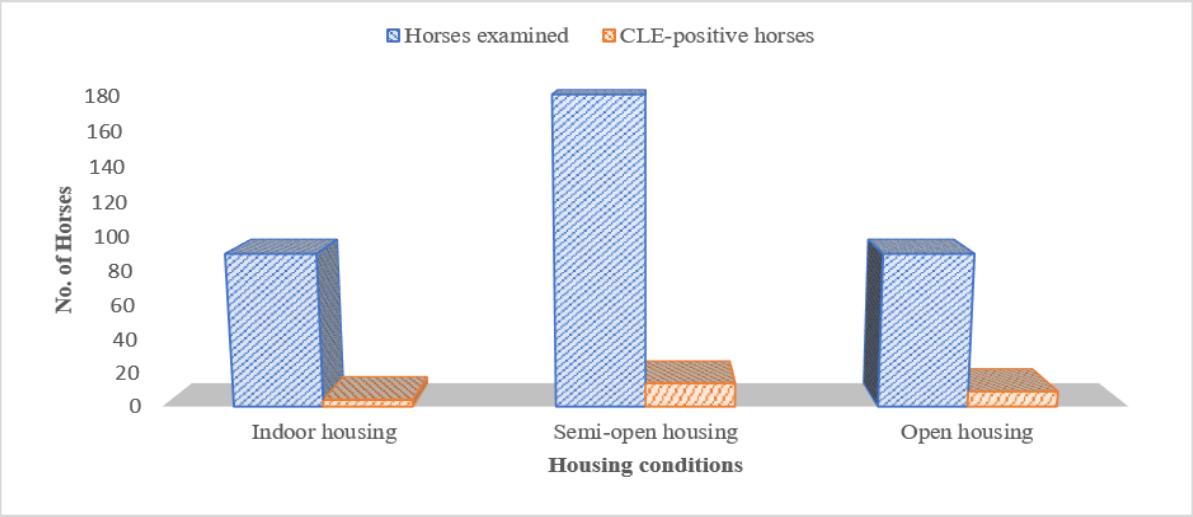


Figure 5: Association between housing system and occurrence of CLE in horses maintained under various housing conditions.

Effect of Shade Availability on CLE Occurrence

Shade availability demonstrated an inverse relationship with CLE occurrence. Horses with adequate shade protection showed lower prevalence compared with animals having limited or no shade availability. The results indicate that absence of shade may increase exposure to solar radiation and contribute to higher CLE occurrence.

Table 5. Shade availability and CLE prevalence

Shade availability	Horses examined	CLE-positive horses	Prevalence (%)
Adequate shade	120	5	4.2
Partial shade	150	12	8.0
No shade	90	10	11.1
Total	360	27	7.5

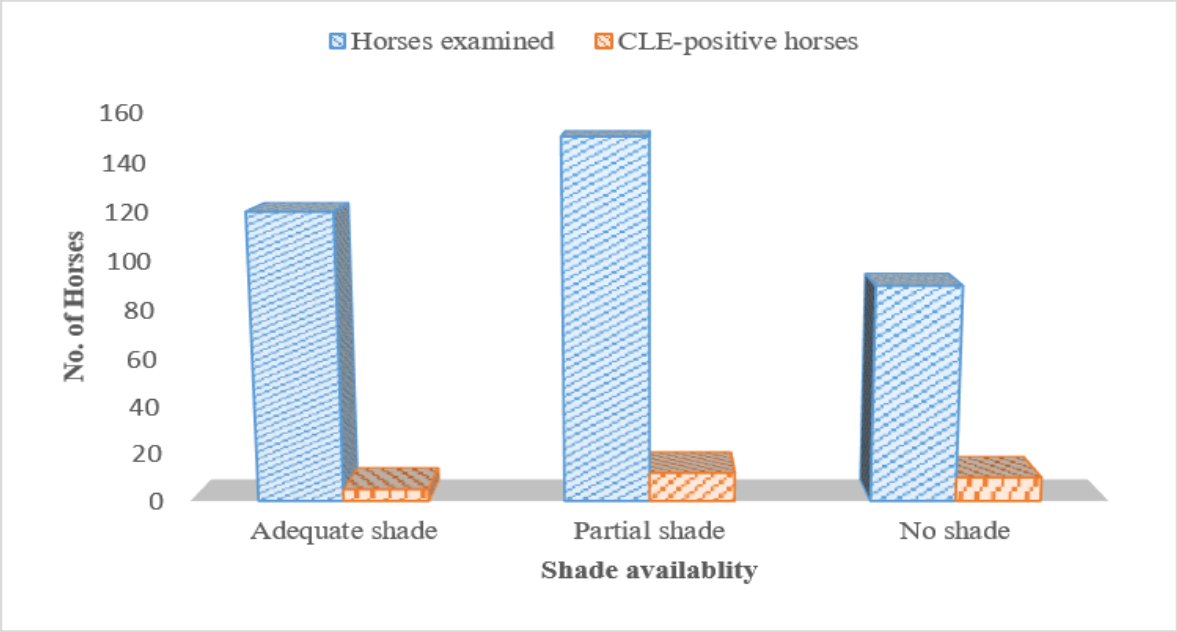


Figure 6: Effect of shade availability on prevalence of Cutaneous Lupus Erythematosus among horses under different levels of solar protection

Effect of Outdoor Management Practices on CLE Occurrence

Outdoor activity patterns influenced CLE distribution among horses. Animals maintained under continuous outdoor management showed greater prevalence compared with horses having

restricted outdoor activity. Higher prevalence was observed among horses exposed continuously to outdoor environmental conditions.

Table 6. Outdoor management practices and CLE prevalence

Outdoor management	Horses examined	CLE-positive horses	Prevalence (%)
Restricted outdoor activity	90	4	4.4
Moderate outdoor activity	180	13	7.2
Continuous outdoor exposure	90	10	11.1
Total	360	27	7.5

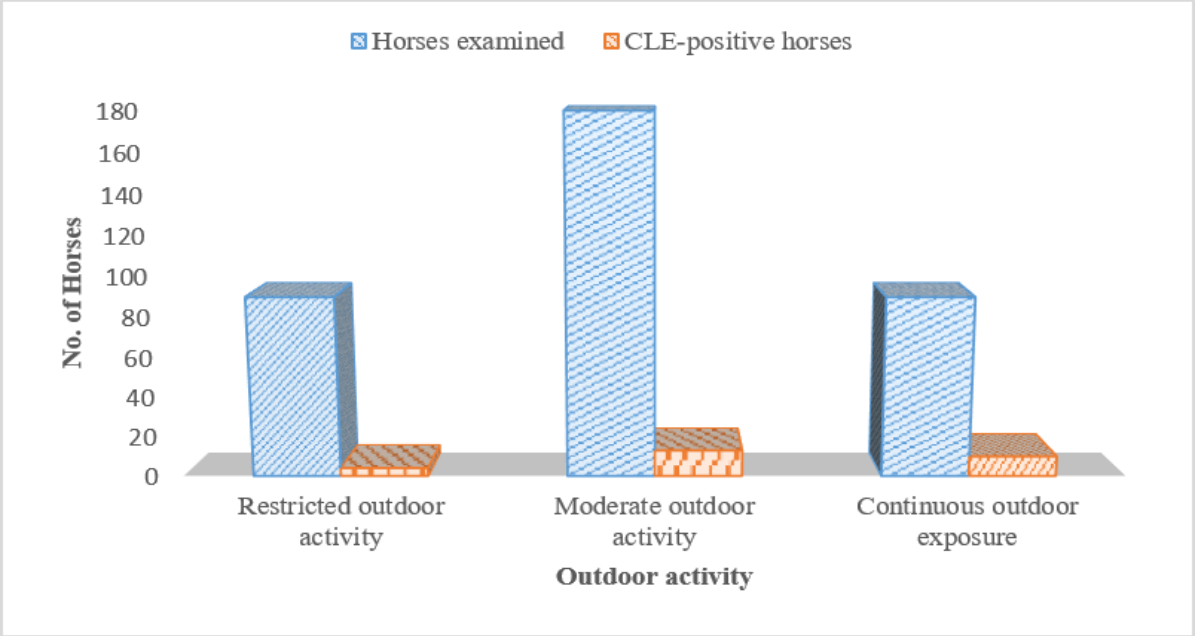


Figure 7: Relationship between outdoor exposure duration and prevalence of CLE in horses under various outdoor management conditions

Effect of Protective Management Practices on CLE Occurrence

Protective management practices showed a negative association with CLE occurrence. Horses maintained under good protective management showed lower prevalence compared with animals maintained under poor management conditions.

Table 7. Management practices and CLE prevalence

Management category	Horses examined	CLE-positive horses	Prevalence (%)
Good management	90	4	4.4
Moderate management	180	14	7.8
Poor management	90	9	10.0
Total	360	27	7.5

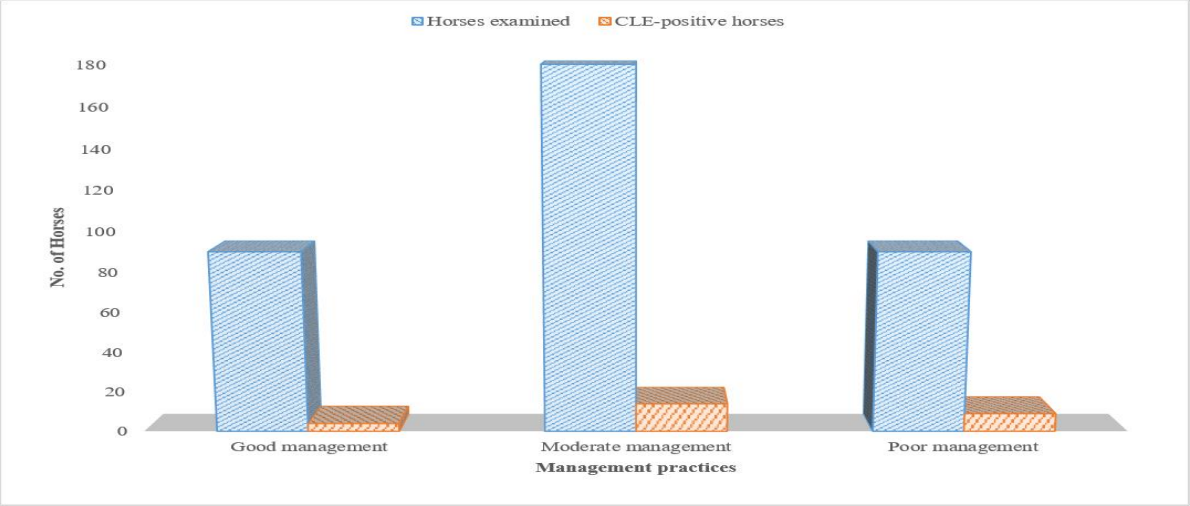


Figure 8: Influence of protective management practices on occurrence of CLE among horses under good, moderate, and poor management systems.

Statistical Analysis of Environmental, Climatic and Management Factors

The influence of environmental, climatic, and management variables on CLE occurrence was assessed using one-way ANOVA. Climatic factors, including daily maximum temperature and relative humidity, and environmental and management factors, such as sunlight exposure, housing system, shade availability, outdoor exposure, and protective management practices, were analysed for their association with CLE status. CLE prevalence varied across categories, with higher occurrence among horses exposed to prolonged sunlight, elevated temperatures (>40°C: 9.3% vs <35°C: 4.4%; η^2 = 0.019), low relative humidity (<30%: 9.3% vs >50%: 5.6%; η^2 = 0.016), open housing, inadequate shade (no shade: 11.1% vs adequate shade: 4.2%; η^2 = 0.028), continuous outdoor exposure (η^2 = 0.025), and poor protective management practices (η^2 = 0.021). Sunlight exposure alone explained 2.3% of the variation (η^2 = 0.023), while housing system contributed 1.7% (η^2 = 0.017). These results indicate that prolonged ultraviolet exposure, higher thermal stress, dry environmental conditions, and insufficient protection significantly increase CLE occurrence, whereas improved management practices, adequate shade, and controlled outdoor activity reduce disease prevalence. Overall, climatic, environmental, and management conditions collectively contribute to the expression of CLE, highlighting the importance of integrated environmental and husbandry strategies for mitigating disease risk in horses under semi-arid conditions.

Table 8 One-way ANOVA analysis of environmental and management factors associated with CLE occurrence

Environmental/Climatic factor	Prevalence pattern	Source of variation	Sum of squares	df	Mean square	F-value	p-value	η^2	Interpretation
Daily maximum temperature	<35°C: 4.4%; 3 40°C: 8.0%; >40° 9.3%	Between groups	0.115	2	0.058	3.42	0.034	0.019	Significant effe temperature explained 1.9 variation
		Within group	5.902	357	0.017				
		Total	6.017	359					
Relative humidity	<30%: 9.3%; 3 50%: 7.4%; >50%: 5.6	Between groups	0.096	2	0.048	2.91	0.056	0.016	Marginal effe humidity explain 1.6% variation
		Within group	5.921	357	0.017				
		Total	6.017	359					
Sunlight exposure	Low: 4.4 Moderate: 7.3%; High: 10.6	Between groups	0.140	2	0.070	4.21	0.016	0.023	Significant effe sunlight Exposu explained 2.3 variation
		Within group	5.877	357	0.016				
		Total	6.017	359					
Housing system	Indoor: 4.4 Semi-open: 7.8%; Ope	Between groups	0.102	2	0.051	3.12	0.045	0.017	Significant effe housing explain 1.7% variation

	10.0%								
		Within group	5.915	357	0.017				
		Total	6.017	359					
Shade availability	Adequate: 4.2% Partial: 8.0%; No shad 11.1%	Between groups	0.168	2	0.084	5.02	0.008	0.028	Significant effec shade explaine 2.8% variation
		Within groups	5.849	357	0.016				
		Total	6.017	359					
Outdoor exposure	Restricted: 4.4%; Moderat 7.2%; Continuous: 11.1%	Between groups	0.150	2	0.075	4.65	0.012	0.025	Significant effec outdoor exposu explained 2.5 variation
		Within groups	5.867	357	0.016				
		Total	6.017	359					
Management practices	Good: 4.4% Moderate: 7.8% Poor: 10.0%	Between groups	0.126	2	0.063	3.86	0.022	0.021	Significant effec management explained 2.1 variation
		Within groups	5.891	357	0.017				
		Total	6.017	359					

Correlation Analysis of Environmental and Climatic Variables

Correlation analysis was performed to evaluate the strength and direction of relationships between climatic, environmental, and management variables with CLE occurrence. Environmental variables were converted into numerical scores, where higher scores for sunlight exposure, temperature, and outdoor exposure represented increased environmental stress, whereas higher shade availability and management scores represented improved protective conditions.

Correlation between Temperature and CLE Occurrence

Daily maximum temperature categories were coded as <35°C = 1, 35–40°C = 2, and >40°C = 3. Spearman rank correlation analysis showed a positive association between increasing temperature category and CLE occurrence. The findings indicate that higher temperature conditions were associated with increased CLE prevalence.

Table 9. Correlation between daily maximum temperature and CLE occurrence

Variable	Method	Correlation coefficient (ρ)	p-value	Interpretation
Temperature category	Spearman correlation	0.142	0.007	Very weak positive association

Correlation between Relative Humidity and CLE Occurrence

Relative humidity categories were coded as low humidity = 1, moderate humidity = 2, and high humidity = 3. A negative correlation was observed between humidity category and CLE occurrence, indicating higher disease occurrence under lower humidity conditions.

Table 10. Correlation between relative humidity and CLE occurrence

Variable	Method	Correlation coefficient (ρ)	p-value	Interpretation
Relative humidity category	Spearman correlatio	−0.128	0.015	Very weak negative associatio

Correlation between Sunlight Exposure and CLE Occurrence

Sunlight exposure was categorized as low exposure = 1, moderate exposure = 2, and high exposure = 3. A positive correlation was observed, indicating increased CLE occurrence with increasing sunlight exposure.

Table 11. Correlation between sunlight exposure and CLE occurrence

Variable	Method	Correlation coefficient (ρ)	p-value	Interpretation
Sunlight exposure score	Spearman correlation	0.160	0.003	Very weak positive association

Correlation between Shade Availability and CLE Occurrence

Shade availability was scored as adequate shade = 3, partial shade = 2, and no shade = 1. A negative correlation was observed, indicating that improved shade availability was associated with reduced CLE occurrence.

Table 12. Correlation between shade availability and CLE occurrence

Variable	Method	Correlation coefficient (ρ)	p-value	Interpretation
Shade availability score	Spearman correlation	−0.180	0.001	Very weak negative association

Correlation between Management Practices and CLE Occurrence

Management practices were scored according to protective measures provided against excessive environmental exposure. Better management conditions showed a negative association with CLE occurrence.

Table 13. Correlation between management score and CLE occurrence

Variable	Method	Correlation coefficient (ρ)	p-value	Interpretation
Management score	Spearman correlation	−0.150	0.005	Very weak negative association

Correlation Matrix Among Climatic, Environmental and Management Variables

A correlation matrix was generated to evaluate the relationships between CLE occurrence and different climatic, environmental, and management variables. CLE occurrence showed positive associations with daily maximum temperature (r = 0.142), sunlight exposure (r = 0.160), and outdoor exposure (r = 0.140), indicating increased disease occurrence under conditions of greater environmental stress. Relative humidity (r = −0.128), shade availability (r = −0.180), and management score (r = −0.150) showed negative relationships with CLE occurrence, suggesting a protective influence of higher humidity, improved shade availability, and better management practices.

Among environmental variables, temperature showed a positive association with sunlight exposure and outdoor exposure, indicating that horses exposed to higher temperatures were also more likely to experience greater solar exposure. Shade availability showed a positive relationship with management score, suggesting that better-managed horses generally received improved environmental protection. Although the strength of

individual correlations was weak, the observed patterns indicate that CLE occurrence is influenced by multiple interacting climatic and management-related factors rather than a single environmental determinant.

Table 14. Correlation matrix between environmental variables and CLE occurrence

Variable	CLE status	Temperature	Relative humidity	Sunlight exposure	Outdoor exposure	Shade availability	Management score
CLE status	1.000	0.142	-0.128	0.160	0.140	-0.180	-0.150
Temperature	0.142	1.000	-0.215	0.420	0.365	-0.280	-0.240
Relative humidity	-0.128	-0.215	1.000	-0.180	-0.120	0.210	0.195
Sunlight exposure	0.160	0.420	-0.180	1.000	0.520	-0.310	-0.280
Outdoor exposure	0.140	0.365	-0.120	0.520	1.000	-0.260	-0.340
Shade availability	-0.180	-0.280	0.210	-0.310	-0.260	1.000	0.410
Management score	-0.150	-0.240	0.195	-0.280	-0.340	0.410	1.000

DISCUSSION

Cutaneous Lupus Erythematosus (CLE) is a photosensitive autoimmune dermatological disorder influenced by interactions among environmental triggers, immune regulation, and genetic susceptibility. The present study evaluated climatic, environmental, and management factors associated with CLE occurrence among 360 horses maintained under semi-arid conditions of Rajasthan. A total of 27 horses were identified as CLE-positive, resulting in an overall prevalence of 7.5%. The observed clinical manifestations, including alopecia, erythema, scaling, crusting, depigmentation, and lesions on sun-exposed regions, were consistent with previously described features of CLE. Ultraviolet (UV) radiation plays a central role in CLE pathogenesis by inducing keratinocyte apoptosis, increasing nuclear antigen exposure, stimulating inflammatory cytokines, and promoting autoimmune activation (Jessop & Whitelaw, 2014; Walling & Sontheimer, 2009; Grönhagen & Nyberg, 2014). Similar mechanisms have been reported in veterinary autoimmune dermatological disorders (Gross et al., 2005; Olivry & Chan, 2001).

Sunlight exposure showed a clear association with CLE occurrence, with higher prevalence among horses exposed to prolonged sunlight (10.0%) compared with those receiving limited exposure (4.4%). Increased cumulative UV exposure may enhance photosensitivity and inflammatory skin responses in susceptible animals. Previous studies have identified UV radiation as a major environmental trigger of lupus-associated skin lesions through immune dysregulation and inflammatory activation (Werth, 2007; Klein & Kunz, 2022). Corbin et al. (2023) further demonstrated that abnormal UV responses contribute significantly to lupus pathogenesis. Therefore, intense solar radiation and prolonged outdoor exposure under Rajasthan conditions may contribute to increased CLE expression.

Climatic factors, including temperature and relative humidity, also showed associations with CLE occurrence. Horses examined during periods of higher daily maximum temperature (>40°C) showed greater prevalence (9.3%) compared with those examined below 35°C (4.4%). Elevated temperature may indirectly influence disease development by increasing thermal stress, oxidative imbalance, and inflammatory responses, thereby enhancing susceptibility to UV-induced skin injury. Heat stress has been reported to affect physiological adaptation and immune responses in domestic animals (Bernabucci et al., 2010; Lacetera, 2019). Similarly, lower relative humidity (<30%) was associated with higher CLE prevalence (9.3%) compared with higher humidity conditions (>50%; 5.6%). Dry atmospheric conditions may reduce skin hydration, impair epidermal barrier function, and increase susceptibility to inflammatory skin disorders (Proksch et al., 2008; Elias, 2012). However, temperature and humidity should be considered modifying environmental factors rather than independent causes because CLE results from multiple interacting mechanisms.

Management-related factors further influenced CLE distribution. Horses maintained under open housing systems showed higher prevalence (10.0%) compared with indoor housing (4.4%), likely due to greater exposure to sunlight and climatic stress. Similar relationships between environmental exposure and immune-mediated skin disorders have been reported in veterinary dermatology (Scott & Miller, 2011; Rosenkrantz, 2018). Shade availability demonstrated a protective effect, as horses without adequate shade showed higher prevalence (11.1%) than those provided with

adequate shade (4.2%). Environmental modification, particularly reduction of direct solar exposure, is considered an important approach for managing photosensitive disorders (Klein & Kunz, 2022; Dropsy et al., 2026).

Outdoor exposure and protective management practices showed similar trends. Continuously exposed horses had higher CLE occurrence than horses with restricted outdoor activity, suggesting that increased cumulative UV burden may enhance disease expression. However, autoimmune disorders develop through interactions between environmental exposure, immune responses, and individual susceptibility rather than a single risk factor (Day, 2010; Day & Schultz, 2014). Better management practices, including shade provision, avoidance of peak sunlight hours, protective coverings, and regular skin monitoring, were associated with reduced CLE prevalence. The successful management of equine CLE using UV protection and topical tacrolimus further supports the importance of environmental control (Dropsy et al., 2026).

Environmental and climatic factors showed measurable contributions to CLE variation. Among evaluated factors, shade availability showed the highest effect size ($\eta^2 = 0.028$), followed by outdoor exposure ($\eta^2 = 0.025$), sunlight exposure ($\eta^2 = 0.023$), management practices ($\eta^2 = 0.021$), temperature ($\eta^2 = 0.019$), housing system ($\eta^2 = 0.017$), and relative humidity ($\eta^2 = 0.016$). These findings indicate that environmental conditions may play an important role in CLE expression, consistent with the multifactorial nature of autoimmune skin diseases involving environmental triggers, immune regulation, and genetic susceptibility (Kuhn & Landmann, 2014; Olivry & Chan, 2001).

Correlation analysis showed positive associations of CLE occurrence with sunlight exposure, temperature, and outdoor activity, whereas humidity, shade availability, and management quality showed negative associations. Although correlation strengths were weak, the direction of relationships supports the biological relevance of climatic and environmental exposure in CLE development. Similar weak associations are common in complex autoimmune disorders due to multiple interacting determinants (Doria et al., 2008). The semi-arid climate of Rajasthan, characterized by intense solar radiation, elevated temperature, prolonged sunshine, and dry atmospheric conditions, may provide favourable conditions for photosensitive autoimmune disorders. Previous studies have emphasized the influence of climatic and geographical factors on lupus-related skin conditions (Grönhagen & Nyberg, 2014; Corbin et al., 2023). Therefore, practical interventions such as shade provision, controlled outdoor exposure, and regular dermatological monitoring may reduce CLE risk.

The study limitations include reliance on field observations and owner-reported information, absence of individual UV exposure measurements, lack of pigmentation assessment, and absence of molecular and immunological investigations. The cross-sectional design also limits causal interpretation. Future longitudinal studies integrating climatic monitoring, genetic analysis, and immune profiling are required.

Moreover, the present study demonstrates that climatic, environmental, and management conditions influence CLE occurrence among horses in Ajmer district. Prolonged sunlight exposure, high temperature, low humidity, inadequate shade, open housing, and poor management were associated with increased CLE prevalence, whereas improved environmental management showed a protective effect.

CONCLUSION

The present study provides preliminary evidence regarding the influence of environmental and management factors on the occurrence of Cutaneous Lupus Erythematosus (CLE) among horses in Ajmer district, Rajasthan. Among 360 examined horses, 27 animals were identified as CLE-positive, resulting in an overall prevalence of 7.5%. Environmental evaluation revealed that horses exposed to prolonged sunlight, maintained under open housing systems, and lacking adequate shade protection showed comparatively higher CLE occurrence. Increased sunlight exposure and outdoor management demonstrated positive associations with CLE occurrence, whereas shade availability and improved protective management practices showed negative associations. Statistical analysis indicated that environmental factors contributed more variation in CLE occurrence than demographic factors, with shade availability, outdoor exposure, sunlight exposure, and management practices showing measurable effects on disease distribution.

The findings suggest that prolonged ultraviolet radiation exposure and inadequate environmental protection may contribute to the development and expression of equine CLE, particularly under semi-arid climatic conditions. Although environmental factors alone cannot fully explain disease occurrence, modification of management practices, including provision of adequate shade, reduction of excessive sunlight exposure, and regular dermatological monitoring, may help reduce disease risk and severity. Further longitudinal studies incorporating quantitative UV exposure measurements, genetic susceptibility, immune biomarkers, and detailed management assessment are required to identify independent environmental

determinants and develop effective preventive strategies for equine CLE.

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