EFFECTS OF FLOORING SYSTEM ON HOOF HEALTH OF DAIRY COWS IN SOME SELECTED AREAS OF BANGLADESH AND INDIA

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ABSTRACT

A nine month cross-sectional prospective survey was made on dairy cows to explore the prevalence and predisposing factors of different hoof disorders from June 2012 to February 2013 at Chittagong and Potuakhali districts of Bangladesh and Tamil Nadu state of India. Approximately 2100 cattle population was examined from where 497 cases were identified having crack 19%, partially broken 19%, fissure 37%, swollen 16% and 9% multiple disorders in backyard dairy cows whereas 17%, 20%, 37%, 20% and 6% in commercial cows respectively. Significantly higher prevalence ($p<0.05$) rate was recorded in the cows reared under concrete floor (68.4%) compared to brick (13.27%) and concrete with rubber bedding (18.30%). Other major predisposing factors established were autumn season (42.86%), older animals of 6 to 8 years (70.42%), high milk yield (10 to 14 liter per day) (72.43%) and cows where floor washing practiced twice a day (58.14%) though the findings were not significant ($p>0.05$). The study will address the frequency of hoof diseases in the survey areas along with factors causing risk to cows will benefit the local farmers and veterinarians to take required steps to avoid extra sufferings and loss. Further extensive survey and investigations are recommended to economic analysis and laboratory identification of agents responsible for hoof disorders.

Keywords: Hoof disease, prevalence, pre-disposing factors.

CHAPTER I
INTRODUCTION

Hoof health has a great impact directly on cattle and indirectly on the dairy production system. In cattle, it is one of the major issues of economic profit in dairy production (Hernandez *et al.,* 2005; Kossaibati *et al.,* 1997). Hoof diseases considered as the most important health problem having a negative effect on the welfare of dairy cows unswervingly (Alban, 1995; Webster, 1987).

Absence of hoof/hooves, sloughed-off, cracked, fissured, broken, luxated hooves are commonly reported disorders of hooves disturbing the hoof health. Different local and systemic diseases like foot and mouth disease, laminitis, foot rot, physical trauma, wound, arthritis, bed sore, abscess, milk fever, Downer's cow syndrome predispose the cow towards abnormalities of hoof/hooves leading to lameness and recumbancy of animal (Cook *et al.,* 2005). In addition, high yielding dairy cows reared intensively, over-nourished and heavy weight animals, and the animals housed on concrete floored are found equally susceptible to claw disorders.

There are some other intrinsic risks for lameness that cannot be changed. These include season gestation and stage of lactation (Green *et al.,* 2002; Knight, 2001), previous disease (Hirst *et al.,* 2002; Alban *et al.,* 1995) and parity (Hirst *et al.,* 2002; Hedges *et al.,* 2001). Genetically determined intrinsic risk for development of lesions also reported by Koenig *et al.* 2005 and Boettcher *et al.,* 1998.

Lameness due to hoof disorder has also been identified as a major welfare determinant in cattle because of discomfort and pain that it causes (Offer *et al.,* 2000). Hoof lesions account for 60% to 90% of all lameness incidences in cattle in various countries of the world (Manske *et al.,* 2002; Weaver, 2000; Bergsten & Christer 2004). More than 60% of lameness in cattle is caused by lesions and disorders affecting the horn of the hoof such as sole ulcers, heel erosion, sole bruising, and white line separation and under run (double) soles. All these hoof disorders and lesions have a direct or indirect effect on the dermis (corium) of the hoof and are associated with laminitis (Belge & Bakir, 2005; Manske *et al.,* 2002).

Reduction of milk yield through discarding of milk due to withdrawal period of drugs used to treat the lameness condition, cost of veterinary drugs and professional services in managing the conditions lowered the farm profit (Hernandez *et al.,* 2005). Reduced conception rate and increased calving interval, reduced ovarian activity during early postpartum period, as well as premature culling and occasional mortalities sometimes reported associated with lameness (Sogstad *et al.,* 2006; Garbarino *et al.,* 2004; Enting *et al.,* 1997). Finally lame animals show more susceptibility to mastitis, the most important economic disease of dairy animals leading to poor production and loss of the farm profit.

Worldwide incidence of lameness is reported as high as 26% of all dairy cattle with a much higher incidence in high producing dairies in temperate countries. Canada has an incidence rate of 35% whereas the US suffered from 46% and a staggering 62% in the UK. In Manitoba, lameness accounted for just under 10% of all culls however it would have contributed to low condition and fertility problems as lame cows have reduced intakes leading to poorer body condition (http://www.gov.mb.ca/agriculture/livestock/dairy/cda21s02.html).

Claw disorders of animals were investigated by many researchers on various aspects like Enting *et al.,* 1997 worked on welfare problem related to lameness in today's milk production, Greenough *et al.,* 1997 explored the multi-factorial etiology of claw disorders, Alban 1995 found breed and conformation of claw were the main influencing factors related to hoof deformities. Similarly, Green *et al.* 2002, Hirst *et al.* 2002, Hedges *et al.* 2001, Knight 2001, Vokey *et al.,* 2001, Heuer *et al.,* 1999 along with several other scientists worked on hoof disorders associated with production and reproduction of cows and farm profit. But limited information was recorded on these topics in Chittagong and Potuakhali districts of Bangladesh and Tamil Nadu state of India.

Considering the above facts the present study was designed to explore:

- The prevalence of hoof diseases in dairy cows at Chittagong and Potuakhali districts of Bangladesh and Tamil Nadu state of India.
- The associated risk factors with special emphasis on predisposing factors leading to hoof disorders of dairy cow.

CHAPTER II
REVIEW OF LITERATURE

2.1. General study

2.1.1. Risk factors of hoof disorder: Several factors have been reported by various researchers leading to claw disorders in animals.

2.1.1. I. Intrinsic risks: There are intrinsic risks for lameness that cannot be changed. These include seasons, gestation and stage of lactation (Green *et al.,* 2002; Knight, 2001), previous disease (Hirst *et al.,* 2002; Alban *et al.,* 1995) and parity (Hirst *et al.,* 2002; Hedges *et al.,* 2001). There is also a genetic determined intrinsic risk for development of lesions (Koenig *et al.,* 2005; Boettcher *et al.,* 1998). Older cows may be more likely to become lame and so allocating time for prompt treatment or through a culling program for cows that are repeatedly lame. It is, however, possible to moderate the extrinsic risks from the environment and herd management to better suit the dairy cow's requirements, help her to cope in her environment and thereby minimize the impact of external risks on the intrinsic risks that face the modern dairy cow.

2.1.1. II. Extrinsic risks: There are obvious pragmatic reasons for studying lesions rather than lameness. Lesions are more frequent (80% prevalence) (Manske, 2002) and their severity changes fairly rapidly (Leach and Logue, 1997) and so one can study a smaller number of cattle for a short time period and collect a similar amount of data to that collected by studying many cattle over a long period of time to get record lameness events. Using lesions to identify risks for lameness is acceptable if the presence of lesions is a good proxy for risk of lameness. We cannot always be sure of this because there is not necessarily a direct correlation between the size and severity of a lesion and the lameness caused by this lesion (Flower & Weary, 2006; Green & Mülling, 2005).

There are six key areas that we can consider when attempting to reduce lameness in dairy cows. These are listed in Table 1 with the specific lesions that may be targeted through improved management in these areas.

Table 1: Key areas for external risks and the associated lameness Risk area

Key areas for external risks and the associated lameness risk area	Effect of good environment/ management	Associated lesion in poor environment
Cow comfort Maximizing lying times Comfortable lying surface Good walking and standing surfaces	Reduces wear on the sole Reduces pressure on the feet Reduces damage to the bony prominences	Sole ulcer Heel ulcer Laminitis Hock damage/swelling
Cow hygiene Dry environment Slurry free environment Good herd biosecurity	Reduces contact between pathogen and host Prevents introduction of infectious pathogens Reduces exposure of feet to corrosive environment	Digital dermatitis, Heel erosion/inter-digital dermatitis Other infectious causes of lameness
Social and physical integration for heifers and dry cows	Reduces defensive movements Avoids cow to cow confrontation Reduces standing times Improves eating and drinking behavior	White line disease
Cow flow on the farm Good routes around Buildings Parlor To pasture To feed	Allow a cow to express normal gait Reduces defensive movements from humans to avoid confrontation Reduces standing times Improves eating and drinking behavior	White line disease Sole ulcer
Diet Macronutrients	Reduces ruminal acidosis and macro and micronutrient	White line disease Sole ulcer

Micronutrients	deficiencies or excesses Improves hoof horn quality and integrity	
Correct routine professional functional preventive hoof trimming	Corrects abnormal growth of the hoof horn Prevents excessive/abnormal wear Prevents areas of deep sole horn Interrupts vicious circle of increased horn production Balances the weight load on lateral & medial claw Avoids high loading of localised areas of the sole	All causes of lameness

2.1.1. II. a. Cow comfort

Prolonged standing has been associated with the presence of sole ulcers (Cook *et al.,* 2005) and increased foot lesions and lameness (Leonard *et al.,* 1994; Singh *et al.,* 1993). It is also reported to reduce the efficiency of rumination, which may impact on diet and exacerbate diet related lameness.

2.1.1. II. A .i. Excessive standing may occur for two reasons:

The lying conditions are not comfortable. In this situation cows will lie down for larger time if there is enough lying space; Bowell (2003) reported that the ratio of cubicles to cows was negatively correlated with locomotion score. Cattle will also lie down for longer if lying conditions were comfortable. Longer lying times have been reported in straw yards compared with cubicle houses (Singh *et al.,* 1993) and shallow vs deep quantities of bedding in cubicle houses (Faull *et al.,* 1996). Longer lying times have also been observed when cows lie on mattresses compared with mats (Chaplin *et al.,* 2000) and on deep sand when compared with mats and sawdust (Cook *et al.,* 2004). Hard lying

surfaces, which result in cattle bearing weight on a few points of the body, may lead to superficial damage which may in turn discourage cattle from lying down. Wechsler *et al.* (2000) reported a significantly higher incidence of leg injuries over the tarsus (hock) in cows housed in cubicles with mats compared with cubicles bedded with straw. Given a choice, cows preferred cubicles deeply bedded with sawdust or sand to cow mattresses (Tucker *et al.,* 2003). Other factors linked with uncomfortable lying conditions include those associated with cubicles; Leonard *et al.,* (1994) reported that small Newton Rigg cubicles were associated with decreased lying times and increased haemorrhage scores in cattle when compared with large Dutch comfort cubicles. Faull *et al.,* (1996) reported increased locomotion scores associated with limited "borrowing" space at the front and side of cubicles, low side rails and high kerb heights (> 16cm) in the cubicle houses in 37 herds. In summary, cows lie down more when the lying area is comfortable. There are many suggested lying times for cattle. There is probably no absolute since a cow's activity will depend upon her yield, however, cows should not stand while ruminating, and they should lie down at every opportunity.

2.1.1. II.a.ii. Type and quality floor surfaces

Type of floor surface

Gitau *et al.,* (1996) studied cattle in Kenya; none were kept on concrete and no sole ulcers or white line disease was reported. This may be of huge importance to our understanding of the etiology of these lesions. Concrete is ubiquitous in most intensive dairy industries and so we cannot assess the impact of concrete without turning to countries where it is not used. Clearly the breeds and production of Kenyan cattle may also vary but the information from this study cannot be ignored. The data from New Zealand is similar and horn lesions have increased since concrete standing has been used on farms (Chesterton, 2004). A sudden change from one floor type to another has been reported to affect lameness. Cattle moving from resilient floors, e.g. straw bedded, to hard floors, e.g. concrete, have more lameness (Hultgren & Bergsten, 2001) and lesions (Webster, 2002). This is hypothesized to occur because of the following chain of cause and effects. If animals are moved to a hard floor the claw is exposed to higher pressure, in particular high circumscribed/local load. This pressure stimulates horn production, more horn is produced and the claw gets bigger. Because of the initial asymmetry of the

two metatarsal bones the outer claw on the hind limb is more loaded which causes more stimulation of horn production. As a consequence the claw gets bigger, carries more load and more horn is produced. Thus for cows on hard floor a vicious circle of pressure and horn production is activated. This can only be interrupted by regular professional functional claw trimming. A sudden change onto an abrasive floor may wear out the sole horn before the rate of horn growth has increased. This may explain the thin soles often reported in early lactation cows.

Quality of floor surface

As well as floor material the quality of the floor surface whilst standing or walking also affects cow comfort. Poor quality includes surfaces that are too smooth and lead to slipping, too abrasive leading to wear of hoof horn, too uneven leading to tripping and presence of loose stones that may penetrate the sole, particularly the white line. Smooth walking surfaces have been associated with poor locomotion (Faull *et al.,* 1996). The quality of concrete in the feeding area, on tracks in the housed environment and tracks to and from pasture has been identified as an associated risk for lameness (Chesterton, 1998), particularly white line disease. Good management of the above will lead to optimal lying times of 14-16 hours a day and reduce physical damage to soft and hard tissues of the claw. Reduction of excessive standing times prevents prolonged pressure on the weight bearing parts of the claw thus preventing direct damage to the soft living tissue and improving microcirculation in the dermal vascular system required for nutritional and oxygen supply of the horn producing tissue.

Changing lying conditions is in reality highly complex. On farms often look at a combination of stocking density, cubicle type, lying surface, bedding material and depth and possibly even a slurry system that constrains changes in cubicle design and bedding type. This poses two challenges: which of the features of the housing is “causing” the lameness and how can we change only one aspect e.g. recommending sand over sawdust as a bedding material may not be acceptable if the slurry system will not handle sand. This is where the farmer and advisor need to work together to agree a practical solution. Evidence for loss of productivity through premature culling, treatment costs and milk loss may help to persuade a reluctant farmer to consider changing the environment.

2.1.1. II.b. Biosecurity

One aspect of hygiene is biosecurity. The evidence to date indicates that digital dermatitis is most easily introduced into a herd through purchase of an infected animal. Maintaining a closed herd at a high level of hygiene is the best way to prevent introduction of infectious lameness or most other infectious diseases. If this is not possible then quarantine for two weeks and careful examination of the lifted and cleaned feet of newly purchased animals will assist in reduction of introduction of new infections.

2.1.1. II.c. Hygiene

A second area for risk of lameness, and indeed any infectious disease, is hygiene. Cleanliness of cows is a good general indicator of hygiene status. Dry feet have greater integrity than wet, the hoof horn and the barrier of the skin between and above the claws is intact reducing the chances of bacteria invading the tissue. In wet conditions, slurry and water soften the horn and weaken or even disrupt the skin barrier; slurry may also corrode the horn. Lesions associated with exposure to slurry are digital dermatitis and heel erosion (also known as interdigital dermatitis). Somers *et al.*, (2003) reported an increased risk of digital dermatitis for cows housed on solid concrete floors compared with those on slatted floors without scrapers. It was also reported that cows with restricted or zero grazing had an increased risk of digital dermatitis, suggesting that both improved cleanliness and reduced stocking may be important factors in reducing digital dermatitis.

2.1.2. Types of hoof problem

Foot infections, abscesses or sole ulcers may stem from cracks that result when feet are too soft or hard.

Excessively soft feet are more apt to occur in free stall systems from standing in manure and urine. This may result in heel and sole cracks allowing ulcers, abscesses or infections to occur. Excessively hard feet usually occur in stall-barns, especially when kiln-dried shavings or sawdust are used for bedding. This may result in cracks at the top of the foot, which may extend down from the hairline and allow infections relatively high in the foot.

Basically problem can be broadly categorized into 2 types:

Infectious and Non-infectious disease

Table 2: Infectious and Non-infectious disease

Infectious Disease	Non-infectious Disease
Heel warts Digital and inter-digital dermatitis Foot rot	Laminitis While line disease Sole ulcers Joint and upper leg trauma/deformity

Foot rot: A smelly infection of the foot, which generally occurs high between the claws or toes, is referred to as foot rot. This results mainly from an infection caused by the bacterium *Fusiformis necrophorus*. The organism may build-up in barnyards, exercise lots, mud-holes, and pastures. Cattle with foot rot show lameness, usually on one leg only. The foot swells above the coronet and the toes spread. Cracks and fissures develop in the inter-digital space. There are characteristic, foul-smelling exudates at these fissures. If left untreated, the infection can progress into the joint space or tendon sheath producing permanent damage.

Heel erosions: Heel erosions or under run heels begin at the bulb of the heel. They start out as pits on the surface that can develop into parallel grooves that get filled in with black material and bacteria. The horn can separate at the grooves to form a 'flap'. A new sole develops underneath and material becomes packed in between the layers. This condition is usually seen in confined cattle in wet, dirty lots. Overgrown hooves shift the weight toward the heels, exposing the heels to erosion, mostly in the hind claws.

Laminitis

Founder or laminitis can result in long, overgrown and deformed feet or toes. Animals may appear quite lame or stiff and have difficulty in getting up and down. Hemorrhages can be found in the soles and walls of the feet. Infections, abscesses or ulcers may occur when foreign material enters places where the wall and sole have separated. The highest incidence of laminitis often occurs during the first 100 days postpartum.

Sole ulcers

Sole ulcers are raw sores usually occurring on the inner side of the outside claw. It is a bulge of granular-like tissue sticking through the sole. Sole ulcers are usually associated with clinical manifestations of laminitis. A general rule of thumb is that if 10 percent of a herd has documented sole ulcers, the herd should be suspected for laminitis. However, there are other factors that can predispose cows to sole ulcers such as moisture and manure, excessive wear and poor hoof trimming. Sole ulcers usually occur in both hind legs.

Digital dermatitis

In the past 10 years, digital dermatitis has developed as a serious problem in several dairy regions in North America. They are heel warts, hairy foot warts, strawberry foot disease, raspberry heel, digital papillomatosis and Mortellaro disease. Affected animals have pronounced lameness and spend excessive time lying down. First-calf heifers are often affected, and to a greater degree in the hind feet. There is little to no digital swelling with this disease.

2.1.3. Clinical Signs and Diagnosis

Clinical signs are acute to per acute, severe lameness with marked swelling around the coronary band and in the interdigital space (Stokka *et al.*, 2001; Berg and Franklin, 2000, Bergsten, C. 2001). It is commonly found in one foot and is more common on rear feet. The first signs of disease are erythema and swelling in the interdigital space and around the coronet. Animals show slight lameness for 18 to 24 hours, which is often missed (Baggot and Russell, 1981). Other signs are pyrexia, decreased feed intake, and decreased milk yield. Culture of *Fusobacterium necrophorum* is rarely used to confirm diagnosis. A form of the disease that is more rapid in onset and less responsive to antimicrobials (super foot rot or super foul) has been reported in the US (Guard, 1997). Septic arthritis might be mistaken for interdigital phlegmon but most septic arthritis involves swelling of only one digit and would not have a necrotizing interdigital lesion (Bergsten, 2001). Deep digital sepsis, however, can be a sequel to chronic or non-responsive interdigital phlegmon (Reinohl-DeSouza *et al.*, 2004).

2.1.4. Treatment of hoof disorder

Prompt treatment of lame individuals requires several steps. First the detection of the disease or lameness in the affected cow must take place. Secondly, the predisposing factors responsible for the hoof disorder need to be addressed. Finally, immediate alteration of floor or provision of comfortable bedding should be done with clinical management of specific disease condition.

2. 2. Review study: Several scientists have been taken different experimental and survey type studies throughout the world at different point in time. Some of the important citations interrelated to this study are illustrated below:

Mishamo Sulayeman and Abebe Fromsa (2012) carried out a study on 432 dairy cattle that belonged to 23 randomly selected farms from Hawasa town to determine the prevalence of lameness, identify the associated risk factors and assess the effect on milk production. The result showed an overall lameness prevalence of 3.5%. Lameness of one or more animal was detected in 11 (47.83%) of the 23 visited farms. Milking status, pregnancy, feeding, floor type, length of rough track, frequency of floor cleaning, age, and sex and herd size were considered as risk factors and statistically tested. All the risk factors except milking status were not significantly associated with lameness ($P>0.05$). Lameness was more frequent in hind limbs (2.8%) than in forelimbs (0.7%). In milking dairy cows, the mean daily milk yield was significantly reduced after the onset of lameness. The study showed that lameness is an economically important dairy herd problem.

Somers *et al.* (2003) investigated at two consecutive periods each study having 3078 (49 herds) and 3190 (47 herds) cows respectively. Due to different hoof trimming strategy, data collected during both observation periods in straw yards (SY) herds (638 cows; 16 herds) were combined. Cows in SY had by far the lowest numbers of claw disorders. Over 80% of cows exposed to concrete flooring had at least one claw disorder at the time of observation, whereas on SY surfaces, this percentage was between 55 and 60.

Somers *et al.* (2001) focused on epidemiological and ethological aspects of claw disorders and disturbed locomotion with special emphasizes on floor type and

implications for animal welfare. The majority of the 1.5 million dairy cows in The Netherlands are now-a-days housed in cubicle houses with concrete stall floors. A small percentage of dairy cows are housed in straw yards. This housing system has a deep litter (straw-bedded) area where animals can rest collectively, accompanied by a concrete walking surface in front of the feed alley. At first, investigation was done on the claw health of more than 7500 dairy cows on different stall floors. Four-fifths of the cows on a concrete stall floor suffered from one or more claw problems. Reduced figures in affected claws (58%) were found in cows housed in straw-yard systems. Additional risk-factor analyses showed that specific measures in the area of accommodation and management could improve the situation on dairy farms.

Michael *et al.,* found laminitis was a disease that reduces overall profitability of the dairy operation. Cows that become lame showed a drop in milk production, have more reproductive problems and increase labor costs as personnel on the dairy spend more time moving cattle and loading the milking parlor. It is estimated that each case of laminitis cost the dairy producer $302 and that 15% of cows culled for slaughter are culled due to laminitis.

Dembele *et al.,* (2006) reported the prevalence of lameness on farms in a wide range from 6% to 42% (median 22%). At the farm level, floor slipperiness and poor animal care were associated with high lameness prevalence (Spearman correlations, $P < 0.05$), and the proportion of cows with overgrown claws tended to be associated with it ($P < 0.01$). Within farms, cows with overgrown claws and dirty cows were at an increased risk of being lame (multiple logistic regression, $P < 0.05$) and cows with skin lesions tended to be more lame ($P < 0.01$).The risk of lameness had an inverted U-shape dependence on age ($P < 0.05$), with cows at 7–8 years of age being the most endangered by lameness.

Vanegas *et al.*,(2006) studied on two groups of cows were housed in identical free-stall facilities, except that 1pen (rubber, n = 84) had rubber alley mats covering the entire concrete floor of the pen, whereas cows in the second pen were exposed to concrete flooring (concrete, n = 82) without rubber alley mats. All cows were evaluated 3 times between 10 and 30, 74 and 94, and 110 and 130 DIM for 1) the presence of claw lesions

on their rear feet, 2) the occurrence of clinical lameness based on a locomotion score, and 3) rates of claw growth and wear as observed on the dorsal wall of the right lateral claw. Cows on rubber flooring had decreased claw growth and wear between the first and last examination compared with cows on concrete. Regardless of flooring surface, second-lactation cows had greater wear rates than those in third or greater parities. Results of the study suggest that a soft flooring surface, such as interlocking rubber, is beneficial for hoof health.

Nguhiu-Mwangi *et.al.*, (2012) concluded that, the cow-level factors that strongly contribute to the development of claw lesions are 3rd or higher parities and being in the lactation period between 1 to 90 days. The farm level factors that strongly enhance claw lesion development are frequent high concentrate feeding, lack of regular mineral supplement, concrete and earthen floors, overstocking, the presence of a curb between walk-alley and cubicles, and leaving manure in the walk-alley for a long time. These associations are supported strongly by statistics that indicate the direction and strength of the relationship. It can also be concluded that non-infective claw disorders in dairy cows particularly the disorders related to laminitis are insidious in nature, which gradually but progressively damage the integrity of the claw. The subclinical occurrence of these disorders makes them subtle and careful early diagnosis so that remedial measures can be instituted early before these irreversible damages have occurred is essential. The fact that a cow does not show signs of lameness does not necessarily imply her claws are sound, but only calls for further careful scrutiny. Claw trimming is one of the major ways of discerning these underlying claw disorders at the subclinical phase.

Bielfeldt (2012) investigated claw health of dairy cows in an observational study in different housing systems in Switzerland. Twenty-five professional hoof trimmers examined lameness (LN) and claw disorders on 4,621 cows in 290 farms within routine hoof trimming. 82 farms had tie-stall barns without exercise (T1) and 166 had tie-stall barns with exercise (T2), another 42 farms kept their animals in loose housing systems with exercise (L2). Observation period lasted from September 2001 until June 2002. Single claw disorders were joined together to four different diagnosis-complexes: Sole disorders (SD), white line disorders (WD), heel erosions (HE), and disorders of skin and

inter-digital space (ID). Environmental and management factors were documented in a questionnaire for analyzing possible risk factors on claw health. Data from three breeding associations were available, including animal information and performance parameters. Prevalence was 15.7 % (SD), 13.6 % (HE), 10.0 % (LN), 6.1 % (WD), and 5 % (ID). LN and SD showed highest prevalence (13.2 %; 16.4 %) and highest odds ratio (OR = 1.89; 1.33) in T1. WD were more often detected in L2, accounting for 9.4 % (OR = 1.0). HE was identified most in T2 (17.1 %, OR = 4.72) and T1 (13.2 %, OR = 4.45). Disorders of skin and inter-digital space were most frequently found in T2 (7.5 %, OR = 1.55).

Christoph *et al.*, (2006) reported that lameness in cattle is a clinical sign with a multi-factorial etiology. A focused program for lameness reduction requires that farmers and their advisors recognize the main types of lameness occurring in cattle on their farm(s) and know the seasonal and lactation patterns of lameness and the management and environment of these cattle. In this paper we propose an approach to targeting cattle lameness using the above information together with published and new findings on risks for lameness in cattle to move towards targeted programs for reduction in lameness. Whilst there still have many questions on the etiology and pathogenesis of the lesions associated with lameness, research from the last 10 years can assist our understanding and anticipation cab be made that research in the next 10 years will strengthen this understanding so that we can be more accurate in targeted programs that reduce lameness in dairy cows.

Haufe *et al.*, (2012**)** conducted a study to assess the effects on the claw health of dairy cows of three different floor types and access to pasture were investigated on 35 farms. During each visit, the claw health of the same 10 cows per farm was assessed on the occasion of routine claw trimming. The proportion of cows with hemorrhages increased from mastic asphalt to rubber and slatted concrete floors. A lower proportion of cows kept on mastic asphalt was affected by white-line fissures and needed intermittent claw-trimming, an indicator for lameness. Cows housed in cubicle systems with slatted concrete floors were at the lowest risk of having heel-horn erosions. Access to pasture was associated with a lower incidence of slight white-line fissures and dermatitis digitalis. A higher proportion of cows with sole hemorrhages and sole ulcers were found

on all floor types at the end of the summer period than at the end of the winter indoor-housing period. Floor type did not influence the presence of sole ulcers and deep white-line fissures. In conclusion, the effect of floor type on claw health was slight, and none of the investigated floor types was clearly superior to the others. Access to pasture was not effective in reducing the presence of most types of claw lesions associated with the floor type used in the indoor walking area.

Shearer and Amstel (2000) stated that the majority of lameness (> 90%) involves the foot. Claw diseases (sole ulcers and white line disease) are a primary cause of lameness in most herds and are predisposed by laminitis and confinement on concrete. Foot rot, inter-digital dermatitis, and digital dermatitis are diseases with an infectious component responsive to antibiotic treatment, particularly when identified early-on in the course of disease. Manure slurry, mud, and otherwise wet conditions seem to favor the occurrence of these diseases, however specific data to support these thoughts is limited.

CHAPTER III
MATERIALS AND METHODS

3. I. Area and study population

The study was conducted on commercial and backyard dairy cows at Chittagong metropolitan area (CMA), Shikolbaha area of Chittagong, Bauphal of Potuakhali district of Bangladesh and Tamil Nadu state of India. The total period was divided into three seasons namely rainy (June 2012 to August 2012), autumn (September 2012 to November 2012) and winter (December 2012 to February 2013). Among 500 cases, different breeds were examined (1700 cross breeds and 400 local). The examined animals were categorized into three age groups as >8 years, <5 years and within 5 to 8 years old. The study was done only on the dairy cows. The commercial dairy farms were located at city and rural areas. The type of animals kept under commercial farming system were cent-percent cross of local with different exotic breeds and the backyard system mostly of indigenous. A total of 300 cows from CMA, 1400 cows from Shikolbaha, 250 cows from Bauphal and 150 from Tamil Nadu, India were examined under the study.

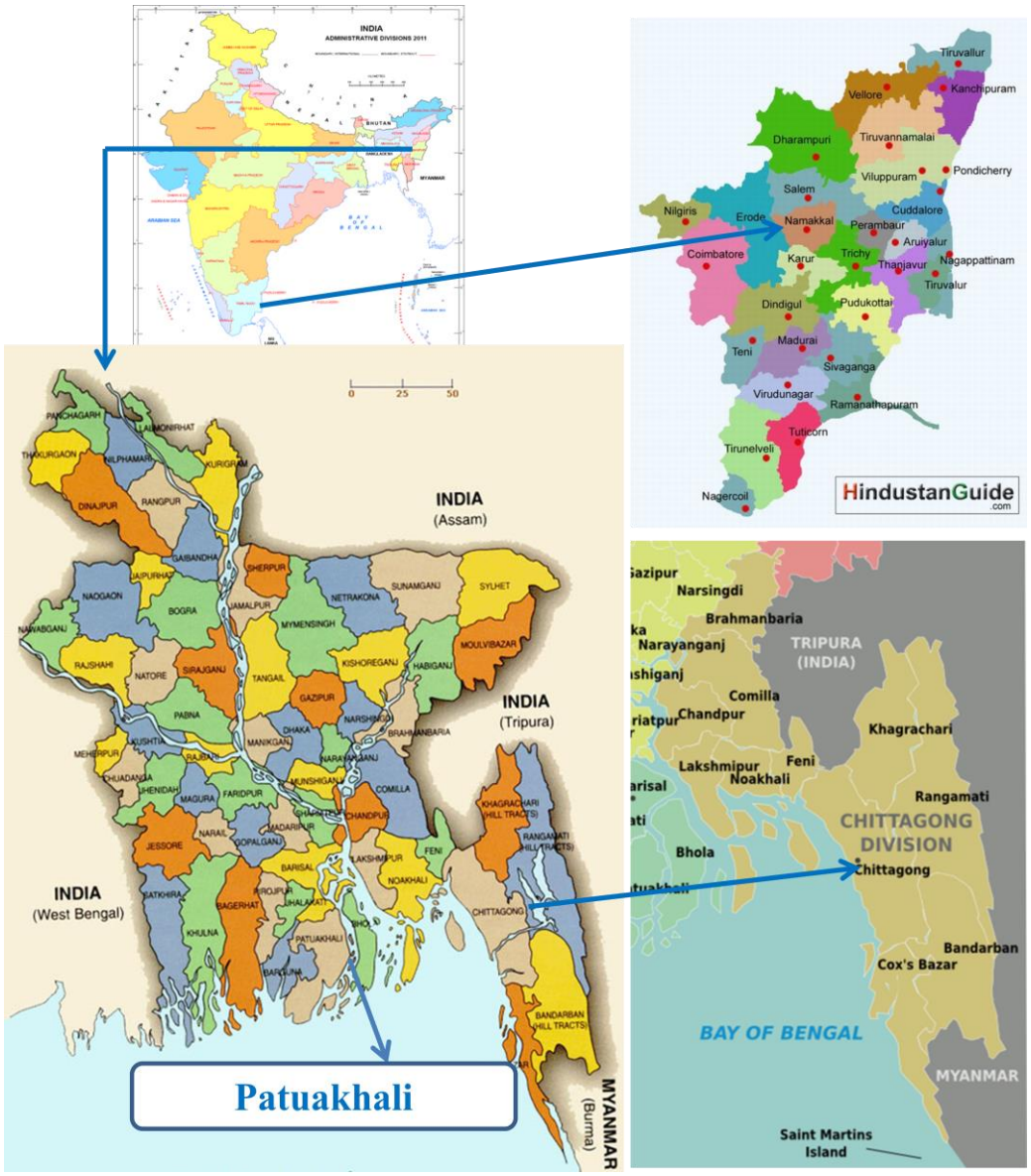

Figure 1: Map of Study Area (Chittagong region and Patuakhali of Bangladesh and Tamilnadu state of India)

3. II. Study design

A prospective study was undertaken from March 2012 to February 2013. The study was conducted on 2100 dairy animals belonging to 85 farms (including small backyard dairy farms) kept under different management system. On October 2012, cases are observed at Tamil Nadu state of India. The farms were selected by simple random sampling technique and all animals of each selected farm were included under the study. The study design is schematically shown in the Figure 2.

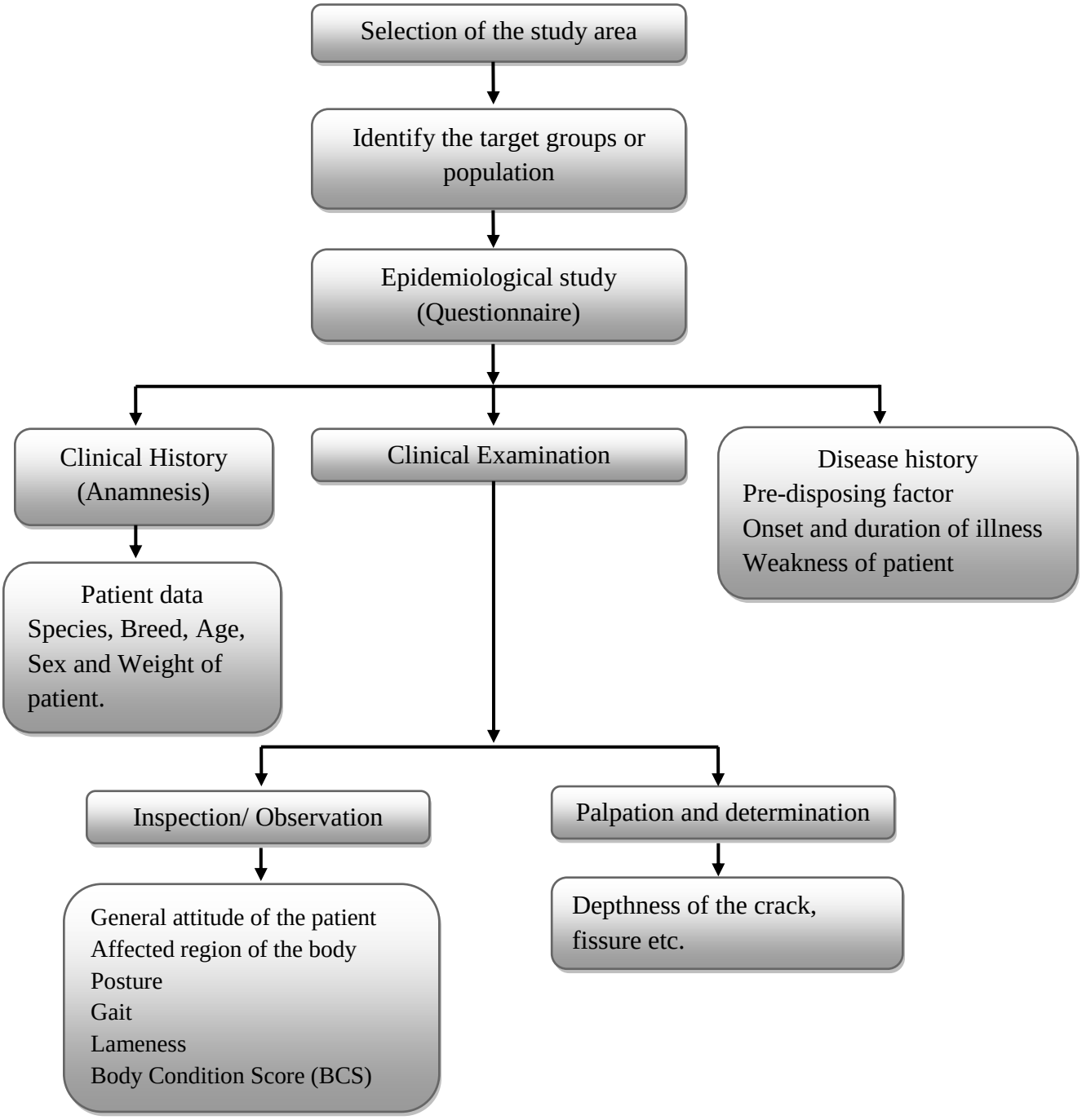

Figure 2: Schematic representation of the study design

3. III. Questionnaire design and Data collection

In order to collect relevant case for the study, a structured questionnaire was carefully prepared on the basis of the objectives. The questionnaire was designed to comprise mostly closed ended (categorical) questions to ease data processing, minimize variation and improve precision of responses (Thrusfield, 2005). The questionnaire was filled up by repeated questioning to the animal owner, personal observation of patient and taking records from register book. On this work, Important animal level data recorded including affected animals (species), breed, age, sex, body condition of the animal, posture, major diseases, type of floor, rearing system, washing system, involvement of hoof diseases of hoof, physical status, parity, housing pattern, type of the floor in the animal house (katcha/ dirt/ muddy/ brick/ concrete/ rubber bedded), rearing system (intensive/ semi-intensive/ free-range) as well as whether or not a system of grazing or zero-grazing was practiced. Clinical examinations findings were noted down accordingly. A complete form of questionnaire is given in the **Annex-I**.

3. IV. Case identification

In the study, a total of 500 cases were investigated from approximately 2100 cows. Diagnosis was made on the basis of clinical history and close, careful examination of hooves scientifically. Firstly, careful inspection was performed to detect the general attitude of the cows like alertness, dullness or depression. In addition, body condition scores (BCS) of the animals were taken into account whether cachectic, poor, fair, good, fatty or obese. Posture and gait were examined according to the condition of the animal as well. Finally, closed examinations of hooves were done upon proper physical restraining of cows to detect hoof disorders. The major disorders like fissure, crack, luxation, avulsion or overgrowth as well as major diseases seems FMD, foot rot, laminitis, physical injury, wounds, abscess, arthritis, bed sore revealed were recorded.

3. V. Data Analysis

All the data that were collected (categorical variables like breed, season, type of floor, housing system etc. and continuous variables like age, milk yield etc.) were entered into MS excel (Microsoft office excel-2007, USA). Data management and data analysis were done by STATA version-12.1 (STATA Corporation, College Station, Texus,

USA). Descriptive analysis was done by means of creating histogram, pie chart and boxplot. To identify the association between a categorical explanatory variable with the outcome (occurrence of hoof problems), chi- square (χ^2 test) test was performed. An association was regarded as significant if the p value was <0.05.

CHAPTER IV
RESULTS

4 .1 Proportions of investigated areas and species of animals:

The present study was designed to explore the prevalence of various disorders of hooves of cow causing poor production and health hazards and identification of risk factors associated, at different regions of Bangladesh and Tamil Nadu state of India. In Bangladesh, the highest (472) and lowest (3) number of cases were recorded from Shikolbaha area of Potya upazila, Chittagong and Chittagong Metropolitan Area (CMA) of Chittagong respectively whereas from India only 3 cases were recorded under the study (Figure 1).

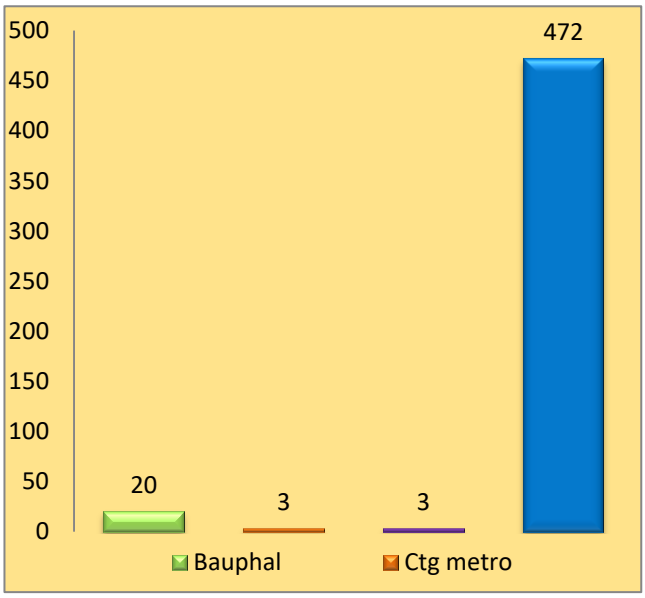

Figure 13: Frequency of patients with hoof problems from study areas.

4. 2. Prevalence of different hoof problems:

During the whole survey period a total of 500 cases were identified having hoof diseases. Among the animals the most and least common disorders recorded were fissure (37%) and crack (19%) accordingly. The comparative prevalence of different hoof diseases are shown in the Figure 2.

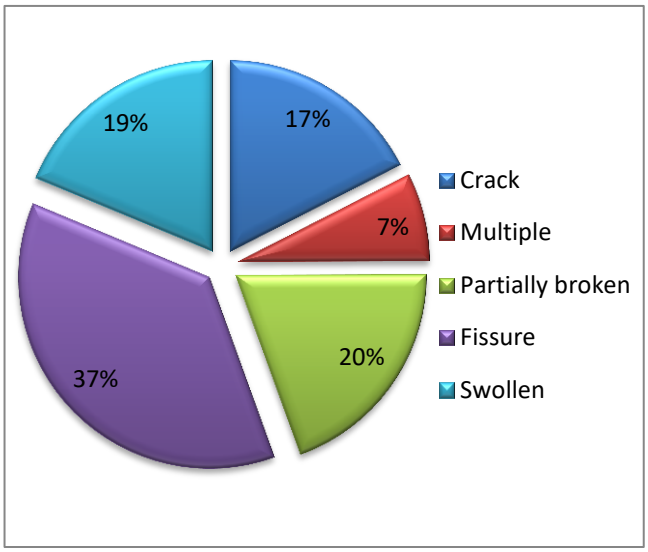

Figure 14: Proportion of different hoof problems recorded in the study population.

The surveyed data were processed and analyzed to observe the strength of correlation between the outcome and explanatory variables. It was found that only rearing system of cows was significantly associated ($p<0.05$) with the different hoof disorders. The details of the other relationship with their p values are illustrated in the Table 1.

Table 1: Different explanatory variables with different types of hoof problems tested (using Chi square test)

Variables	Level	Hoof problems					*p*-value
		Crack N (%)	Partially Brocken N (%)	Fissure N (%)	Swollen N (%)	Multiple problems N (%)	
Farm type	Backyard	21 (19)	21 (19)	40 (37)	17 (16)	10 (9)	0.82
	Commercial	66 (17)	76 (20)	143 (37)	76 (20)	27 (6)	
Season	Autumn	37 (17)	41 (19)	79 (37)	40 (19)	16 (8)	0.99
	Rainy	18 (18)	19 (19)	38 (38)	19 (19)	6 (6)	
	Winter	32 (17)	37 (20)	66 (36)	34 (18)	15 (8)	
Rearing system	Intensive	85 (17)	91 (19)	182 (37)	92 (19)	37 (8)	**0.01**
	Semi-intensive	2 (20)	6 (60)	1 (10)	1 (10)	0	
Type of floor	Brick	13 (20)	13 (20)	26 (39)	12 (18)	2 (3)	0.29
	Concrete	53 (16)	72 (21)	129 (38)	60 (18)	26 (8)	
	Combined	21 (23)	12 (13)	28 (31)	21 (23)	9 (10)	
Floor washing	BID	55 (19)	54 (19)	111 (38)	50 (17)	19 (7)	0.86
	SID	8 (15)	10 (19)	19 (35)	13 (24)	4 (7)	
	TID	24 (16)	33 (21)	53 (34)	30 (19)	14 (9)	
Age (years)	≤ 5 years	10 (12)	19 (23)	30 (37)	18 (22)	4 (5)	0.19
	6 to 8 years	58 (17)	66 (19)	129 (37)	68 (19)	29 (8)	
	> 8 years	19 (29)	12 (18)	24 (36)	7 (11)	4 (6)	
Milk yield (liter)	< 10 Litres	11 (12)	20 (21)	38 (40)	17 (18)	9 (10)	0.76
	10 to 14 Litres	68 (19)	68 (19)	133 (37)	66 (18)	25 (7)	
	> 14 Litres	8 (19)	9 (21)	12 (29)	10 (24)	3 (7)	

4. 3. 1 Comparative prevalence of hoof disorders with farming system:

From the study, it was observed that commercially reared cows (22%) showed more prone to hoof problem compared to backyard farming system (78%). Among those disorders, fissure and swelling of hoof are comparatively higher and common in both two types of cows. Therefore the overall prevalence of hoof disorders in different observation that was little difference reported between backyard and commercial farming (P>0.05) (Figure 3).

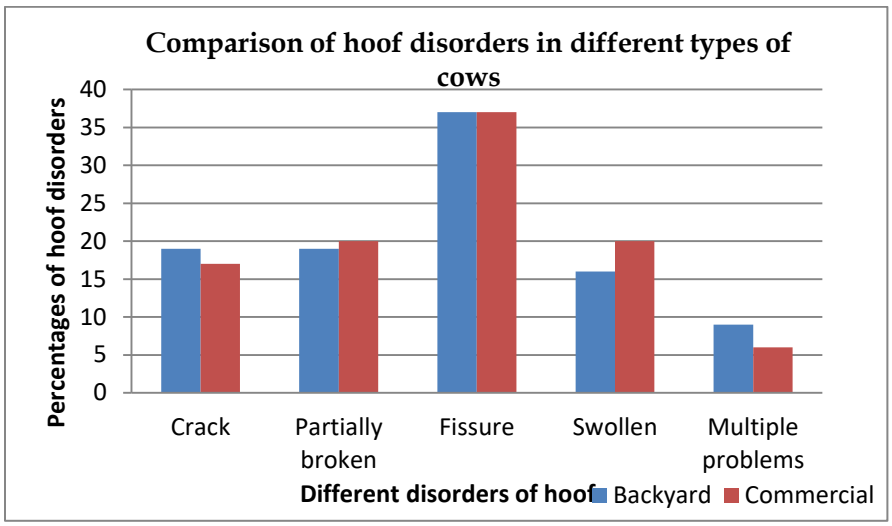

Fig 15: Prevalence of hoof diseases in backyard and commercial dairy cows

4. 3. 2 Prevalence of hoof disorders according to season:

The hoof disorders are more or less equally prevailed throughout the year. Among the three consecutive periods autumn, rainy and winter, the hoof diseases were found highest (42%) in autumn season and lowest (20%) in rainy season though the result was found statistically not significant (p>0.05) (Figure 4).

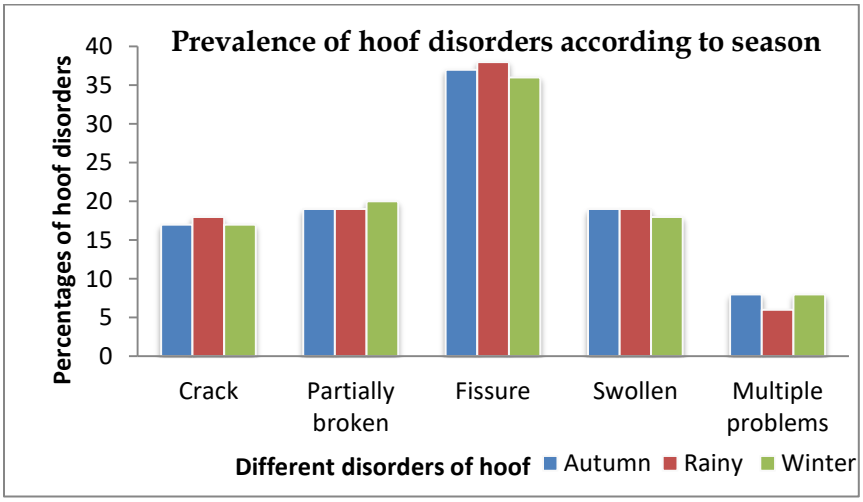

Fig 16: Season specific prevalence of hoof diseases.

4. 3. 3 Prevalence of hoof disorders according to rearing system:

The study revealed that the prevalence of disorders was maximum in cows reared under intensive housing (98%) compared to semi-intensive (2%). Moreover, partially broken (60%) hooves mostly found in semi-intensive cows whereas fissured (37%) hooves found in intensive cows and the results were found statistically significant ($p<0.05$) (Figure 5).

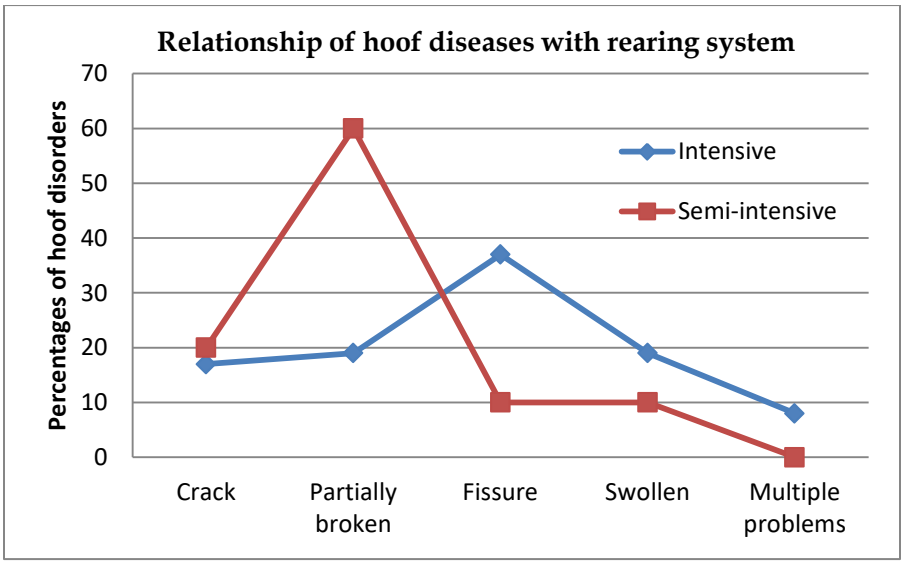

Fig 17: Prevalence of hoof disorders based on rearing system.

4. 3. 4 Prevalence of hoof disorders according to type of floor:

According to the study, hoof disorders are highly related to the floor design. Fissured and cracked hooves are mostly observed in brick and concrete floor whereas rubber bedded cows showed lowest ($P>0.05$) (Figure 6).

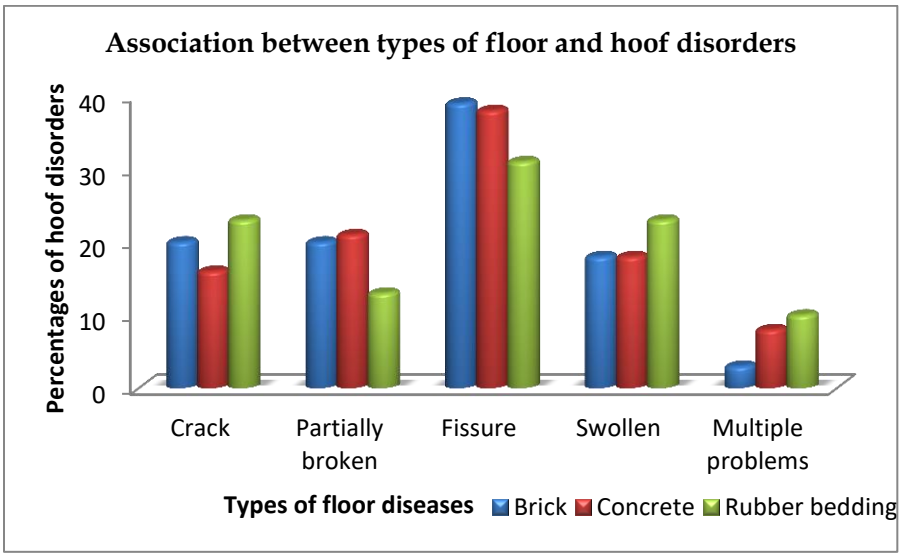

Fig 18: Floor specific prevalence of hoof disorders.

4. 3. 5Prevalence of hoof disorders with frequency of floor washing:

It was observed that the floor washing is less related for hoof disorders. The cows reared under twice washing of floor (BID) per day showed highest (58%) disorders while lowest (11%) in once (SID) though the findings were statistically non significant (P>0.05) (Figure 7).

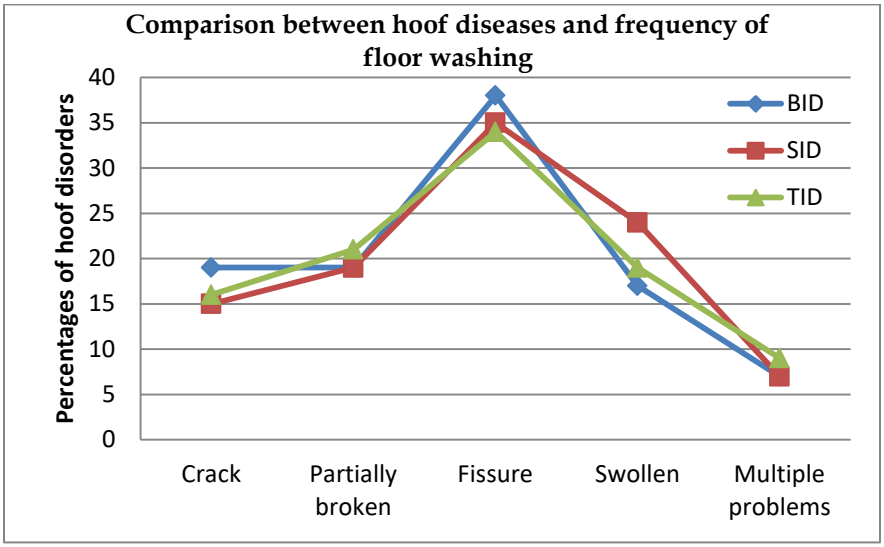

Figure19: prevalence of hoof disorders with frequency of floor washing

4. 3. 6 Prevalence of hoof disorders according to age:

The survey revealed that the diseases of hooves were mostly prevailed in the cows of 6 to 8 years old. Fissured hooves were found more regardless of the age where cracked hooves were reported mostly in older animal though the results were not significant (p>0.05) (Figure 08).

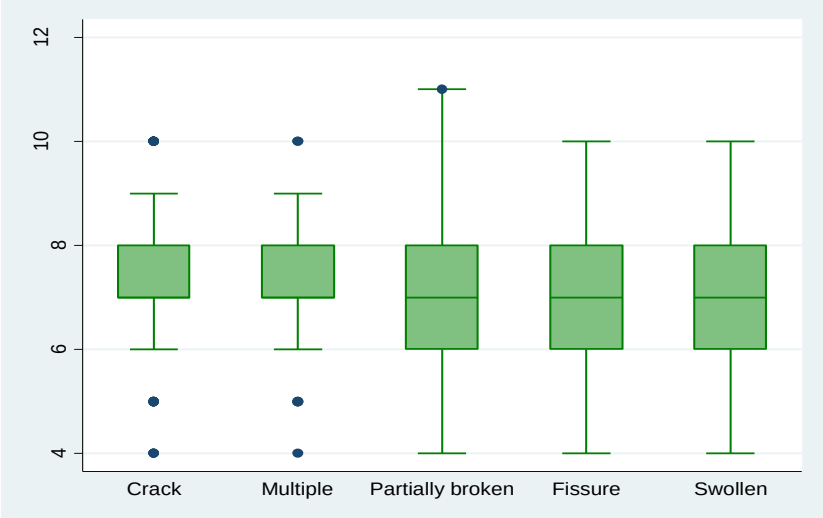

Fig 20: Age specific prevalence of hoof disorders.

4. 3. 7Prevalence of hoof disorders according to milk yield:

The study finding also exposed that the hoof disorders were mostly found in the moderately high yielding dairy cows where the highest (72%) hoof disorders observed in the cows having 10 to 14 liter of milk yield per day (P>0.05) (Figure 9).

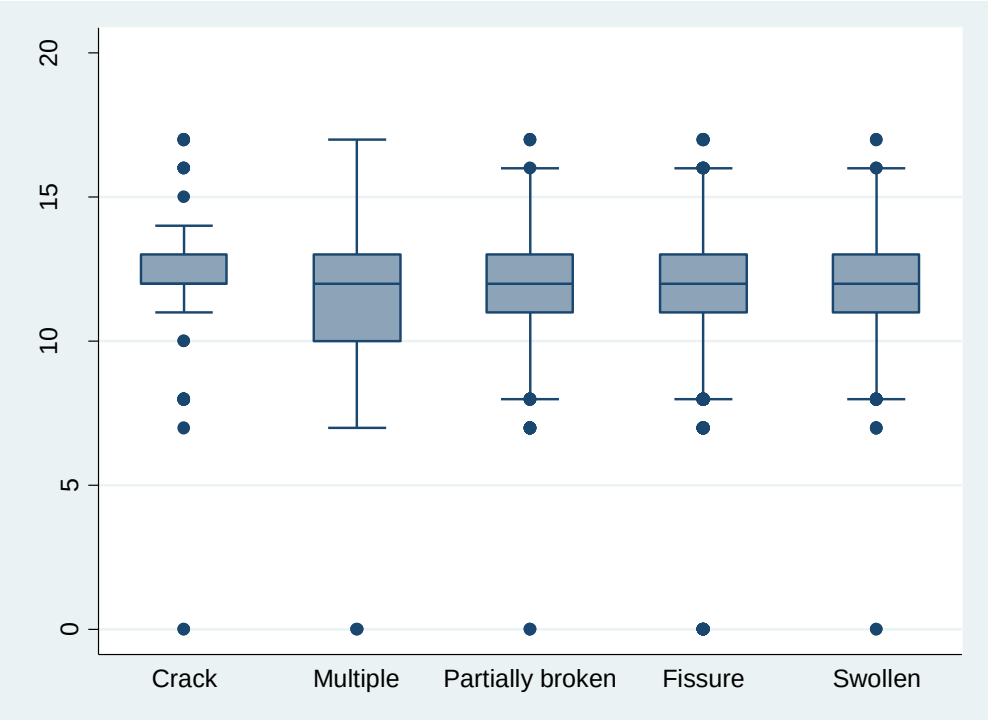

Fig 21: Prevalence of hoof disorders based on milk yield.

CHAPTER VI
DISCUSSIONS

A cross-sectional study was carried out to determine the possible hoof disorders and their proportion in dairy cows correlated to different risk factors. About 2100 dairy cows were examined and a sum of 500 was identified to have different kinds of hoof diseases and disorders. The study revealed that in commercial and backyard dairy cows, the prevalence of hoof cracks was 17% and 19% respectively that were almost similar to the findings of Bielfeldt *et al.* (2012) who reported 15.7% to 21% in Switzerland dairy cows. However, higher than the present rates was recorded by Mishamo and Fromsa, (2012) and Thomas *et al.* (2002) who reported 40% in Ethiopia and 27% in Sweden accordingly. On the other hand, wide varieties of lower rates were published as 0.5% and 12% in UK by J.Hedges *et al.*,(2001) correspondingly, 7% in US by Vanegas (2005), 7.9% in Germany by Schopke, 0.01% to 0.1% in Denmark by Vander-Waaij *et al.,* (2005). The commercial dairy cows showed higher risk to suffer from different hoof disorders compared to backyard or grazing cows (Haskell *et al.,* 2006; Hultgren *et al.,* 2004; Chesterton *et al.,* 1989). The variations might be due to the variations in climatic and farming system among the studied areas.

Among the disorders of hooves, prevalence of fissure was discovered the highest 37% while Clarkson *et al.* (1993), Vanegas (2006), Schopke and Vander-Waaij *et al.,* (2005) recorded 22-28%, 4%, 12.6% and 0.13-0.91% in UK, US, Germany and Denmark respectively. In addition, the present study showed 16% to 20% prevalence of swollen hooves that were approximate to the findings of Hedges *et al.* (2001) (13.8%), Bielfeldt *et al.,* (2012) (20%) and Mishamo and Fromsa, (2012) (16.6%). Whereas a higher 26.6% prevalence was recorded by Global veterineria (2012) and lower 5%, 5.5.% and 10% were published by Clarkson *et al.,* (1993), Schopke and Mishamo and Fromsa, (2012) (16.6%) accordingly. Moreover, the survey exposed 19% to 20% prevalence of partially broken hooves among the cows which was agreed by Bielfeldt *et al.,* (2012) who reported 18% on a cross-sectional study at Canada. But comparatively higher and lower rates than the present study findings were found by Vanegas (2005) (60%) and Clarkson *et al.*

(1996) (8%) and Schopke (7.1%) who worked at US, UK and Germany respectively. Finally, a range of 6% to 9% cows were found to have more than one hoof problem under the study. Whereas, Schopke and Vander-Waaij *et al.* (2005) found 57.8% and 39.9% prevalence of hematoma at German and Danish dairy cows accordingly, Bielfeldt *et al.* (2012) and Mishamo and Fromsa, (2012) reported 30.3% and 13.3% prevalence of overgrown hooves in Switzerland and Ethiopia correspondingly. Variable sizes of the study population, climatic effect and flooring type of the study farms and genetic make-up of different breeds might be reflected into the variations in results.

Seasonal prevalence of the study showed 17% cracked, 19% partially broken, 37% fissured, 19% swollen and 8% cows having multiple disorders during autumn while Wells *et al.* (1993), Hedges *et al.* (70%), Whitakes *et al.,* (2000), Alban (1995) and Manske *et al.,* (2002) reported overall prevalence of 16.7% in US, 70% and 23.7% in UK, 6.92% in Denmark and 5.1% in Sweden respectively. In addition, the rainy season prevalence of hoof disorders were found as crack 18%, partially broken 19%, fissure 38%, swollen 19% and cows having more than single diseases were 6% whereas Wells *et al.,* (1993) and Clarkson *et al.,* (1996) recorded 13.7%, 20% and 18.6% in US and UK accordingly. Furthermore, prevalence at winter were noticed as crack 17%, partially broken 20%, fissure 36%, swollen hooves 18% and multiple problem 8% though Clarkson *et al.,*(1996) published 80% and 25% in US and UK consequently. Geographical distribution of animals might be adapted to a particular climate favorable to avoid unnecessary sufferings by seasonal variations.

Type of floor on which cows were inhabited had a variably greater impact on hoof disorders. The study established 13.27% prevalence on cows housed on bricked floor and 68.40% prevalence on concrete floor though lower prevalence rates were reported by Faye (1989) that was 19.8%, Frankena *et al.,* (1991) that stands for 44.6%, Frankena *et al.* (2008) (20.1%) and Bergsten (2001) (10.21%). Additionally, 18.30% prevalence on concrete floor having rubber bedding was revealed by this study was much higher than the findings of Bergsten (2001).

The present study also noticed that the commercial dairy cows housed in intensive condition showed significantly higher prevalence of hoof disorders compared to free-range or semi-intensive. The findings was disagreed by Somers *et al.*, (2003) who reported higher 63% prevalence in pasture grazing animals than lower 37.4% prevalence in housed animals. On the other hand, Vander-Waaij *et al.*,(2005), Amory *et al.*, (2008),) and Nielsen *et al.* recorded 21.2%, 21.7%, 7.5%, 195 and 62% digital dermatitis as hoof lesions in Netherland, UK and Denmark accordingly. The type of soil and floor materials used in different countries might have variable effects on production of hoof disorders.

The cows identified having hoof diseases all were cross of local whereas Global Veterinaria (2012) reported 3.8% prevalence in both local jebu and Holstein Friesian cow with 1.6% in cross breeds. The study also showed a higher 70.42% prevalence in the cow of 6 to 8 years old with lower in the cows below 5 years (16.29%) and above 8 years (13.27%) while Global Veterinaria (2012) published a higher 4% prevalence in the cows of ≥2 years and a lower 2.2% in <2 years old cows. In addition, Talukdar *et al.* (2005) found 2.11% and 2.82% prevalence in calves and heifer cow respectively in Bangladesh.

The cows having 10 to 14 liter of milk production were found more prone to hoof disorders (72%) compared to 19.1% in <10 liter and 8.45% in >14 liter milk yielding cows and the findings were agreed by Hultgren *et al.* (2004). In addition, Shearer and Amster (2013) recorded 11.4%, 13.3% and 8.1% in the cows with 1st, 2nd and subsequent lactations. High yielding cows suffer from more disorders might be due to inadequate nutrient supply and management.

CHAPTER VI
SUMMARY

A nine month cross-sectional prospective survey was made on dairy cows to explore the prevalence and predisposing factors of different hoof disorders from June 2012 to February 2013 at Chittagong and Potuakhali districts of Bangladesh and Tamil Nadu state of India. Approximately 2100 cattle population was examined from where 497 cases were identified having crack 19%, partially broken 19%, fissure 37%, swollen 16% and 9% multiple disorders in backyard dairy cows whereas 17%, 20%, 37%, 20% and 6% in commercial cows respectively. Significantly higher prevalence ($p<0.05$) rate was recorded in the cows reared under concrete floor (68.4%) compared to brick (13.27%) and concrete with rubber bedding (18.30%). Other major predisposing factors established were autumn season (42.86%), older animals of 6 to 8 years (70.42%), high milk yield (10 to 14 liter per day) (72.43%) and cows where floor washing practiced twice a day (58.14%) though the findings were not significant ($p>0.05$).

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CHAPTER VII
CONCLUSION

The hoof disorders were mostly found in the cows reared commercially under intensive housing where autumn season, concrete floor, aging and high milk yield were found most probable risk factors contributing to do these. The study will address the prevalence and factors causing hoof diseases to the farmers, attendants as well as the veterinarians of Bangladesh and Tamil Nadu of India so that they can take necessary steps for better welfare and management of cows and profit of the farmers. Further extensive studies are needed to economic analysis caused by hoof disorders and intensive identification of specific causal agents responsible for alteration of claw health.

Images Gallery

Figure3: Types of floor effects on hoof health

Concrete floor

Brick floor

Kacha/Earthy floor

Floor with rubber bedded

Figure 4: Partially broken hoof of cows. (Indicating mark)

Fig 5: Avulsion of hoof.

Fig 6: Crack of hoof (Indicating mark)

Fig 7: Over-growth of hoof (Indicating mark)

Fig 8: Inter-digital necro-bacillosis on hoof (Indicating mark)

Fig 9: Erosion, Sole ulcer and sloughing off of hoof

Fig 10: FMD on hoof

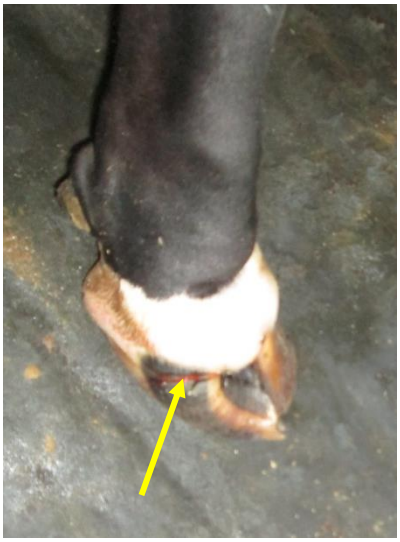

Fig 11: Complicated case

Fig 12: Fissure on hoof

Questionnaire for

Effect of Flooring System on Hoof Health of Dairy Cow, Bangladesh

Animal Data

- Cow ID: …… • Date: ……
- Address: …….....
- Breed: Local / HF / Cross (Local × ……..).
- Age: ……....
- BCS: 1 / 2 / 3 / 4 / 5.
- Grazing: Zero / Partial / Full time / Cut & carry / ……..
- Milk yield: ……L.
- Posture: Standing / Recumbent / …….
- Lameness: + / --
- Major disease/disorder: Mastitis / Downer's cow / Pneumonia / ……

Housing Data

- Type of floor: Kacha / Concrete / Brick / Rubber bedded / ……..
- Rearing system: Intensive / Semi-intensive / Free-range / ……
- Floor washing: -- / SID / BID / TID / QID / …….
- Disinfectants used during washing: -- / PPM / Lime / ……..

Hoof Data

- Hoof: + / --
- Involvement of hoof: LF / RF / RR / LR.
- Deformities of hoof: Fissured / Cracked / Sloughed off / Luxated / ……..
- Diseases of hoof: FMD / Foot rot / Laminitis / ……..
- Any physical injury to limbs: Wound / Abscess / Arthritis / Bed sore / …….
  LF / RF / RR / LR.

……

Signature