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Determinants of Equine Foot Diseases in Assam, India

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Authors' contributions

This work was carried out in collaboration among all authors. Authors KKS and NNB were responsible for the conception and design of the research. Author DD conducted the cross-sectional study, data assessment and drafted the manuscript. Authors JK and JR oversaw the management of study analyses. Authors SAA and TD conducted comprehensive literature searches and revision of the drafted manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Aim: Equine foot problems is crucial for maintaining the overall health and performance of horses, as these issues can significantly impact their mobility, comfort, and quality of life. A lot of studies have been conducted in these aspects, however, no such detail history have been reported from this part of the country. The present study deals with the prevalence of various foot disorders in

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riding horses and their correlation to the type of ration provided, work engagement and immediate environmental conditions like equine housing patterns. The study also tries to understand the correlations between the prevalence of diverse foot ailments and the temporal variations specific to the region.

Study Design: A cross-sectional observational work designed to collect data regarding various foot affections prevalent in the equine population of selected locations of Assam, India.

Place of Study:4th Assam Police Battalion, Kahilipara, North-East Police Academy, Barapani, 47 Assam NCC Squadron, Khanapara and SSB horse unit, Debendra Nagar, Tezpur.

Methodology: Surveys were conducted to assess the prevalence of hoof-related conditions in horses through interviews, physical examinations and radiographic examinations. Etiological factors were investigated by recording the history of affected animals, including ration type, quantity, foot care practices.

Results: Thirty-five (71.42%) exhibited various foot lesions while the remaining 14 horses were detected with minor cuts/abrasions. The Prevalence of foot afflictions was found to be higher during the summer (42.86%) in comparison to the winter (28.57%). The spectrum of foot ailments documented includes hoof overgrowth (57.14%), hoof cracks (20%), thrush (8.57%), suppurative sole conditions (5.71%), quittor (2.86%), laminitis (2.86%) and bulb fibromas (2.86%). The occurrences of various types of foot afflictions were elevated in equine enclosures with concrete flooring (94.29%), as opposed to sand flooring (5.71%). Hematological analyses indicated significant ($P<0.05$) alterations in various blood parameters during both summer and winter for both healthy and affected equines in Hb and mean values of Red blood cells (RBC) and White Blood cells (WBC) except for neutrophils. Biochemical assessments revealed an increase in mean values of serum creatinine, creatine kinase (CK) and alkaline phosphatase (ALP) in affected horses, though aspartate amino transferase (AST) levels remained unaffected.

Conclusion: The multifaceted interplay between equine health, housing conditions, dietary patterns, and seasonal factors in the prevalence of foot disorders in stabled horses.

Keywords: Assam; equine; foot affections; quittor; thrush.

1. INTRODUCTION

Horses have been an important part of human culture since time immemorial. According to Hindu mythology, the horse is related to Lord Hayagriva- the God of '*knowledge'* and '*wisdom',* who had the body of a human and the head of a horse. Horses have been an integral part of warfare since ancient times. The first archaeological evidence of horses being used in warfare dates between 4000 and 3000 BC and the use of horses in warfare were widespread by the end of the Bronze Age. In early ages, horses were also used in ploughing the paddy fields in some parts of the globe.

In the present-day scenario, horses are used as sporting animals in various equestrian events throughout the globe. Many sports, such as dressage and show jumping are being played. However, with the increase of the equine population as a utility animal in various fields, the challenges of diseases are also increasing [1]. Any disease or discomfort to these sensitive animals may lead to a decrease in their performance and economic losses to the owner. Traumatic injury during work and prolonged standing on hard concrete floor may lead to various types of foot affections which result in lameness. During the summer season, the wet condition of the foot due to soiling with dung and urine leads to the growth of numerous microorganisms. Investigating the prevalence and correlates of hoof disorders in horses is paramount for optimizing equine welfare, as these conditions can substantially affect their mobility, comfort, and overall quality of life. Understanding the multifaceted interplay between foot problems, environmental factors, and management practices allows for the development of effective strategies to prevent and manage these ailments, thereby enhancing the health and performance of equine populations.

Organisms with the morphology of *Fusobacterium necrophorum*were reported to cause foot affections resulting in lameness in equine [2]. There are some serious sequelae of chronic *Fusobacterium necrophorum*in the frog of the horny hoof resulting in offensive blackish discharge from the sulci of the frog commonly called thrush. Apart from thrush, canker and pododermatitis is another cause of equine

lameness which results in keratolysis of the hoof. Chronic manifestation of a hoof infected with canker progresses to verrucose proliferation (non-neoplastic) of the hoof [3]. A lot of comprehensive investigation has been reported on various equine foot affections across the globe but paucity of information is available in this region of country. The present study investigates the prevalence of various foot disorders in riding horses and their correlation to immediate environmental conditions, particularly equine housing patterns, as well as to establish correlations between the prevalence of diverse foot ailments and the temporal variations specific to the region.

2. MATERIALS AND METHODS

2.1 Study Design

We investigated for eight months on horses from various military and paramilitary equine establishments, including the 4th Assam Police Battalion, Kahilipara (26.145911, 91.755089), North-East Police Academy, Barapani (25.679846, 91.895100), 47 Assam NCC Squadron, Khanapara (26.118861, 91.816576), and the SSB horse unit in Debendra Nagar, Tezpur (26.735574, 92.824117). The study encompassed horses of diverse cross-breeds, rendering breed-specific categorization unnecessary. Extensive surveys were conducted in these regions to assess the prevalence of hoof-related conditions, with a particular focus on their correlation with seasonal variations, flooring patterns, functional roles, dietary habits, and hemato-biochemical parameters.

Data were gathered through interviews with horse handlers and meticulous physical examinations, including visual assessments for external defects and soundness, as well as a comprehensive locomotor examination, including gait analysis and hoof assessment using a hoof tester (Figs. 1-4).

Radiographic examinations were carried out for cases that did not reveal any anomalies through initial assessments (Fig. 11). The annual cycle was divided into winter and summer seasons to analyze the seasonal impact on foot conditions, while the type of stable flooring (Figs. 13 & 14) and hygiene status were documented to explore their role in development of hoof ailments. Etiological factors were investigated by recording the history of affected animals, including type of ration fed, quantity, foot care practices and hoof trimming routines.

2.2 Estimation of Haemato-biochemical Parameters

Blood was collected from the jugular vein of apparently healthy and affected animals for haemato-biochemical studies. Four (4) ml of whole blood was collected by putting two(2) ml in an EDTA vial) and rest two (2) ml in a clot activator vial undisturbed for collection of serum.

2.3 Statistical Analysis

The quantitative estimates were analyzed using one-way ANOVA as per the method described by Snedecor and Cochran [4] and SPSS 16.0 for Windows.

3. RESULTS AND DISCUSSION

3.1 Prevalence

A total of forty-nine horses were surveyed in both summer and winter, out of which 35 (71.42%) horses were found to be affected with different foot affections (Table 1A). The study revealed that the prevalence of foot affections in this managerial setting was much higher compared to the observations of Talukdar [4] who studied 142 animals and found 19.01% with various claw lesions. Among the different foot affections, hoof overgrowth was the most predominant hoof lesion (57.14%) as also depicted in Table 1B and Figs. 5-12. Nelson and Cattell [5] also observed that laminitis was found to be highest among other foot affections with a prevalence of rate of 9.8 % in the culling horses and 43.5% in the culling cows (Fig. 10). However, Talukdar [4] recorded an overall prevalence rate of 22.22% in equine farms. This discrepancy in prevalence rate may be attributed to several factors, such as variations in specific conditions or environments under which the animals in the two studies were managed. It could also be influenced by differences in the methodology employed, the selection criteria for the animals, sample size or the time frame in which the studies were conducted.

The study revealed that the prevalence of foot affection was highest during the summer season i.e., 42.86% while in winter it decreased to 28.57% (Table 1C). This might be due to the wet condition due to the high humidity of the north-eastern region of India during the summer which

favours the multiplication and proliferation of numerous microorganisms. In support of that, French et al. [6] reported that wet weather also reduces hygiene and dryness of the hoof.

Out of the two different types of floor patterns observed in the present study, a higher prevalence was found in horses housed on concrete floors i.e., 94.29%, on the contrary, the foot affection in horses housed on sand floors was much lower i.e., 5.71 % (Table 1D) &(Fig. 13 & 14). Floors made up of concrete were generally not properly laid with cement or the stables considered under this study were very old and due to this the surface concrete was eroded resulting in exposure of small gravels of the floor and causing damage to the solar surface. Moreover, due to breakage in the floor, the dung and urine get lodged in it and bacterial multiplication takes place. Bergsten[7] also opined a similar statement regarding the effect of flooring on claw health and lameness. However, Gooch [8] in his investigation concluded that, the concrete was the material of choice for flooring house for minimal foot and leg problem. On the contrary, Blowey[9] reported that higher quality horns are produced by animals that walk on rubber floors than on concrete.

The highest prevalence of foot affection in the present study was found in animals that were raised on a high concentrate ration (77.14%) compared to a low concentrate ration (22.86%)as depicted in Table 1E. A higher quantity of concentrates was given to animals to support their capability to work and also to compensate for the scarcity of roughages leading to a tilt in the ratio of concentrate to roughages which might be one of the possible causes of inciting foot-related problems. In support of this, Livesey and Fleming [10] reported that 64% of cows on a high concentrate but low fiber diet developed sole ulcers leading to lameness compared with only 8% of animals receiving a high fiber ration with low concentrate.Pollitt [11] also reported that a carbohydrate-rich diet can also induce laminitis leading to separation of the sensitive laminae.

Table 1. Prevalence Study

A. Animals surveyed		**Number of animals affected**	**Overall prevalence (%)**
49		**35**	**71.42**
B. Prevalence (%) of various foot affections (**n=35**)			
Sl. no.	Type of affections observed	Number of Animals affected	Positive prevalence (%)
1	Hoof overgrowth	20	57.14
2	Hoof wall crack	7	20.00
3	Thrush	3	8.57
4	Suppurative sole	2	5.71
5	Quittor	1	2.86
6	Laminitis	1	2.86
7	Bulb fibroma	1	2.86
C. Season			
1.	Winter (Nov-Dec-Jan-Feb)	14	28.57
2.	Summer (Feb-March-April-May)	21	42.86
D. Floor pattern			
1.	Concrete	33	94.29
2.	Sand	2	5.71
E. Feeding practice			
1.	High concentrate (low fibre)	27	77.14
2.	Low concentrate (high fibre)	8	22.86
F. Utility/work (n=35)			
1	Sports	31	88.57
2	Working	1	2.86
3	Miscellaneous	3	8.57
G. Appendages (n=35)			
1.	Fore	21	60.00
2.	Hind	9	25.71
3.	Both	5	14.29

Table 2. Blood profile of apparently healthy and affected animals

Parameters	Healthy				Affected			
	Summer		Winter		Summer		Winter	
	Mean	+SE	Mean	+SE	Mean	+SE	Mean	+SE
Hb (g/dl)	10.48	0.04^{B}	10.08	0.02^{B}	13.79	0.70^{A}	8.33	0.14^{C}
RBC(106/cu mm)	7.17	0.05^{B}	7.12	0.03^{B}	9.04	0.37^{A}	5.80	0.22^{C}
WBC(103/cu mm)	7.18	0.13^{B}	7.75	0.13^{B}	8.72	0.48^{C}	7.47	0.60^{B}
PCV %	31.90	0.42^{C}	38.54	1.10^{B}	44.08	1.12^{A}	23.63	0.77^{D}
Neutrophil (%)	60.38	0.94^{A}	58.78	0.84^{A}	53.10	3.66^{A}	52.16	5.37^{A}
Lymphocyte (%)	25.13	0.71^{B}	28.24	0.78^{B}	44.59	3.02^{A}	28.21	3.89^{B}
Monocyte (%)	2.88	0.13^{B}	3.81	0.23^{B}	10.53	1.24^{A}	6.92	1.30^{A}
Eosinophil (%)	2.20	0.21^{B}	1.50	0.13^{B}	3.88	0.15^{A}	2.64	0.21^{A}
Basophil (%)	0.46	0.06^{B}	0.83	0.08^{A}	0.88	0.11^{A}	0.88	0.12^{A}
Creatinine (mg/dl)	1.12	0.03^{B}	1.31	0.07^{B}	2.91	0.14^{A}	1.40	0.12^{B}
Creatine Kinase (U/L)	50.93	1.23^{D}	122.65	3.46^{C}	243.34	22.06^{A}	185.52	9.90^{B}
AST(U/L)	206.19	7.56^{A}	212.65	8.46^{A}	156.74	13.48^{B}	146.83	13.14^{B}
ALP(U/L)	90.48	2.87^{C}	140.32	5.74^{C}	492.92	54.55^{A}	318.96	16.01^{B}

Script after the figure is the result of Turkey's post hoc HSD test presented row wise (α=0.05;Q=2.64252). Letter not similar are significantly different

The highest prevalence of foot diseases in the present investigation was found in animals that were engaged in various sporting events (88.57%) compared to the other two categories of work that involved either routine work (2.86%) or kept for miscellaneous purposes (6.12%) as depicted in Table 1F. The reason behind the highest prevalence of foot affection under the sports category may be because of various activities like long-distance walking/running on hard surfaces. Such activities often subject the animal to mechanical injuries leading to diseases like laminitis [12].

In the present study, fore foot affection (60.00%) in horses was more common than in hind foot (25.71%) (Table 1G); this might be because the horses whenever take a jump, always land on the fore feet first, so there is every possibility of injury to forelimb [12]. Another important reason may be that the horses use their limbs in getting up and lying down which may predispose them to various foot affections. Also, the hygienic status of the stables was another reason for this as less exposure time of the hind limbs to dung and urine as a result of good hygienic practices may minimize the affections on the hind limbs. This investigation was contrary to the reports of Talukdar et al. [4] and Konwar et al. [13] as they opined that foot affections were less significant in the fore limbs compared to the hind limbs.

3.2 Haematology

The present study revealed hemoglobin, Packed cell volume (PCV) and mean of red cell count (RBC) and white blood cell count (WBC) of the affected animals were significantly ($P<0.05$) higher in comparison to the normal animals during summer, while showing an insignificant decrease during the winter (Tables 2 and 3). Nilsson [14] also recorded an increase in the mean Hb values & mean RBC count in animals with laminitis to that of normal animals. This transient rise in Hb & RBC values was apparently due to the acute inflammatory state of the laminae as mentioned by Sastry [15]. On contrary to that, Khalafizadeh et al. [16] recorded a significant decrease ($P>0.05$) in the mean Hb and RBC values in affected animals than in normal animals. A Significant ($P<0.05$) rise in WBC level was observed in the case of animals suffering from bulb fibroma during summer as compared to the other diseases while in the case of hoof wall crack, during summer and hoof over growth during winter it decreased insignificantly (Tables 2 and 3). Similar report was also published by Khalafizadeh et al. [16]. The significant rise in WBC values might be attributed to the body's immune response against ongoing infection or inflammation within the hoof tissues. The body's immune system responds to these changes by recruiting white blood cells to the site of infection, leading to an increase in WBC count [17]. However, Hussain and his associates [18] failed to record any significant difference in the values of WBC count between the normal and mules affected with foot infection. The findings of PCV values in our study were in line with Rezazadeh et al. [19] who conducted a study on Arab mules. A maximum significant ($P<0.05$) rise in PCV value was observed in the case of animals suffering from quittor during summer followed by hoof over growth and hoof wall crack. Fluctuations in PCV values are non-specific and can be indirectly related to various ongoing

Table 3. Hematological parameters in correlation to the various studied determinants

Source	df	Mean Square								
		Hb (g/dl)	RBC (106/cumm)	WBC (103/ cumm)	PCV (%)	Neutrophil (%)	Lymphocyte (%)	Monocyte (%)	Eosinophil (%)	Basophil (%)
Animal	334	1.74 (.89 ^{NS})	0.45 (.981 ^{NS})	1.4 (.963 ^{NS})	30.67 (.062 ^{NS})	129.45 (.526 ^{NS})	65.53 (.848 ^{NS})	9.33 (.780 ^{NS})	0.79 (.406 ^{NS})	0.14 (.923 ^{NS})
Season	11	184.11 (<.001**)	59.27 (<.001**)	1.88 (.387 ^{NS})	1049.94 (<.001**)	91.09 (.412 ^{NS})	716.76 (.007**)	19.05 (.212 ^{NS})	23.18 (<.001**)	0.98 (.036*)
Affected	11	9.12 (.064 ^{NS})	0.96 (.298 ^{NS})	8.72 (.065 ^{NS})	13.74 (.404 ^{NS})	1126.09 (.005**)	2210.81 (<.001**)	574.36 (<.001**)	30.16 (<.001**)	0.98 (.036*)
Season × Affected	11	137.47 (<.001**)	53.5 (<.001**)	16.45 (.012*)	3598.09 (<.001**)	69.66 (.019*)	1.65 (.139 ^{NS})	0.7 (.075 ^{NS})	69.66 (.019*)	1.65 (.139 ^{NS})
Error	A60	2.57	0.88	2.47	19.48	133.21	90.95	11.95	0.74	0.21

The figure within parenthesis indicates the P-value. P-value < .05 is significant; P-value < .01 is highly significant; P-value > .05 is not significant

Table 4. Biochemical profile in correlation to the various studied determinants

Source	df	Mean Square			
		Creatinine (mg/dl)	Creatine Kinase (U/L)	AST(U/L)	ALP(U/L)
Animal	34	0.16 (.700^{NS})	2265.02 (.697 ^{NS})	2899.76 (.210 ^{NS})	10208.3 (.936 ^{NS})
Season	1	8.94 (<.001**)	1994.78 (.391 ^{NS})	598.19 (.611 ^{NS})	58994.1 (.064 ^{NS})
Affected	1	14.25 (<.001**)	295382 (<.001**)	65136.4 (<.001**)	1560741 (<.001**)
Season × Affected	1	16.04 (<.001**)	77519.8 (<.001**)	1796.56 (.38 ^{NS})	225035 (<.001**)
Error	60	0.19	2676.78	2292	16578.6

The figure within parenthesis indicates the P-value. P-value < .05 is significant; P-value < .01 is highly significant; P-value > .05 is not significant

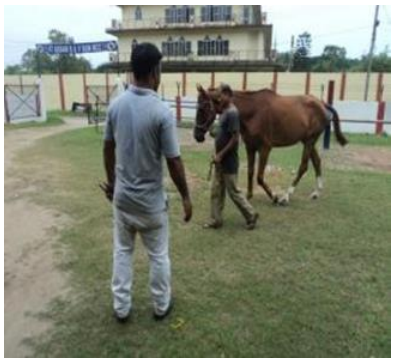

Fig. 1. Lame horse subjected to walk

Fig. 2. Application of hoof tester

Fig. 3. Percussion of hoof

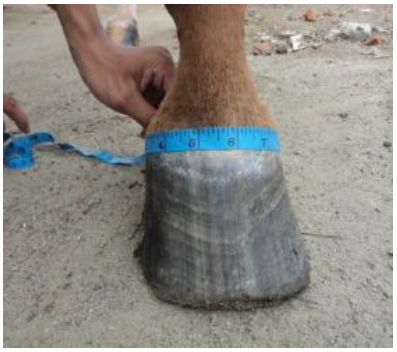

Fig. 4. Measuring of coronary band

Fig. 5. Hoof overgrowth

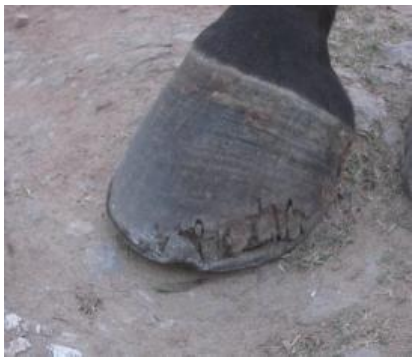

Fig. 6. Hoof wall crack

Fig. 7. Thrush

Fig. 8. Suppurative sole

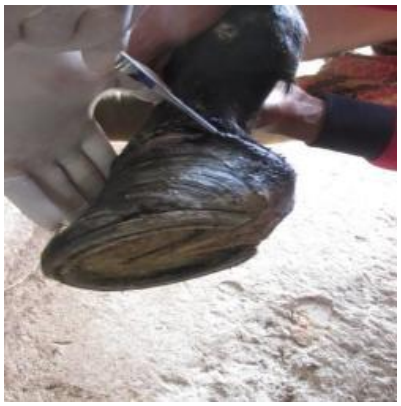

Fig. 9. Quittor

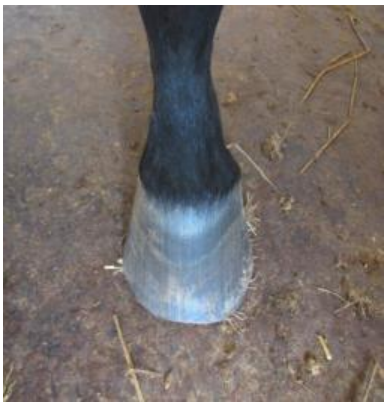

Fig. 10. Laminitis showing circular rings on hoof wall

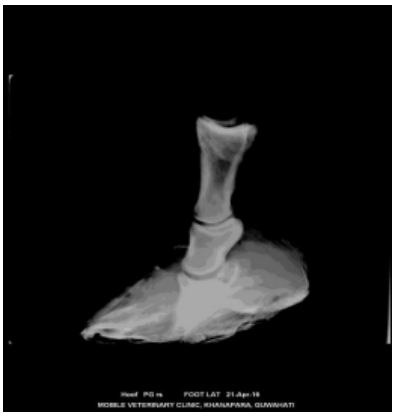

Fig. 11. Laminitis (3rd phalanx rotation)

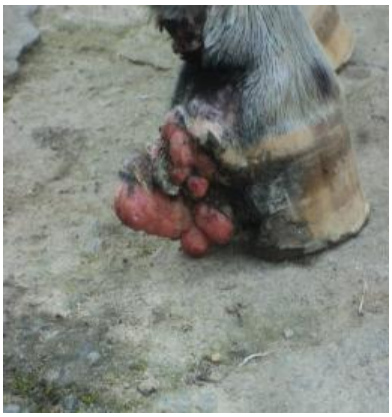

Fig. 12. Bulb fibroma

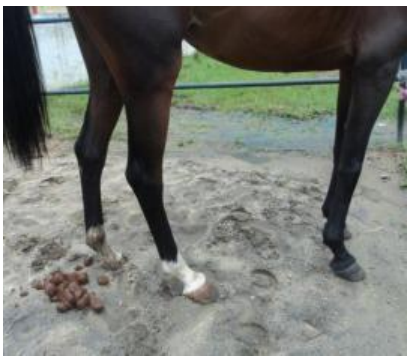

Fig. 13. Sand floor

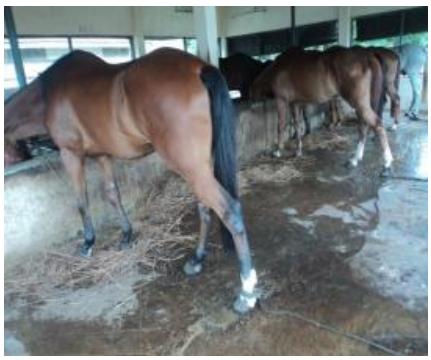

Fig. 14. Concrete floor

physiological and pathological reasons like oxidative stress and inflammatory responses occurring within the hoof microenvironment [20]. Non-significant differences were found in case of neutrophil, eosinophil and basophil both in summer and winter, however highly significant (P<0.01) increase was found between the mean values of lymphocyte and monocyte both in summer and winter seasons. Whereas, when observed individually a significant (P<0.05) rises were recorded in Differential leucocyte count (DLC) values of animals suffering from quittor, laminitis and thrush during summer whereas during winter, an insignificant decrease in neutrophils only was recorded (Tables 2 and 3). Khalafizadeh et al. [16] recorded a significant (P<0.05) difference between the mean values of neutrophils and monocytes, while non-significant

difference between the mean values of Lymphocyte and Eosinophil between control and affected groups. Pouyade and Serteyn [21] reported that a significant (P<0.05) increase in neutrophil count in laminitis due to the release of pro-inflammatory cytokines.

3.3 Serum Biochemistry

Serum enzyme values recorded a highly significant (P<0.01) rise in the mean values of the Creatinine, Creatine Kinase (CK) and Alkaline Phosphatase (ALP) inaffected animals compared to the normal animals during summer, while it was observed that slight and significant (P<0.05) increase Creatinine values were obtained from affected animals during winter but values of CK and ALP were decreased insignificantly (Tables 2 and 4).Similar observations were reported by O'Driscoll et al. [22], Mohebbi et al. [23] and Hussain et al. [18]. They also reported that the values of diseased mules with acute laminitis and lameness due to sole ulcer were significantly (P<0.05) higher when compared with those of healthy mules. The values for Aspartate amino transferase (AST) in our study showed insignificant differences between the normal values of the affected animals compared to the normal animals both in summer and winter. A significant (P<0.05) increase in AST value was observed in animals with hoof wall cracks and in thrush in summer. Yaylak et al. [24] in their study had also recorded an insignificant decrease in the mean AST values in affected animals compared to the normal animals. Elevated levels of Creatinine, CK, and ALP in our study showed horses with foot disease suggest potential muscle damage, compromised renal function, and increased bone turnover, respectively, reflecting the systemic impact of hoof pathology on various physiological processes and could be suggestive of potential biomarkers when study hoof pathology in equines (Patterson-Kane et al., 2018). Also, decreased AST values can be due to reduced muscular damage due reduced mobility of the horse due to pain and medication against pain management that indirectly lowers AST values in the blood

4. CONCLUSION

A total of 35 cases involving diverse foot afflictions were examined. Among these, hoof over-growth emerged as the most prevalent malady, followed in incidence by hoof wall cracks, thrush, suppurative sole conditions, quittor, laminitis, and bulb fibromas. Notably, equines subsisting on a diet predominantly composed of high-concentrate rations exhibited a heightened susceptibility to these foot ailments when compared to their counterparts with diets primarily composed of roughages. The exacerbation of such conditions was found to be associated with the suboptimal maintenance of equine living environments, particularly manifesting as unhygienic concrete flooring. In conjunction with the clinical findings, hematological and biochemical analyses unveiled a noteworthy elevation in various blood indices and serum concentrations of creatinine, CK and ALP values, shedding light on the systemic ramifications of these foot afflictions. This research underscores the imperative need for holistic equine health management and maintenance practices, aiming to mitigate the incidence and severity of foot disorders in equine populations.

ETHICAL APPROVAL

The present study was approved by the Institutional Animal Ethics Committee (IAEC), College of Veterinary Science, Assam Agricultural University. (Approval No-770/ac/CPCSEA/FVSc/AAU/16-17/458)

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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