report

on

the second symposium

on

bovine

digital diseases

BIBLIOTEK

SCHOLA VETERINARIA
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SEPT. 25th - 28th 1978

VETERINARY INSTITUTE

SKARA, SWEDEN

bovine digital diseases, 2 (Skara 1978).

(SECOND) SYMPOSIUM ON ~~ABNORMAL FOOT CONDITIONS IN CATTLE~~

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elf lån från

Monday September 25

09.00-09.10 Opening of the symposium.

I. Månsson. Dean of the Veterinary Faculty, University of Agriculture Sciences, Uppsala

09.10-09.30 Introduction. Review of the Utrecht symposium.

E. Toussaint-Raven

09.30-11.30 Morphology of the bovine foot in relation to discription and understanding of abnormal foot conditions.

The nomenclature of anatomical features of the bovine foot as it may be related to the study of the pathogenesis of some commonly encountered lesions. 30 min

P.R. Greenough

11.30-12.30 Luncheon

12.30-16.30 Bacteriological influence on the health of the bovine foot.

The importance of specific bacterial species in foot conditions in cattle. 30 min

J. Berg

Influence of bacterial invasion into the epidermis on horn formation. 20 min

E. Toussaint-Raven

Zink deficiency as a cause of foot diseases in ruminants. 15 min

P.N. Demertzis

Bacterial infections in the aetiology of foot disease of ruminants.

J.R. Egerton and E.A. Laing

Tuesday September 26

09.00-11.45 Environmental and nutritional influence on the health of the bovine foot.

Effect of the environment on claw diseases. 30 min.
I. Ekesbo

Prevention of deformed claws by orthopeadic trimming. 30 min.
P.F. Knezevic

Some remarks about the influence of housing on claw disorders. 15 min.
D.J. Peterse

Influence of feeding on the health of the bovine foot. 20 min.
A.D. Weaver

11.45-13.00 Luncheon

13.00-16.00 (Continued)

Histamine metabolism in ruminants. 15 min.
Ö. Sjaastad

Bovine laminitis and sequelae of it. 30 min.
S.A. Nilsson

Some remarks about laminitis in the Netherlands. 30 min.
D.J. Peterse

Synovial fluid in laminitic dairy cows. 15 min.
L. Andersson

...t lån från

Wednesday September 27

Visits at farms.

Sightseeing in the county of Skaraborg.

Thursday September 28

09.00-12.00 Specific diseases.

Aspects on pododermatitis circumscripta. 20 min
A. Modrakowski

Pathogenesis of circumscribed pododermatitis. 30 min
E. Toussaint-Raven

Is ulceration of the hoof always caused by trauma? 15 min
S.A. Nilsson

Free papers

12.00-13.00 Luncheon

13.00-15.30 General discussion.

Important investigations in future.

15.30-16.00 Conference review.
A.D. Weaver

There will be a break (5 - 10 min) after each paper for questions and remarks. A general discussion will finish each session.

...t lån från

Protocol of the general discussion

A. The first part of the discussion concerned the paper of Greenough on the anatomy.

The proposals made there referred to Nomina Anatomica Veterinaria. Weaver considered this was difficult to apply in praxis, but accepted it as a base for the nomenclature of diseases.

1. Greenough's opinion was, that as a description of the distal part of the leg (horny capsule and surrounding tissues) "digit" was the adequate word. "Foot also includes carpus/tarsus and metacarpus/metatarsus. Strictly hoof means just the horny capsule. Claw is the horny capsule in all animals, including birds.

The meeting agreed, and decided to use the term digit in future.

2. Next queation: Pododerm or corium. In the intention to make all terminology Latin Greenough liked to exclude the word "pododerm" and use "corium". In consequense pododermatitits should be coreitis and so on.

After discussion the meeting decided to use both terms. Corium consists of stratum papillare and stratum reticulare. Pododerm means corium and epidermis.

3. The meeting decided to use the terminology described by Greenough in figures I, II, III and IV.

4. The suggested principle with different regions of the horny capsule (Fig V) was discussed.

Detta är ett lån från

Toussaint Raven meant that the regions were too theoretically made, as one cannot see the zones when looking at a hoof. Greenough considered that there are no obvious histological differences between for example zone 1, 2, 3, 4 and 5. The diagram is only a try to facilitate registration of disorders. Weaver presented a diagram used by practioners in a big survey of lameness in cattle in U.K.

The meeting considered that there is a place for diagrammatic division of the external regions of the hoof in the description of bovine digital diseases. The diagram of Greenough can be used as one example.

B. One intention of the symposion was to make decisions on the nomenclature of diseases. The general opinion was that the list from the Utrecht symposium could be a good base for discussion. However, it should not be a list of diseases, but rather a list of clinical signs of disease.

There was a proposal to exclude the term "dermatitis interdigitalis contagiosa" from the Utrecht list. Berg disagreed as the causing agent B.nodosus is not normally occurring in the environment. Toussaint Raven wanted to put together the terms "dermatitis interdigitalis" and "erosio ungulae" as he saw them as parts of one syndrom. As the list should be a description of disease entities, the meeting decided to exclude "dermatitis interdigitalis contagiosa" and to change the order of the other terms.

There also was a decision to change the term "pododermatitis traumatica" to "podermatitis septica". The former term has an etiological aspect which is not quite adequate in a description of entities.

The meeting decided on a short description of every entity except the last one, "ungulae deformans", which was left to a committee, (Knezevic and Toussaint Raven) for description of different kinds of deformed claws. (Addendum 1).

Detta är ett lån från

C. The symposium decided

1. to constitute the International Council on Disorders of the Ruminant Digit.
2. to elect the members themselves as interim council
3. to accept the constitution proposed by Greenough as interim constitution. (Addendum 2).
4. to elect five members as an interim executive with their own elected chairman. The executive shall perform the function of secretary general until next meeting.
5. that the executive should contain at least one specialist on sheep, and also one additional member from the organizing committees of the present and the next meeting respectively. Demertzis, Sankovic, Knezevic, Weaver, Toussaint Raven, Banting and Andersson were proposed and elected as interim executive.
6. to arrange next meeting preferable within two years time, if possible in Athens or Vienna.

Detta är ett lån från

Addendum 1

Nomenclature and Definitions of entities of Bovine Digital diseases decided on the Symposium at Skara, September 25-28, 1978.

1. Dermatitis interdigitalis.
   An inflammation of the interdigital skin without extension to the deeper interdigital tissues.

2. Erosio ungulae.
   An irregular loss of solear or bulbar surfaces of the horny capsule.

3. Dermatitis verrucosa.
   A chronic proliferative inflammation of the dorsal and/or plantar/palmar skin.

4. Hyperplasia interdigitalis.
   A proliferative reaction of the interdigital skin and/or subcutaneous tissues.

5. Dermatitis digitalis.
   A diffuse or circumscribed inflammation of the skin proximal to the coronary margin.

6. Phlegmona interdigitalis.
   An inflammation of the interdigital skin and underlying tissues, characterized by necroses and fissures of the skin, usually accompanied by lameness.

7. Pododermatitis aseptica diffusa.
   A diffuse acute, subacute, or chronic aseptic inflammation of the pododerm, usually involving several feet.

8. Pododermatitis circumscripta.
   A circumscribed reaction of the pododerm, often characterized by erosion of the horn.

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9. Pododermatitis septica.
   A diffuse or localized septic inflammation of the pododerm.

10. Fissura ungulae longitudinalis s. transversalis.
    A fissure of the horny wall, running parallel to the dorsal surface or parallel to the coronary margin.

11. Ungulae deformans.
    (Definition will not be decided until the committee has made a proposal.)

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Addendum 2

Constitution of:

The International Council on Disorders of the Ruminant Digit

Objectives

1. The council shall make recommendations to the veterinary profession on nomenclature and terminology that may be applied to the structure or diseases of the ruminant digits.
2. The council shall make recommendations to the veterinary profession regarding acceptable methods of recording clinical data concerning the ruminant digits.
3. The council shall take such action as it is able, to bring to the attention of the veterinary profession advances in knowledge related to the ruminant digits.
4. The council will recommend to the veterinary profession areas of research in studies of the ruminant digits that should be given particular attention.
5. The council will serve as an international advisory body in matters related to disorders of the ruminant digits.
6. The council shall seek funds to support their activities.

Constitution of the Council

1. The council in the first instance shall be formed by not more than two persons from each country participating in the Skara symposium.
2. The council will thereafter receive nominations from schools of veterinary medicine, govement veterinary organisations or national veterinary associations. The council will select members on the basis of their contribution to studies of disorders of the ruminant digit.
3. Membership shall in the first instance be for a two or four year term with the possibility of renewal for a further four years.
4. The council shall elect an executive of five of its members who will serve for two or four years in the first instance but will not be eligable for reelection until a two year period shall have passed. Chairmanship of the executive shall rotate.

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5. The council shall in addition elect a secretary general who shall be elected for a four year period and be eligable for reelection.
Elections and nominations to the executive and secretary generalship shall be secret.
6. The executive shall make decisions necessary between meetings of the council and consider and recommed to the council its own membership.

Meetings

The executive or council may meet at any time but preferably once each year.
The council shall arrange a symposium on alternate years seeking a host country and if possible a host school of veterinary medicine. In the period required to organise the symposium four additional representatives of the host country may be added to the membership of the council.

Detta är ett lån från

Introduction of the Symposium.

E Toussaint Raven

Looking through the diagnosis and denomenations produced by the Cattle Section of the first Symposium on Abnormal Footconditions in Ruminants, and thinking over the comments on the report of this happening, one realise at the beginning of the second symposium that decisions on nomenclature should be supported by a more basic discussion, especially concerning

1. the relation between deep and superficial inflammations in the region of the interdigital skin, and

2. the relation between circumscribed inflammations of the pododerm, and more general affections of this pododerm. The relation between symptom and disease.

1. As far as the relation between deep and superficial inflammation in the region of the interdigital skin, f o o t r o t is the key-word. Can it be used?, the two affections being two symptoms or stages of one disease?.

Or shall it be r e p l a c e d by interdigital phlegmon and interdigital dermatitis?, the two affections being two different pathologic entities?.

Important in this discussion are the proper use of "pus" and "necrosis". "Necrosis" of the epidermis has to be distinguished from necrosis of corium and underlying tissues, and should not be described as purulent exsudate.

2. The recognition of a possible relation between disease and symptom is of major importance in the discussion about the pathogenesis of pododermatitis circumscripta.

Second hand necrosis ("ulceration") in the course of interdigital dermatitis or severe erosio, should be distinguished from necrosis caused by interdigital phlegmon.

What is the relation between local ischaemia/necrosis in "laminitis", and pododermatitis circumscripta profunda?

These discussions, consciously evaded during the first symposium, should be a support in reevaluation of nomenclature at the end of this second sumposium.

É Toussaint Raven

Detta är ett lån från

THE NOMENCLATURE OF ANATOMICAL FEATURES OF THE BOVINE DIGITS

Paul R. Greenough
Western College of Veterinary Medicine
University of Saskatchewan
Saskatoon, Canada

Introduction

In this paper the official nomenclature that may be applied to various regions of the bovine digits is reviewed. A comprehensive and accurate system of nomenclature is necessary in order to make a precise anatomical description of the sites at which lesions occur.

The majority of the nomenclature employed is taken from the Second Edition of the Nomina Anatomica Veterinaria (N.A.V.) and applied according to the advice of Dr. Robert Habel of Cornell University. The author is much indebted to Dr. Habel for the time he has devoted to clarifying certain misconceptions.

The Official Nomenclature That May Be Used To Describe The External Surface Of the Hoof

Inaccuracies in the use of terminology that is applied to the bovine foot are common. The "foot" or "pes" is that region of the pelvic limb that includes the tarsus and extends to the distal phalanx, it is, therefore, preferable whenever referring to the distal extremity to refer to the digits or digital region.

For convenience it is recommended that the interdigital space enclosed by skin shall be referred to as the proximal interdigital space and that space between the claws be referred to as the distal interdigital space.

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The term "derma" also presents problems. Derma is a Greek word and one that has been adopted widely for usage by clinicians, however, the N.A.V. adheres to Latin (corium). Derma indicates the whole skin, not the layer lying immediately below the epidermis which has been referred to by Sisson as corium when applied to the hoof. The term "pododerm" has not been recognized in any nomenclature and is not valid in comparative anatomy, however, it has been used by clinicians for well over fifteen years. It is argued that in none of the conditions to which we have ascribed, the term "pododermatitis" is the epidermis involved in an active inflammatory process. Nevertheless, there are living cells distal to the basal layer and these can be affected by inflammatory changes; therefore, it is recommended by the International Council for Disorders of the Ruminent Digit that the term pododerm shall be applied to those tissues lying distal to the basal layer of the epidermis of the capula ungulae: and that the "corium" is used for that layer of tissues lying immediately below the pododerm.

The epidermis, which refers to the horny hoof, is itself broken into several layers. (Figure I)

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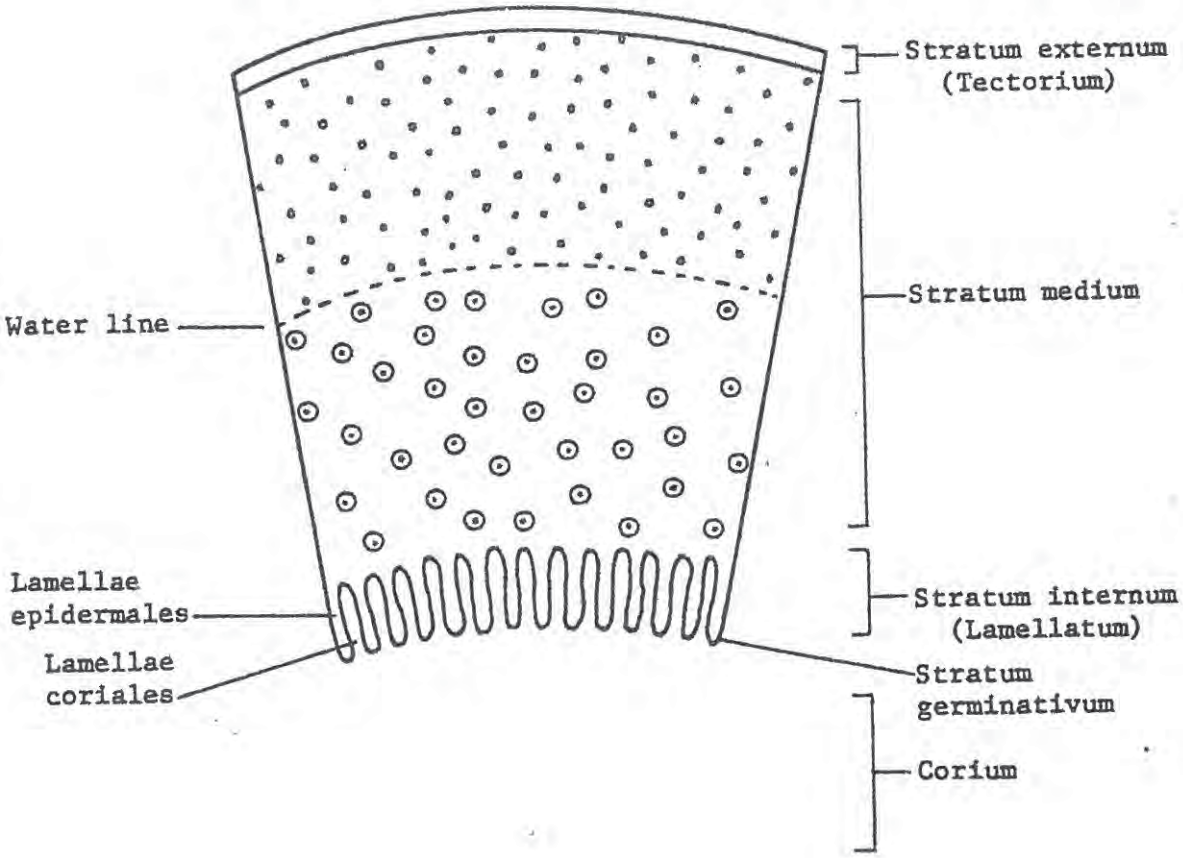
FIGURE I. PARIES CORNEUS



The most superficial is the stratum externum (stratum tectorium) often mistakenly referred to as the periople. The periople is a distinct narrow area bordering the proximal edge of the coronary band, the stratum germinativum of which produces the stratum externum. The stratum medium forms the bulk of the hoof wall and in the horse, Wilkins (64) has pointed out that there are two distinct layers. The outer layer contains less water than the inner. Emery (77) has used the term "water line" to identify the line of demarkation between the two layers. Nickels (38) working on the horse, points out that the tubules in the outer zone are smaller and more numerous than the inner zone. Leach (78) observed that the outer zone has considerably greater compressive strength than the inner zone and that the

tensile strength at the proximal wall is greater than at the distal wall. This observation leads him to believe that the dorsal wall may function in a manner different from potulations previously put forward. The stratum internum or stratum lamellatum is the region that will include the lamellae and extends inwards to terminate with the straum spinosum and stratum germinativum Stump (66).

The corium of the hoof has two layers: the stratum papillare next to the epidermis and the deeper stratum reticulare. The stratum reticulare is composed of a dense collagen network supporting a network of arterioles.

In the part of the wall covering the distal phalanx there is no subcutaneous tissue because the corium is fused with the periostum.

Elsewhere within the hoof, the tissue beneath the corium is composed of fat and loose connective tissue and is referred to as the "Tela subcutanea". In the region of the coronet and bulb, the tela is developed to form a cushion or "pulvinus". The tela subcutanea coronae (Pulvinus coronae) is highly vascular containing a venous network, in the cow the cushion is wider and flatter than the horse. In the bulb the pulvinus digitalis (digital cushion) is not very vascular but contains much fat.

Habel, in describing regions of the wall near the sole, uses the word distal; and conversely, proximal in relation to those regions nearer to the coronet.

The anterior surface of the hoof is referred to as the dorsal surface whilst the region relating to the bulb is referred to as either palmar or plantar. Such an arrangement is convenient for it permits specific regions of the hoof wall to be identified, such as the dorsal wall, the dorsal abaxial

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wall, the palmar abaxial wall, the abaxial groove and abaxial surface of the bulb.

The sole is more difficult to describe because the line of demarkation between heel and sole is not evident in some specimens. The palmar or plantar aspects of the heel is referred to as the base of the bulb and that area bearing on the ground, the apex. The apex extends distally between the axial and abaxial angles of the sole. The former is juxtaposed to the axial groove, the latter the common site for white line disease. The remaining sole is the body of the sole and may be divided into a palmar (bulbar) and dorsal (apical) region. The term solear is often more convenient than palmar or plantar.

The Practical Application of Nomenclature

The description of diseases of the bovine foot must, in the first instances, be related to the anatomical structure involved. In the second instance, the site of lesion must be described in anatomical terms that are both acceptable to the anatomist and the clinical investigator. The need of the clinical investigator will be most readily met if the sites at which lesions regularly occur can be identified and the region identified in anatomically terms. Figure V attempts to make such an analysis of the sites.

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FIGURE II. AXIAL PERSPECTIVE OF THE BOVINE HOOF

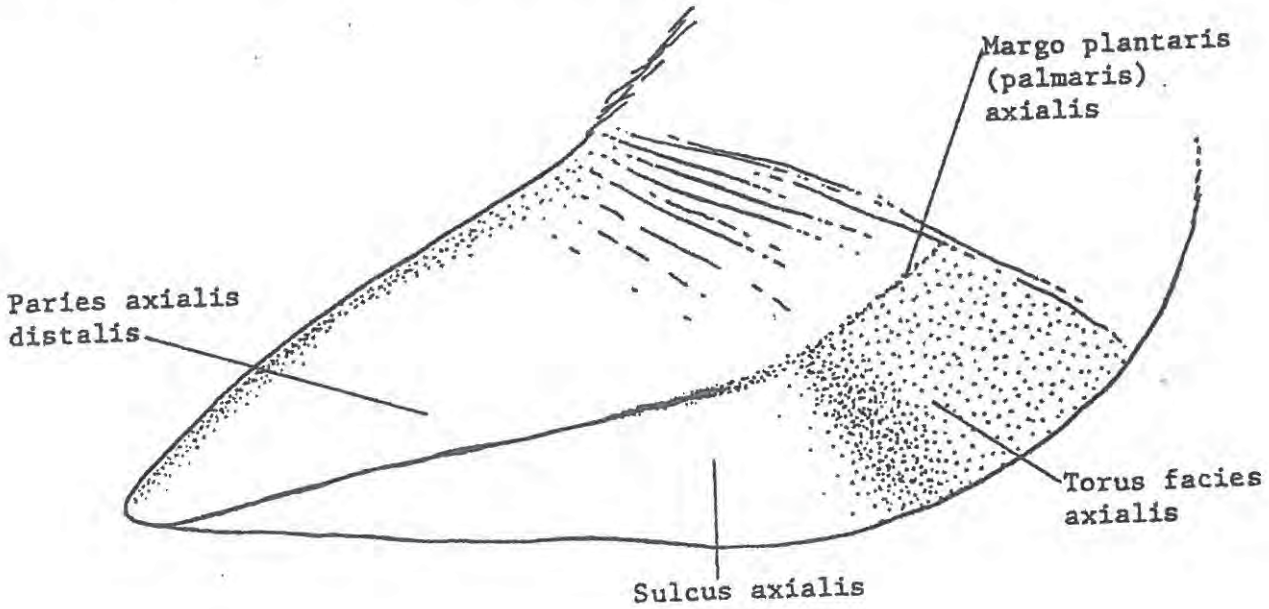


FIGURE IV. SOLEAR PERSPECTIVE OF THE BOVINE HOOF

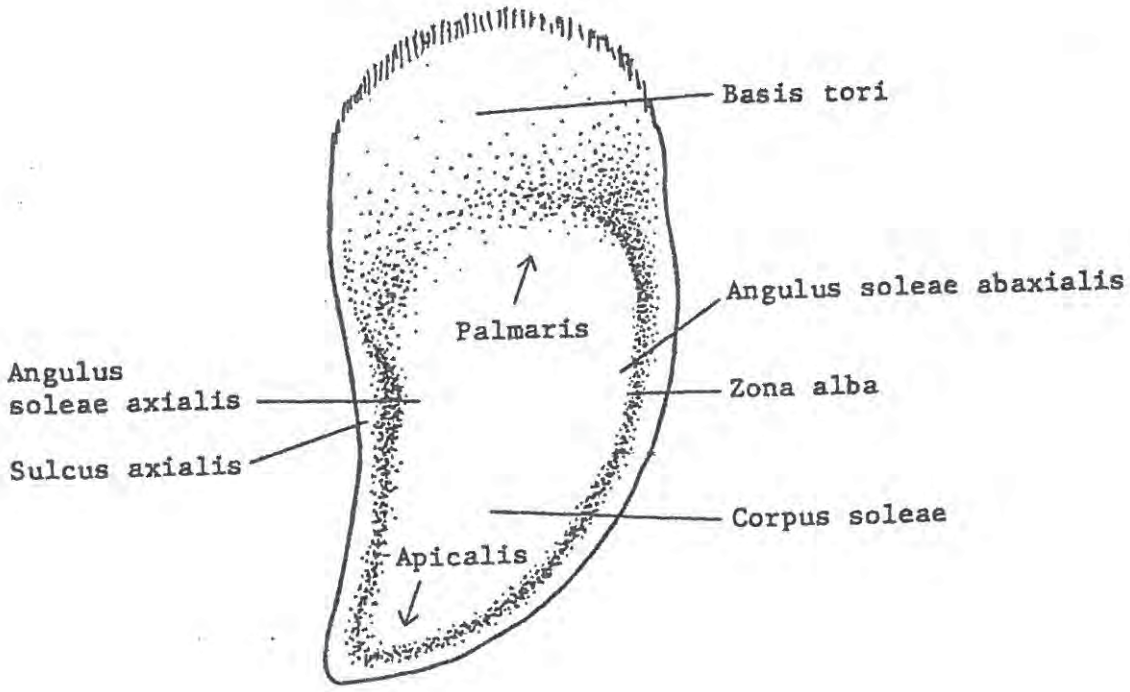
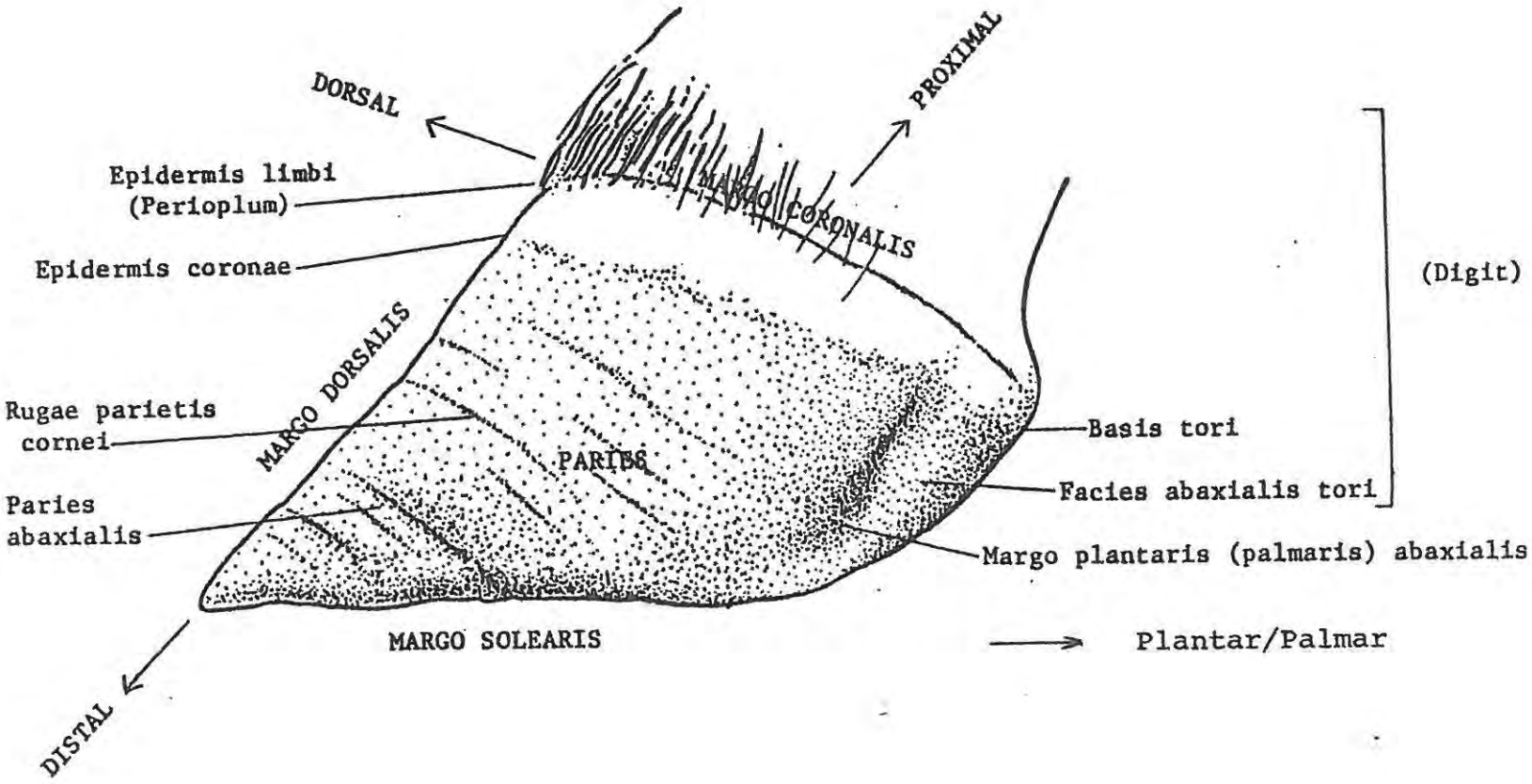


FIGURE III. ABAXIAL PERSPECTIVE OF THE HORNY HOOF



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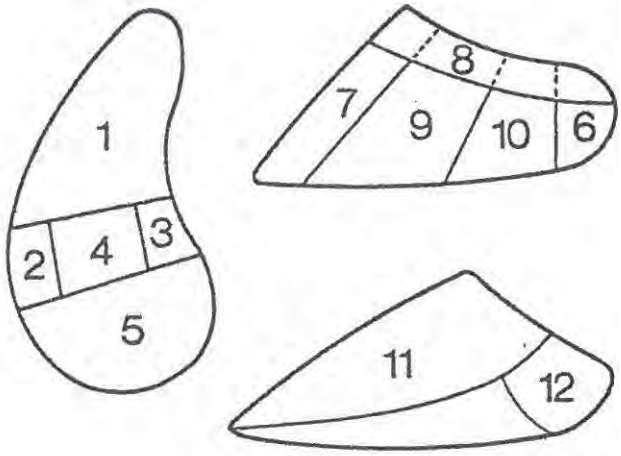
The Clinical Significance Of Regions Of The Hoof

Figure V.

FIGURE V.



REGION 1 PALMAR (PLANTAR) APEX OF THE SOLE

a) Pododermatitis traumatica

Penetrating foreign bodies causing septic foci to establish between distal phalanx and the hoof.

b) Pododermatitis aseptica diffusa

Changes comparable to those associated with laminitis.

Bruising of the sole with extravasation of sanguineous fluid (Traumatica).

REGION 2 ABAXIAL ANGLE OF THE SOLE

Coreitis septica resulting from a separation of the sole from the wall. Infection penetrating this space, the distal abaxial wall will either cause infection of the distal sesamoidean bursa or result in an abscess beneath the proximal abaxial coronet.

REGION 3 AXIAL ANGLE OF THE SOLE

A common location for erosions to occur.

Detta är ett lån f.

REGION 4 CENTRAL SOLE

Anatomically this region should be referred to as the apex of the bulb because a thin layer of the digital cushion lies beneath; however, because there is no external evidence of this feature, it is preferable for clinicians to use a simple term.

a) Coreitis circumscripta. It is probable that most of these lesions will be encountered in region 3 although extension into region 4 is regularly observed.

b) Erosio ungulae (Erosio capsulae ungulae) or trauma may result in the loss of continuity of this region.

REGION 5 BASE OF THE BULB

Erosio capsulae ungulae occurs most commonly in this region and advances opically as the condition progresses. Separation of the sole is also encountered in this region.

REGION 6 ABAXIAL SURFACE OF THE BULB

REGION 7 DORSAL WALL OF THE HOOF (margo dorsalis)

Fissura ungulae longitudinalis et transversalis.

REGION 8 ABAXIAL CORONET

Fissura ungulae longitudinalis in the dorsal region of the abaxial coronet may be located directly over the dorsal pouch of the distal interphalangeal joint capsule. Infection of the coronary corium in this region presents a risk of septic arthritis occurring at this site. Fissures occurring dorsal to this site do not present the same risk by virtue of the presence of the extensor process. This risk is minimal at locations more palmar to the site because the joint capsule is situated below the level of the coronet.

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REGION 9 *DORSAL ABAXIAL WALL* *(Pars collateralis abaxialis)*

This is the common site for fissura ungulae longitudinalis which may be quite large and infrequently result in serious complications. Although fissura ungulae horizontalis will be seen in this region, they are usually mobile with the distal hoof freely detached.

REGION 10 *PALMAR (PLANTAR) ABAXIAL WALL* *(Pars collateralis axialis)*

This region overlies the abaxial border of the bursa of the distal sesamoid and the abaxial surface of the joint capsule of the distal interphalangeal joint. The region is important for surgical access to both of these structures.

REGION 11 *AXIAL WALL*

REGION 12 *AXIAL SURFACES OF THE BULB*

Detta är ett lån fr...

THE IMPORTANCE OF SPECIFIC BACTERIAL SPECIES IN FOOT CONDITIONS OF CATTLE

John N. Berg, College of Veterinary Medicine, University of Missouri, Columbia, Missouri 65211

There has been great difficulty over the years in identifying the specific pathogens involved in foot disease of the bovine. This is true even for some well-recognized clinical entities that are known to have infectious agents involved in their pathogenesis. The reasons for this include: (1) the lesions occur in areas that are highly contaminated with fecal flora which results in highly complex mixed infections in which the pathogen may be in low numbers; (2) most of the pathogens involved are not highly invasive, thus predisposing factors are an important aspect of the etiology; (3) many of the suspected pathogens require highly complex specialized media and growth conditions.

Phlegmona interdigitalis (acute foot rot) of cattle as seen in the United States does have a defined etiology. Two anaerobic bacteria, Fusobacterium necrophorum (synonyms: Sphaerophorus necrophorus; Fusiformis necrophorus) and Bacteroides melaninogenicus, will consistently induce the disease when mixed cultures of the two bacteria are inoculated in small doses intradermally in the interdigital space. It also has been shown that if materials such as soil are incorporated into the inoculum an enhanced infection results.

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Phlegmona interdigitalis (acute foot rot) of cattle as seen in the United States does have a defined etiology. Two anaerobic bacteria, Fusobacterium necrophorum (synonyms: Sphaerophorus necrophorus; Fusiformis necrophorus) and Bacteroides melaninogenicus, will consistently induce the disease when mixed cultures of the two bacteria are inoculated in small doses intradermally in the interdigital space. It also has been shown that if materials such as soil are incorporated into the inoculum an enhanced infection results.

Detta är ett lån frå...

Fusobacterium necrophorum has also been associated with epidermatitis contagiosa digitalis (foot rot) in sheep as part of a synergistic infection with B. nodosus, a motile spirochete and possibly Corynebacterium pyogenes. Toussaint Raven reported a similar type infection in cattle, dermatitis interdigitalis contagiosa, which is also assumed to have a similar etiology because Gram stains from the infected interdigital tissues of cattle resemble the stains made from sheep tissues with the disease. Both B. nodosus type cells and large numbers of the spirochetes may be seen on these slides. Recently Thorley reported the isolation of B. nodosus from cattle with similar lesions in Great Britian. We believe this disease exists in the United States and have conducted culture work on two herds. A B. nodosus type bacterium was isolated from one of these herds but the cultures were lost in a laboratory accident before the identification could be confirmed. Gram stains from these lesions did show the B. nodosus type cells and the spirochetes. The role of F. necrophorum in these cattle lesions is unknown. We were able to isolate the bacterium from the lesions but it is often present secondarily in foot lesions of cattle. We also isolated a Gram positive diphtheroid type bacterium, possibly a Corynebacterium, in very high numbers from both groups. It had a very granular type colony and pitted the agar.

The other diseases of cattle feet have not been studied extensively enough to identify a specific etiology for them. However, F. necrophorum is commonly involved in these lesions and in the secondary lesions in the deeper tissues. The reasons for this

Detta är ett lån fr...

may be explained by some experimental results obtained. If fecal material is implanted into the peritoneal cavity of rats, a major simplification of the flora occurs and only certain bacteria survive within the developing lesion, usually 3-4 species. Fusobacterium necrophorum, B. melaninogenicus and C. pyogenes are three of the most common bacteria isolated. Escherichia coli is often present but will disappear as the lesion progresses.

In our cultural studies of the deeper lesions of the bovine foot--abscesses, septic arthritis and septic laminitis--we almost always isolated F. necrophorum. Corynebacterium pyogenes and B. melaninogenicus were the other two most common isolates from these types of lesions.

I would like to mention two cases that illustrate the virulence of F. necrophorum in the bovine. In the first case we had several dairy herds in which there was a serious metabolic upset because of a sudden switch from corn to wheat as the major source of energy in the feed. These animals dropped in feed consumption, milk production and many had a diarrhea. Subsequent to this a high percentage of these cattle became lame in 1-4 feet. Examination of the feet showed a very mild interdigital dermatitis from which F. necrophorum was isolated. Two animals were sacrificed and these had lesions of septic necrotic laminitis, interdigital abscesses, septic arthritis, osteomyelitis and diffuse phlegmon in the subcutaneous tissues. Fusobacterium necrophorum and B. melaninogenicus were isolated from these lesions.

Detta är ett lån frå-

The second case occurred in a dairy herd later in the winter and had similar lesions and cultural results to the previous case. In this case no specific feed change or metabolic upset could be identified in the history. What is unique about both of these cases is that there was no gross or histopathologic evidence of laminitis in the feet unaffected by the septic conditions or in the lamina of feet where the septic condition did not involve the lamina.

Detta är ett lån från

Influence of bacterial invasion into the epidermis on hornformation. Patho-physiology of hornformation.

E. Toussaint Raven

Introduction

In the Netherlands a widespread and often seriously occurring disease of the cow's foot is called "stinkpoot" (stinky foot), and is clinically characterized by a dermatitis of the interdigital skin and/or the softer part of the heel. Lesions of the horn of the bulb in V-shape are typical. The disease occurs in tied-on stables as well as in loose housings, though the environmental circumstances influence the spreading of the disease and the severity of the symptoms.

The patho-physiologic behaviour of the quick, with regard to hornformation, to a high degree determines the pathogenesis of this disease, changing the course from a rather harmless epidermatitis (superficial, STAGE I) into a serious dermatitis (pododermatitis profunda, necro-purulent, possible complications, STAGE II).

Anatomy / Hornformation

The quick produces the horn by celdivision in the deeper epidermal layers, provisioned by the bloodsupply of the corium. Corium and germinal layer, concerning the formation of horn, function as an entity.
The amount of horn is the result of production and wear. In the sound organism and under reasonable conditions a balance can be expected, and regularly observed indeed.
A common property of the quick in the outer hind-claw is the formation of some more horn when compared with the inner claw. This results in more weight bearing, and is not compensated by more wear. There is a new balance between production and wear, on a higher level.
This phenomenon can be observed, the outer hind-claws regularly being somewhat higher than the inner one's.
The more weight bearing is measurable.

Bacteriology / Patho-physiology

Smears of material of the "stinkpoot" (the epidermatitis) are similar to those of foot rot in sheep. As the clinical picture also has the same feature (superficial epidermatitis without entrance into the corium), the bacterial invasion into the epidermis as described by EGERTON and co-workers concerning foot rot in sheep, is used as a model for "stinkpoot" in cattle.
On one hand there is a destruction of horn and hornproduction by the bacterial activity in the epidermis. On the other hand an overgrowth of horn can be observed in surrounding areas, presumable due to activation of the corium.
These two phenomenons in the cow's claw are rather abruptly separated by a deep fissure in the horn of the bulb, or less abruptly by a number of superficial ridges in the same horn. In the two claws these horndefects show a V-shape.

The quick, corium + deeper layers of the epidermis, is the unit for hornformation.
Bacterial invasion into the epidermis affects this hornformation: destroys and activates in immediate adjacent parts of the claw (STAGE I); the process of activating as a rule is far more pronounced in the outer, than in the inner claw of the hind foot.

Both symptoms result in mechanical problems regarding the quick itself: insufficient support in claws with fissures, and more weight bearing by the outer hind-claw. This frequently leads to contusion of the quick and local pododermatitis, especially in the outer hind-claw (STAGE II).

Control

One thourough antibacterial treatment of the epidermis (formalin bath and chloramphenicol tincture) eliminates the clinical symptoms of epidermatitis, and restores the hornformation to normal.
Eradication of the agent(s) responsable for the disease seems difficult.
After several months, or a year, epidermatitis and abnormal hornformation return.
Treatment should be exercized at regular intervals.

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Zinc Deficiency as a Cause of Foot Diseases in Ruminants

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Introduction

Among the diseases causing serious economic damages inruminants footrot occupies a remarkable position,particularely in sheep.

Footrot seriously affects the health of sheep and cattle,the severe lameness being only one aspect,when compared with other derangements which increase as a result of the disease.Furthermore, apart of economic losses,the way in which the disease appears and the course of clinical events,constitues a serious reason of disappointment for the farmer.

It could be said that,at least under greek farming conditions, disappointment has the most adverse effect on the survival of sheep industry than the disease itself.

It is evident that failure in treating and preventing succesfully the disease originates from the inability to elucidate its aetiology.

Most investigators consider the disease as an infectious one (Beveridge 1941,Egerton et al 1969,Roberts and Egerton 1969), whereas others do not fully agree on the infectousness of the disease and consider it rather a syndrom (Katitch 1974).

Indicative of the confusion existing in regard to the aetiology of the disease is the fact that various vaccines are prepared for use,made from different antigens (Banting et al 1978).

It is still rether unclear what constitues aetiological factor, what are predisposing factors,what are the main manifestations of the disease and what are complications.Also it has not been elucidated whether fotrot in sheep and cattle are the same.

The zinc approach

Footrot of ruminants is among the diseases responding to zinc

treatment in both cattle (Demertzis and Mills 1973,Bosticco 1978) and sheep (Demertzis et al 1978,Banting et al 1977).

To low zinc supply was also attributed the occurence of oedematous swelling of the coronet in cattle (Grashuis 1963).

Despite the efforts made there is at present no reliable parameter for the detection of zinc deficiency in any animal species.

Therefore,the responsivness to zinc treatment constitues,for the time being,the only reliable diagnostic criterion.

On this basis numerous diseases and syndroms,in both human and farm animals,respond to zinc treatment,including acne of adolescent boys (Michaëlsson et al 1977),facial aczema of the sheep (Towers 1975), etc.

Being footrot responsive to zinc treatment,the question arises whether experimentally made zinc deficient ruminants will show symptoms of the disease.The only symptom appearing in such animals is an hyperkeratotic/parakeratotic lesion of the interdigital skin.

There is no doubt that the clinical picture of footrot affected animals is the sequence of microbial invasion,while under experimental conditions animals are kept in raised,wooden,kleen pens, in which bacteria have little chances to develop and infect the interdigital skin.

At this point a few manifestations of footrot will be considered in relation to zinc deficiency symptoms in ruminants.

There is agreement among investgators that susceptibility to footrot is greater in wool producing breeds of sheep (Beveridge 1963,Werff 1968) and goats (Van Tonder 1975).

Zinc is essential for wool growth,loss of wool and hair being one of the main manifestations of zinc deficiency in ruminants (Mills et al 1967).Loss of hair in the interdigital space is a constant finding in footrot affected animals (Beveridge 1963).

The influence of zinc deficiency upon keratinogenesis is particularly evident in the sheep,through changes in wool and horns. In horned lambs the normal ring structure disappears from new horn growths (Underwood 1971).In breeds which normally have no horns,zinc depletion leads to the development of keratinous

outgrowths in the position normally occupied by horns in other breeds (Mills et al 1967).Changes in the structure of hoofs which are overgrown,also occure (Mills et al 1967).

In deformed cattle hoofs disturbance of the dehydrogenases system (zinc contaning metaloenzymes) has been noted (Borisevich 1975).

It is well known that a great part of zinc of feed is diverted to the skin and its appendices (Underwood 1971) for keratin formation.

Obviously,with such an important role of zinc in securing keratin formation and integrity of the skin,the establishment of a disease like footrot,affecting the skin and its appendices will be at least fecilitated by even mild zinc deficiency.

Parakeratosis,a specific zinc deficiency manifestation (Tucker and Salmon 1955),is also present in footrot.It is believed that parakeratosis of the interdigital skin predisposes to infection and the soft,abundant,flaking keratin,probably provides numerous crevices where anaerobic bacteria could survive and perhaps multiply (Roberts and Egerton 1969).

Sex is another argument common between footrot and zinc deficiency. In making zinc deficient animals,males are the firs to develop deficiency symptoms.When these symptoms have been established in both sexes,are more severe in the male animal.

Footrot,all investigators agree,affects more severely rams and bulls than ewes or heifers (Thomas 1957,Demertzis and Mills 1973). This indicates an antagonism existing between androgenic hormons from one side and zinc to the other.

Footrot incidence is higher in sheep grazing improved pastures (Clark 1962,Hopkirk 1931),whereas all soils are more apt to produce crops with low zinc content when pushed to high levels of production whith fertilizers,adapted crop varieties and irrigation.Zinc deficiency in, or a response to,zinc applications have never been reported in native vegetation (Viets 1966).

The above mentioned features,like parakeratosis,loss of hair, sex incidence,etc.when taken separately have little significance whereas taken all together,in addition to the fact that footrot responds to zinc treatment,may lead to the thought that zinc deficiency may be involved in the aetiology of the disease.

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A FEW NOTES ON THE PROBABLE ROLE OF ZINC IN ABNORMAL FOOT CONDITIONS IN RUMINANTS

Alan de Laistre Banting

Many different studies seem to indicate that zinc can play an important part in the pathogenesis and therapy of abnormal foot conditions in ruminants and more particularily epidermatitis contagiosa digitalis in sheep and dermatitis interdigitalis in cattle.

The first point that I wish to revise concerns the level of zinc in feedstuffs: a recent survey of the Institut National de la Recherche Agronomique seems to correlate zinc deficient feedstuffs with the frequency of abnormal foot conditions. We have personally observed in the department of Haute Savoie a severe outbreak of epidermatitis contagiosa digitalis of the end of 1976 when, due to very dry weather, the level of zinc in plants had fallen to a very low level.

In itself the fact that one can come across low levels of zinc in feedstuffs is insufficient but one should recall that the availability of zinc to the organism is very variable and that their are multiple interrelationships with, for example copper (zinc and copper competing apparently for absorption in the intestine) but also with other trace elements and sulphur.

It is also known that zinc deficiency brings about changes in the metabolism of vitamin A which could accumulate in the liver instead of beeing distributed in the body.
It is worthwhile remembering that, in contrast to copper, zinc is not stocked by the organism.

However, experimental zinc deficiency is insufficient to initiate by itself the different abnormal foot conditions we have already talked about. An experimental zinc deficiency in adult ewes is at the present time being carried out in our laboratory. In adult animals the first signs appear roughly 6 weeks after the initiation of the trial. The most interesting lesion being loss of hair above the margo coronalis which progress rapidly to the fetlock. The skin becomes red, dry and parakeratotic at this stage and also in the interdigital space. I can say no more today as the trial is still under way.

As far as clinical trials are concerned we have carried out different types of experimental /designs/ on a dozen infected flocks of sheep and our main conclusions are that:

- oral zinc therapy is efficient in controlling epidermatitis contagiosa digitalis only if a certain dose level is attended (at least 110 mg of zinc metal per animal and per day in addition to the normal feed) and for a sufficiently long period (approximately two months). Under this conditions progress may be expected from the third week after the beginning of consumption of zinc.

- if zinc therapy is stopped the disease breaks out again in a very severe form which in some cases seem more contagious than before.

- the optimal approach in infected flocks is associating zinc therapy with vaccination with a Fusobacterium necrophorum antigen vaccine,Pietiman Cogla,under these conditions zinc therapy may be discontinued two weeks after the booster injection (in other words 8 weeks after the first injection of vaccine).

In cattle our experience is more limited, in particular because there is no reliable vaccine available at the present time to our knowledge. We have managed to control foot problem in two important herds of dairy cattle by salt licks containing 2,4 % of zinc oxide at their disposal continually. As soon as the lick is taken away the foot problems reappear.

It seems important to stress the point that we are using doses of zinc that many people would consider much higher than the nutritional needs for an optimal growth rate.

It should be added that the response to zinc therapy does not necessarily imply that zinc deficiency is a main cause of abnormal foot conditions in ruminants,but evidence is accumulating to show that the ability of animals to combat these infections is conditionned by,to some extent,the zinc status of the organism.

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HEAD OF DEPARTMENT
J.R. Egerton

PROFESSORS: J.R. EGERTON
M.J. EDWARDS

14th September, 1978

I would like to comment also on the role of zinc in prevention/ treatment of skin infections about the feet of ruminants. My colleagues and I here have treated Type II bacteroidosis in both sheep and cattle with oral zinc sulphate. We have used a range of dose rates (from 4.5 mg/kg to 20 mg/kg) and have continued treatments for up to 2 days. In no case was there any improvement. Furthermore, we have examined the serum zinc levels of cattle in the field and compared levels of those with and without bacteroidosis. There has been no difference at all. Our conclusion is that oral zinc is of no value in the therapy of these specific infections.

Best wishes to all your participants.

Yours sincerely,

(J.R. Egerton)
PROFESSOR OF VETERINARY CLINICAL STUDIES

BACTERIAL INFECTIONS IN THE AETIOLOGY OF FOOT DISEASE OF RUMINANTS

J.R. Egerton and E.A. Laing

Two clinico-pathological syndromes caused by bacteria of the family Bacteroidaceae occur in both sheep[3,5,9,10] and cattle[1,2,4,6,7,11,12]. A third entity, ovine interdigital dermatitis, occurs in sheep. The features of these diseases are summarised in Table I. This table includes references to publications establishing the role of one or more species of gram negative non-sporing anaerobe in the aetiology and pathogenesis of the diseases. A condition analagous to ovine interdigital dermatitis (O.I.D.)[8] has not been described in cattle.

Proposed nomenclature

Because of the consistent involvement of Bacteroidaceae in these diseases it is proposed that they be described as bacteroidoses.

Type I bacteroidosis is defined as a non-contagious interdigital dermatitis, due to *F. necrophorum*[8].

Type II bacteroidosis is a contagious dermatitis affecting principally epidermal components of the hoof and due to a mixed infection with *B. nodosus* and *F. necrophorum*. *B. nodosus* is the transmitting agent in both sheep and cattle[3,4,7].

Type III bacteroidosis is a non-contagious, necrotising disease of the digits due to deep invasion by *F. necrophorum* accompanied in the case of sheep by *Corynebacterium pyogenes*[10] and in cattle by *B. melaninogenicus*[2].

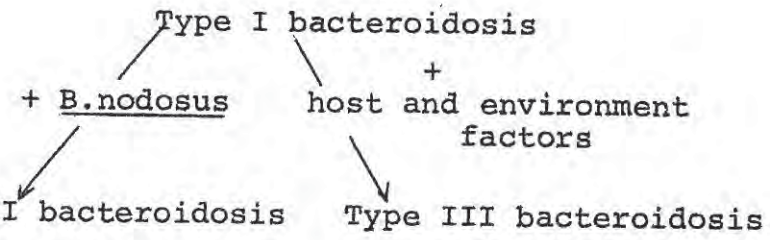
Relationships between bacteroidoses

There is evidence that Type I bacteroidosis precedes both Type II[5,9] and Type III[10] disease in sheep (See Fig. 1).

Fig. 1

Relationship between types of bacteroidosis

(a) Sheep



(b) Cattle

Type II $\xrightarrow{+ \text{ mechanical damage}}$ Type III bacteroidosis

There is no evidence that Type II infection ever precedes Type III infection in sheep. By contrast, Type II infection may predispose to Type III infection in cattle especially if mechanical damage of affected tissue introduces infection into dermal and subdermal components of the digit[6].

Sequelae to bacteroidosis

Type II bacteroidosis in both sheep and cattle results in similar chronic sequelae in both species. These are hyperkeratosis, interdigital hyperplasia, verrucose dermatitis, loss of integrity and distortion of both soft and hard horn. These sequelae are pathological responses to the primary infection and do not warrant recognition as distinct clinical entities.

Predisposing factors

The ruminant bacteroidoses all have common predisposing causes. Each of them requires (a) maceration and hydration of the interdigital skin by water[5,8], (b) exposure of animals to F. necrophorum[2,6,9]. This organism may arise from faeces or the digits of an affected animal in the same environment.

Conclusion

The aetiological role of bacteroidal organisms in foot diseases of cattle and sheep has been established by clinical

observation and experimental study. Confusion about the nomenclature of these diseases would be removed if they were described according to the causal agents. The major clinico-pathological entities that both occur in the two species can be distinguished by referring to them as Type II and Type III bacteroidosis respectively.

The distinction between the two entities is based on -

(a) the tissue affected,
(b) the presence of B. nodosus in Type II bacteroidosis, and
(c) the contagious nature of Type II compared with Type III disease.

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TABLE I

Diseases of Ruminant Feet caused by Non-sporing Gram Negative Anaerobes

Disease	Tissue affected	Aetiology	Synonyms of the disease		References		Proposed nomenclature
			Cattle	Sheep	Cattle	Sheep	
Ovine interdigital dermatitis	Epidermis of interdigital skin	F.necrophorum	Not described	Scald	-	8	Bacteroidosis Type I
Contagious interdigital dermatitis	Epidermis of interdigital skin, horn matrix	B.nodosus F.necrophorum (spirochaetal organisms)*	Foot-rot (UK) stinkpoot klauenfaull fourchet	Foot-rot pietin rotkreupel moderhinke	1,4,7, 11,12	3,5,9	Bacteroidosis Type II
Interdigital phlegmon	Dermal and sub-dermal tissues of digits	F.necrophorum and C.pyogenes (sheep) F.necrophorum and B.melaninogenicus (cattle)	Foot-rot (US) foul in the foot, necro-bacillosis foot abscess phlegmon	Foot abscess, infective bulbar necrosis (IBN)	2,6	10	Bacteroidosis Type III

* usually present - aetiological role not established.

The University of Sydney

Short communication

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Now a few words about the work with B. nodosus that Dr. Andersson and I have done. We have for a little more than a year tried to isolate B. nodosus from cattle with interdigital dermatitis. For this purpose we have used the method described by M. Thorley in J. of Applied Bacteriology 1976 vol. 40 p. 301-309. Beside the culture technique we have also used flouroscein labelled antibodies to detect the presence of B. nodosus in specimens from interdigital dermatitis in cattle. This FLA has kindly been given to us by the Wellcome Research Laboratories in England. Since March this year we have examined 41 specimens and in 29 of these (approximately 71%) we have found B. nodosus by the FLA technique, and in 15 specimens we have isolated B. nodosus on agar plates.

I think these figures gives a fairly good impression of the two techniques, the FLA technique being more simple and reliable at least until one is familiar with the isolation on agar plates and other problems related to this technique such as how to collect specimens, how to transport them to the laboratory, how to store them in the laboratory and so on.

I would like to stress though that once you know how to handle the isolation of B. nodosus, the method from my point of view is simple and reliable with very typical-looking colonies on the agar plates and also a typical apparance of the bacterias in Gram stained preparations. The combination of the two methods is of course the optimal may of confirming the presence of B. nodosus in specimens from interdigital dermatitis.

Short communication [on bulb erosion]

Göran Ahlström

I want to state that erosion of the horn of the bulb including lesions in V-shape are very common in Swedish cattle. But at least in the middle and nothern parts of the country, where I have got my experience, it is in the vast majority of the cases a mere question of stable hygiene and hoof trimming. The problem is described by Fritzböger and Smedegaard.

In short: lack of trimming, which is still common in Sweden, results in long toes and low heels. Most of the body weight is then laid on the heels. The pressure disturbs the hornformation. The abnormal horn is then easily destroyed by ammonium and bacterias from the dung.

Even when the hygiene has not been improved, many herds has got their problem solved or much diminished only by regular hoof trimming, including the cutting away of rotten horn and treatment with tar or bandages.

There are few cases which are of the type that dr Toussaint Raven has described. Though I have heard from colleges that it is more common in southern Sweden, but I think it is nowhere the most common type of bulb erosions.

EFFECTS OF THE ENVIRONMENT ON HOOF DISEASES

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All practising veterinarians know that the animals' environmental conditions are of great importance for the frequency of hoof diseases in a herd. In order to combat disease it is necessary to know the connection between hoof diseases and different types of environmental factors, especially in an age when so many new and different forms of animal husbandry are tried as on one hand ranching (ranch husbandry), where the animals in principle are out of doors the year round, on the other hand the kind of husbandry where the animals are kept indoors all the time.

A good idea of the importance of different factors in bringing about hoof diseases may be obtained by noting the disease frequency. However, so far frequency information is unfortunately very limited in this field.

Exisiting frequency information is of the following three types: the part of the total number of disease which is comprised by hoof diseases; the number of animals treated for hoof diseases by a veterinarian compared to the total number of animals; and finally, added to the previous group, the number of animals which have been suffering from some kind of hoof disease but not treated by a veterinarian. If the information is reliable, the third group is, of course, the most interesting one.

In investigations carried out in Denmark by Rasbech the share of hoof diseases of the disease total is given as 3.7% (Rasbech, 1966).

In three lots of material studied in Sweden 1961 - 1964 and selected i.a. on the basis of type of housing, the animal owners reported for cows altogether 16.882 disease cases of which between 4.9 and 10.5% were hoof diseases and between 1.7 and 5.5% lameness (Ekesbo, 1966). According to German investigations about 75% of all cases of lameness examined by veterinarians in a district was caused by hoof diseases (Prange, 1969).

Based on material from animal hospitals the share of hoof diseases of the total disease frequency is considerably greater. According to a number of different reports the share of hoof diseases of the total number of cases varies between 28 and 34% (Teuscher, 1965; Dietz & Prietz 1968; Mieth & Ritter, 1968).

The frequency of hoof diseases based on the total number of cases examined by a veterinarian compared to the total number of animals in the district is another method of calculation. Danish investigations (Rasbech, 1966) reported the frequency of hoof diseases in this category as 1.2 % in a material of about 84.000 cattle of which about 37.000 were cows. Of about 1.100 cows of Friesian breed in an East-German Veterinary district an average of about 6.4 % per year were treated for hoof diseases during a three-year period (Prange, 1969).

Frequency information is available in Sweden for the third category, where the frequency consists both of cases examined by a veterinarian and of cases noted by the owner but not reported to a veterinarian.

In three lots of material, selected according to type of housing and gathered in Sweden during the control year 1963/64, comprising a total of 7.235 cows the frequency of hoof diseases varied between 2.2 and 6.4 % and the frequency of lameness between 1.3 and 4.9 % (Ekesbo, 1966). In a material of about 7.000 cows 1971 - 1974 Vilson (1976) reports that a yearly average of about 2.5 % of the cows were affected by hoof diseases.

In an English material gathered 1951 - 1954 and including between 3.000 and 6.000 cows per year there is only "foul foot" mentioned for hoof diseases and for this the frequency varied between 1.3 and 3.7 % per year.

In the following three categories of hoof diseases will be examined according to type of husbandry. The first category has been indicated as "hoof diseases with infectious etiology or of inflammatory nature". Included here are interdigital phlegmon, hoof abscess, arthritis of the hoof joint, so called interdigital dermatitis and other hoof diseases, where infection or inflammatory process are considered to exist. If this was not the case, reported cases have been classified as "other hoof diseases". The second category of hoof diseases is hoof injuries caused by violence. The third category, "other hoof diseases" is a heterogeneous collective grouping. Of special interest within this group are hoof diseases caused by manure gas poisoning.

The grouping was the same as for the study of the Swedish material collected between 1960 and 1965.

In the case of the first group, for the sake of simplicity here called "inflammatory hoof diseases", it is interesting to study whether or not the frequency varies between the cowhouse period and the grazing period.

Table 1 shows that there is no definite connection between housing period and grazing period. It is impossible to make a comparison between types of housing based on the information in table 1, as there are differences in breed for this category of hoof diseases. Table 2 gives an example of these breed differences.

The fact that table 1 does not show a definite connection between housing- and grazing period must not tempt one to draw the conclusion that e.g. all diseases in this group are divided equally between housing- and grazing period. A study of e.g. the frequency of diseases reported as panaritium usually shows a predominant percentage for the grazing period in tied herds, while a definite difference between housing- and grazing period does not exist for loose housing herds.

In Sweden the most common pure breeds of dairy cattle are the SLB, the SRB,the SKB, the SJB and the SAB breeds.

In 1977 about 61% of the pure bred cows were SRB, the Swedish Red Breed, and about 27% were SLB or the Swedish Friesian Breed. The SKB, an old breed called the Swedish Polled Breed or the Swedish Highland Breed, has during the last 15 years decreased in numbers from 5% in 1960 to 1% in 1977. The SJB, the Swedish Jersey Breed and the SAB, the Swedish Ayshire Breed, constitute together not more than 3% of pure bred cows in Sweden.

In the Swedish investigation, irrespective of type of housing, SLB-herds showed significantly higher frequency of inflmmatory hoof diseases than SRB- and SKB-herds. The quality of the horn capsule of the two breeds is likely to be one reason for the difference in frequency. Another possible reason is that the SLB-material has infection-reservoirs to a higher degree than SRB and SKB. It seemed by a subjective study of herds of all types of housing that the horn capsule of SLB-cows was of a softer and often more porous horn quality than of SRB and SKB cows. The effect was particularly spectacular for SLB- and SRB-cows placed on a new concrete stall surface without bedding or on new slatted flooring. In both cases the surfaces were usually rough and had a wearing effect on the horny sole. Here the wear of the horny sole was considerably greater for SLB than for SKB. This difference in the quality of the horn was already mentioned by Nilsson (1963). The weaker horn quality in SLB is likely to make the penetration of infectious matter to the corium of the hoof easier than the harder horn quality in SRB. The wear of horny sole is probably also influenced by the weight of the animal. Cows of SLB-breed have a mean weight of 600 kg, of SRB-breed 550 kg and of SKB-breed 400 kg.

The Swedish investigations also showed that there were variations between years for this category of hoof diseases. Such variations are natural for diseases caused by a combination of infection and environmental factors such as dry or wet pastures respectively dry or trampled exercise yards etc.

With regard to the connection between inflammatory hoof disease and type of housing one should not come to a conclusion on the basis of the information in table 1 but should make the studies within breed as has been done in table 3.

However, in the Swedish investigation the subjective conclusion was arrived at, that the disease frequency in loose housing with panaritium cases was much higher in herds where resting places and

exercise yards or feeding places were dirty and trampled than in herds where the resting places were dry and exercise yards and feeding places were scraped daily. It can therefore be said that there is a connection between the care of the housing and disease frequency. Unfortunately there were no resources in the investigation for objective fact-finding regarding these conditions. Definite conclusions can therefore not be drawn based on these observations. However, many authors testify that most hoof diseases are caused by shortcomings in the immediate environment (Jahn, 1957; Drawer 1959; Miet & Riebe, 1959; Rohde, 1963; Smedegaard, 1964; Dietz, 1970; Knezevic, 1971; Toussant, Raven & Cornelisse, 1971; Greenfield et al 1972; Berg & Loan, 1975). By feeding large quantities of draff or large quantities of silage, especially if the silage is not of good quality, the animals are often affected by a softening of the horn capsule, if the feeding place or the stall are not kept clean and the animals are forced to stand in wet dung caused by the continuous diarrhoea which results on these occasions (Prange, 1969).

Prange (1969) found that panaritium almost entirely was to be found as a grazing disease and occurred as a rule in connection with wounds and cracks in the interdigital cleft facilitating infections. The importance of wound injuries for the occurrence of panaritium has been pointed out by Jahn (1957) and Hendrikse (1962).

Also the second category of hoof diseases - traumatically evoked hoof injuries - has in the Swedish material been divided into injuries registered in the cowhouse respectively in the pasture.

Table 4 shows that loose housing herds and tied herds with liquid manure handling display a significantly higher degree of traumatic hoof injuries than tied herds of conventionel type. An examination of types of injuries shows that in loose housing herds injuries often occur on slatted floor or on frozen or otherwise uneven exercise yards. In tied herds with liquid manure handling injuries are usually incurred through tramping into a grating or slatted flooring behind the stall or through a high degree of wear of the hoofs due to rough or coarse surface. Bedding on the stall surface should help to protect the hoofs against wear, especially when the surface is rough.

The following interesting effect of bedding has been clinically observed in many herds: When changing over from a bedding of straw to sawdust an abnormal lateral wear has occurred. This is true for old as well as new cowhouses. The difference is more obvious the rougher and coarser the surface is. A study was carried out in such a way in one herd that the animals, normally on straw bedding, were divided into two groups of which one was given straw as usual whereas the other got sawdust as bedding. Already after three weeks there were signs of lateral wear of the hind hoofs for the sawdust group and became more obvious after a longer time of using sawdust as bedding. One reason for this may be that when the animal is lying down the outer hoof of the undermost leg is scraping against the floor and the sawdust functions as a kind of grinder. The reason may also be that a tied animal lying on straw has a more

comfortable lying position than a tied animal lying on sawdust as the straw functions as a mattress between the concrete surface and the body. A layer of sawdust does not have this effect unless it is very heavy and sawdust used as bedding for tied cows is as a rule only thinly put on the concrete surface. The animal might therefore rest in the same position longer when lying on straw than when lying on sawdust.

The grazing injuries might have been caused by foreign bodies tramped on by the animals and pressed into the hoof or by a high degree of wear incurred when the animals had to walk long distances on hard surfaces.

The third disease category "other hoof diseases" comprises i.a. manure gas poisonings.

By manure gas poisoning the animals often have tender hoofs and relief movements are often seen. The degree of symptom depends on the degree of poisoning and might vary between slightly increased pain reaction to pincers and obious difficulties to stand or to get up. When the disease is developed the animals stand on their toes to relieve weight on the bulbs. On palpation there is often signs of tenderness in the back part of the bulbs. In advanced cases the horn of the bulbs is moistened through, softened and ropy like crude rubber both in looks and consistency. It is often possible to press a finger under the sole from the back part of the bulb towards the toe. Bruises and spots of blood may often be observed in the horny sole even with a very light paring with knife or blade. Cows with a bad attack often stand with one fore-hoof in front of the other; in some cases the same happens with the hind-hoofs. Hind legs turned under and bent back are often seen in cows with manure gas poisoning (Bengtsson, Ekesbo & Jacobsson, 1965).

It is very difficult to estimate the frequency of hoof diseases caused by manure gas poisoning since there are so many different degrees of such poisoning. The etiology behind the hoof changes observed in cases of manure gas poisoning is not altogether determined (Bengtsson, Ekesbo & Jacobsson, 1965; Högsved, 1968). It should be noted, however, that hydrogen sulphide attacks and breaks down horn. Descriptions of the problem of manure gas poisoning is given by Högsved (1968).

As already mentioned, German investigations (Prange, 1969) have shown that 75 % of all lameness is caused by hoof diseases. It is therefore considered necessary to report on the frequency of lameness in different types of husbandry.

In table 5 of the Swedish investigation all cases of lameness where the cause could not be found have been reported as lameness. It turned out that the frequency of lameness regularly was greater in loose housing herds than in tied herds. The reasons seemed to be the exercise yards, frozen in the winter, and slatted floor in some herds. Tied herds in conventional cowhouses showed a lower frequency of lameness than tied herds with liquid manure handling, which shows that grating and slatted flooring increase the tendency to injuries causing lameness.

Combating hoof diseases in cattle is thus largely a question of getting rid of the predisposing disease factors. Most important is, of course, the hoof care but the frequency of hoof diseases depends on the animals' environment on the whole.

The aid of veterinary know-how in designing animal housing, in planning new types of husbandry (year-round feeding indoors, year-round staying outdoors etc.) as well as in trying new methods and techniques should be a natural part of combating disease in animal husbandry. In Sweden this is made possible through a new law dating from 1973. In this is stated that plans or drawings concerning new or rebuilt animal housing should be scrutinized by specially educated veterinarians appointed by the state before building or rebuilding is started.

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Table 1. Number of cows and incidence of "hoof diseases of an inflammatory nature with or without an infectious etiology" within year and within the housing period (h) and the pasture period (p) in loose housing herds (L), in tied cow herds in conventional housing (T_1) and in liquid manure housing (T_2).

Housing system and year	No. cows		% hoof diseases	
	Housing	Pasture	Housing	Pasture
L				
1961/62	1545	1465	3.1	3.9
1962/63	1718	1624	1.9	3.7
1963/64	2326	1851	4.7	3.7
T_1				
1963/64	3467	3426	1.6	1.0
T_2				
1963/64	1411	1322	1.8	1.9

(Ekesbo, 1966)

Table 2. Number of cows and incidence of reported "hoof diseases of an imflammatory nature with or without an infectious etiology" within breed and type of housing.
L=loose housing system, T_1=tied cows in conventional housing. T_2=tied cows in liquid manure housing.

Housing type	No. cows		% hoof diseases	
	SLB	SRB	SLB	SRB
L	2312	2127	8.9	1.5
T_1	402	1731	7.7	2.0
T_2	189	457	10.1	0.4

(Ekesbo, 1966)

Table 3. Number of cows and incidence of reported "hoof diseases of an inflammatory nature with or without an infectious etiology" within breed, year, housing period and housing system in loose housing herds (L), in tied cow herds in conventional housing (T_1) and in liquid manure housing (T_2).

Housing type and year	No. cows SLB	No. cows SRB	% within breed SLB	% within breed SRB
L				
1961/62	823	675	5.2	0.7
1962/63	808	767	2.8	0.8
1963/64	681	685	7.8	1.2
T_1				
1963/64	402	1731	6.5	1.4
T_2				
1963/64	189	457	8.5	0.2

(Ekesbo, 1966)

Table 4. No. of cows and incidence of reported traumatic hoof injuries within housing period and within pasture period in loose housing herds (L), in tied cow herds in conventional housing (T_1) and in liquid manure housing (T_2).

	Housing period			Pasture period		
	L	T_1	T_2	L	T_1	T_2
No. cows	2348	3475	1411	1873	3434	1322
% injuries	4.3	0.5	4.7	0.0	0.6	0.4

(Ekesbo, 1966)

Table 5. Number of cows and incidence of reported cases of lameness within year and within housing respectively pasture period in loose housing herds (L), in tied cow herds in conventional housing (T_1) and in liquid manure housing (T_2).

Housing type and year	No. cows		% lameness	
	Housing	Pasture	Housing	Pasture
L				
1960/61	1107	1107	3.0	0.5
1961/62	1655	1575	3.4	0.3
1962/63	1826	1731	3.0	1.2
1963/64	2438	1873	4.1	0.8
T_1				
1962/63	3946	3924	1.3	1.4
1963/64	3475	3434	1.0	0.3
T_2				
1963/64	1411	1322	1.4	0.4

(Ekesbo, 1966)

Prevention of deformed claws by orthopaedic trimming

Peter F. Knezevic

Summary

After defining the normally shaped claw attention is given to the different forms of stable claws and to diseased claws with pathologic forms such as flat claw, full claw, upright claw, contracted claw and foundered claw.

For the orthopaedic claw trimming method the claws are seen as the base of the limb column. Like the horses hoof they should fit to the position of the toe and limb. In the standing cattle the toe axis should be unbroken when seen from the front, or from behind and from the side.

High production can be attented even in cattle with diseased claws when orthopaedic claw trimming is performed ev. plus orthopaedic shoeing.

Main attention has to be given to the preventive selection of those individuals whose claws, toes and limbs are suited for actual housing practices: short stands, slatted yards etc.

Some remarks on the influence of housing on claw disorders in cattle.

D.J. Peterse

In this paper it is tried to give a summary of the influence of housing and the housing systems on the health of the claws. It is supported by research results and experiences, as far as possible.
The influence on claw health is measured by the incidence of the following claw disorders: phlegmona interdigitalis, dermatitis interdigitalis contagiosa, pododermatitis (not specified).

I. The comparison housed - not housed (winter - summer)

In literature frequency distributions of the incidence of different claw disorders are mentioned. In general a peak in the figures is seen in spring. But it does not mean cattle is falling lame easier in pasture.
a) Cases of phlegmona interdigitalis are most frequent in pasture (e.g. Grommers, 1967; Top, 1975). But our experience is that among cattle on not-tying stall systems in winter the same number of cases occurs. The freedom of movement gives this claw disorder the opportunity to spread among the animals.

b) To the dermatitis interdigitalis contagiosa another pattern applies. This infection starts in the winter, culminates at the end of the housing period and in the pasture the claws recover (see slide).

c) Interpreting the frequency distribution of pododermatitis one has to reckon with the calving pattern. At the end of the winter period most calvings occur and that fact causes the high number of cases of pododermatitis in spring. If those two influences can be seperated, it becomes clear that animals, which calve in pasture time, show les and less severe cases of pododermatitis (see slide).

The conclusions is that housing principally gives more chance for the occurrence of dermatitis interdigitalis contagiosa and pododermatitis.
The cause of this favourable effect of pasture e.g. difference in nutrition, quality of surface, hygienic status, is connected with the etiology of each of the three claw disorders.
This conclusion has consequences for managing systems like zero grazing and housing cattle at night.

II. Comparison between the housing systems tying - non tying system

It is difficult to compare the results of the research , that has undertaken in this field, because most times there are differences in the recorded claw disorders and housing systems. A few dutch examples are mentioned (Grommers, 1967; De Vries, 1971).
An essential difference between the housing systems is or the cow is tied or not tied and freedom of movement is allowed.
a. Phlegmona interdigitalis occurs more often on the not tying stall systems (Grommers, 1967; De Vries, 1971). The easier transfer of the infection makes that quite understandable.

b. The same situation applies to the dermatitis interdigitalis contagiosa (De Vries, 1971).
In the not tying stall systems there are more animals with light symptoms of the infection, but less animals with a severe stage of that disorder. The spread of the infection is easier but deep clefts and cases with a pododermatitis in the cleft are less frequent (see slide).

c) Pododermatitis occurs in both tying stall and not tying stall systems (De Vries, 1971). The cases in the not tying stall system are less severe (see slide). Grommers (1967) has mentioned that sole ulcers on loose housing farms need only half the healing time than ulcers on tying stall farms.

Results from dutch research shows a difference in claw shape deformation, described by Nilsson (1964) in cases of laminitis; they are less outspoken on not tying stalls.
The reason for this favourable influence of not tying stall systems on dermatitis interdigitalis contagiosa and the pododermatitis is not known.
A - maybe - important fact is that the horn production of the claw is higher on that type of stalls (see slide).
It is possible that this fast production of new horn favours the healing of lesions in the claw horn.
Information on differences within types of the tying stall or the not tying stall system is too incomplete to draw conclusions. The conclusions is: Stall systems with freedom of movement permit the spreading of infectious contagious claw disorders like phlegmona interdigitalis and dermatitis interdigitalis, but there are less severe cases of dermatitis interdigitalis contagiosa and pododermatitis.

III. Comparison of the bedding materials

If we forget some practical and for the farmer important points of the bedding, like the price, than is important

- how hard is the surface of the bedding, in view of the weight bearing theory of Toussaint Raven.
- how hygienic is the bedding in view of the transfer of infectious/contagious claw disorders.

The only information about the relationship between bedding material on loose housing and cubicle stalls and lameness is given by Peslier (1976).
Straw, soil and concrete are compared. Concrete, thus the hard surface, is the most unfavourable bedding material. But hygienic rules can be observed most easily on hard flat floor surfaces like concrete and rubber mats, although it is impossible to clean and desinfect some new types of rubber mats. However, there is only a few days effect of desinfection (Bramley e.a. 1975). Sawdust makes often a drier bedding than straw, but sawdust, or woodshavings are sometimes connected with coliform mastitis.
If the claws are in dry circumstances the water content of the horn drops, sometimes to a level (13%) that claw paring becomes impossible. It is our experience that in such situations (e.g. tying stalls with cowtrainers) the dermatitis interdigitalis infection seldom is seen.
In Holland it is advised to make a flat underfloor of concrete and to cover this with rubber mats, straw, sawdust for prevention of teat tramping, bruised knees and hocks and comfort for the cow.
The conclusion is that a bare concrete bedding is toohard and that a covering is needed.

INFLUENCE OF FEEDING ON THE HEALTH OF THE BOVINE FOOT

A.D. Weaver.

INTRODUCTION

This paper is intended to review the literature on the effect of nutrition on the bovine foot, a field in which there are very few experimental studies. One reason is doubtless the difficulty in establishing the parameters to be measured. Possible parameters include the shape of the foot (such as the angle the wall makes with the bearing surface), the growth rate of the wall or the sole, the physical characteristics of hardness or wearing rate, the analysis of dry matter content, specific amino-acids or minerals, and the appearance of clinical abnormalities such as cracks in the wall, solar defects, alterations in the distal phalanx, as well as the appearance of lameness. Such parameters have been measured in cattle, often under differing conditions of husbandry, but the nutritional state has not been detailed, so making the information valueless for this review, which must therefore rely primarily on clinical observations.

HORN

The health of the bovine foot is largely determined by the production of sound horn, the physical and biochemical qualities of which have not been scientifically defined. Some factors affecting diseases of the horn have been reviewed previously (Weaver 1974). Digital horn is composed of keratin, which is basically protein, with small amounts of fat and minerals and a variable amount of water. The protein fraction is made up of amino-acids, and particular attention has been paid to the sulphur - containing amino-acids. Compared with the normal macro- and microstructure of the horn (Wilkens, 1964), the variation in the architecture and reduction in the proportion of cystine and methionine reported by Maclean (1971) and leading to a physically softer and waxy

horn of the sole and associated with laminitis is claimed to result from various nutritional disorders (reviewed by Nilsson 1963), and including oilseed cake (Hirs 1904), protein-rich concentrates other than oilseed cake (Nilsson 1963, Morrow 1966), fungus-contaminated fodder (Nilsson 1963), an 85% barley diet (Maclean 1966), or sudden access to ryegrass pastures (Maclean 1965). The aetiology may be associated with a histaminosis or with an allergic reaction (Maclean 1965, Nilsson 1963). Often clinical outbreaks involve other, non-nutritional factors (Weaver 1971).

The absence of experimental feeding studies in cattle leads to an examination of laminitis in lambs and horses. It has been produced in lambs (Morrow and others 1973) by the injection of lactic acid into the rumen. Doses of 0.25%, 0.35% and 0.50% of the lamb bodyweight of an 85% syrup of D-L lactic acid produced clinical signs within one hour, and within 12-24 hours there was a reluctance to move and tender and warm feet. Pathological changes in the corium included oedema, venous pooling, lymphatic stasis and congestion in the capillaries. There was degeneration of nuclei in the stratum germinativum and separation of the str. germinativum from the str. corneum 7 days after administration of the lactic acid. Blood pressure was not measured.

In a study of the experimental disease in the horse (Garner, Coffman, Hahn, Ackerman and Johnson 1975) lameness and hypertension developed 40 hours after dietary induction. Another study in horses indicated that the increased blood flow results purely from decreased vascular resistance and not from any alteration in capillary permeability. Hypertension was again observed (Robinson, Scott, Dabney and Jones 1976). Nilsson (1963) found that cattle with acute laminitis had a significantly lower mean blood pressure (direct measurement from the caudal aorta) than normal animals, and that cases of subacute and chronic laminitis also had lower values. Nilsson (1963) found in both acute and chronic cases oedema,

hyperaemia, haemorrhages, thromboses and sometimes necrosis in his clinical cases. The horny sole usually had a waxy appearance, and in chronic cases was thinner than normal (3-4 mm compared to 15-18 mm), and in some animals was divided into several layers separated from each other.

A study of 4 Ayrshire cows at grass and indoors for equal periods of six months showed that the rate of horn growth was similar. In both periods some concentrates were fed in addition to either grass (summer grazing) or hay (winter). The posterior wall region grew about 40% faster than the toe, and the growth rate was slower in cows than in calves or yearling cattle (Prentice 1973).

Analysis of hoof horn from young bulls kept under identical conditions of feeding and management has shown significant differences between breeds. Pigmented horn (Angler breed) had more ash, Ca, Zn, less Na, P and Fe and contained more cystine than unpigmented horn (black and white, red and white cattle), and was harder when assessed by a grinding test. Hardness of horn is therefore likely to be dependent not only on the organic structure but also on the variable proportion of inorganic elements (Feder 1969).

Investigating other breeds, Kovacs and Beer (1976) have also found that pigmented horn is harder than unpigmented horn. The resistence of horn was also dependent on the quantity of minerals, in particular the calcium:phosphorus ratio. Kovacs and Szilagyi (1974) found in normal horn much more Ca than P in the hard protective layers, and the opposite in the soft elastic axial or abaxial wall area, while in damaged horn the amounts of the two elements were very similar. Kovacs claims that the mineral content of the horn is affected by that of the feed (Kovacs 1977).

The hardness of horn is related to the water content, which is in

turn related to the microarchitecture (the number of laminae per unit area) and biochemical composition (Dietz and Koch 1972). Ekesbo (1966) has tabulated the incidence of different conditions including lameness in cattle under three housing systems, but was unable to investigate the effect of diet. Other investigations of housing systems in relation to the incidence of foot disease omit any reference to coincident effects of nutrition (e.g., Heizer, Smith and Zehner 1953, Albright, Young, Moeller and Cavanaugh 1965).

In a study of hoof wear in bulls on slats, the excessive wear was attributed to a relative lack of bone minerals or an unsatisfactory Ca:P ratio on the evidence of radiographic and laboratory examination (Kral, Roztocil, Cech and Illek 1974).

A deficiency of selenium can affect cattle at all ages and lead to the production of deformed hooves with deep horizontal rings, and has been reported from several countries including USA, Australia, USSR, Ireland and Israel.

Apart from an isolated clinical report (Udall and Keller 1952), no adverse effects have been reported on the growth and shape of cows hooves resulting from the ingestion of high levels of F over a prolonged period (Shupe 1971).

SKIN

Bovine foot health depends not only on the quality of horn but also on the integrity of the interdigital and coronary skin. Again, the role of nutrition is ill-defined. Zinc deficiency manifesting itself in a parakeratosis which can affect the skin below the fetlock including the interdigital space has been suspected in a number of countries. There have several reports of the beneficial feeding of a Zn supplement to correct interdigital disease in cattle (Demertzis and Mills 1973, Cristea, Cristea, Ivascu, Cociu and Steopan 1977). Mills (1969) claimed that Zn deficiency led to excessive growth of soft horn.

GENERAL

The role of minerals and bovine foot disease has been reviewed and investigated by van de Kerk (1970) who examined six minerals (Ca, P, Mg, S, Cu and Zn) in soil, crops and hoofhorn in a large number of Dutch farms. He failed to demonstrate any fundamental difference in the minerals of soils and crops between farms with and those without hoof diseases. Horn samples taken from the regions of the toe, "sole ulcer site" and coronet in healthy cattle had different mineral contents, the sole ulcer site having, for example, less Ca, P, Zn and ash than the toe region. Van de Kerk was unable to find differences in the mineral content of the sole horn between the nine recorded hoof diseases (which did not include laminitis), and was unable to relate either a high herbage S or a low Zn content to chronic foot rot, which was associated with a higher S content of horn.

Toxic doses of fluorine have been reported to produce fractures of the pedal bone in cattle as a result of osteoporosis (Allcroft and Burns 1958, Burns 1964, Vaughan and Osman 1967).

Gangrene of the foot following ingestion of ergot (Claviceps purpurea) or of tall fescue grass or hay (Festuca arunicea) is a sporadic occurrence in cattle.

STUDIES OF OTHER KERATINS

In view of the similarity of cattle horn to hair and nail, it is tempting to extrapolate results obtained from studies of such keratins. The subject has been reviewed by Godwin (1962). Hair growth is dependent on an adequate blood supply (Durward and Rudall 1958, quoted by Godwin). The main effects of protein malnutrition on the nails are increased brittleness, slowing or cessation of growth, and, experimentally in rats, a correlation of nail growth with the quality of the protein. The sheep is known to be able to synthesise cystine from sulphate (Hale and Garnigus 1953), so that the relatively low cystine content in some plant

materials is not the limiting factor it was postulated to be by Marston and Brailsford-Robertson (1928) in terms of the production of sheep wool.

The formation of keratin is subject to variation according to the nutritional status of the animal (Fraser, Macrae and Rogers 1973), and wool growth of sheep was markedly increased by abomasal infusion of cysteine and S-containing amino-acids and proteins (Reis and Schinckel 1963). Hair growth in cattle was significantly reduced when Holstein Friesian and Jersey calves were fed a low protein (47% of normal) or low energy (60% of normal) diet (Martin, Miller and Blackmon 1969).

CONCLUSION

The role of nutrition in the production and maintenance of a healthy integument of the bovine digit has received little investigation, and in view of the increasing evidence of lameness due to defects of horn and skin, there is an urgent need for in-depth studies.

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Histamine metabolism in ruminants.

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This report is a short review on comparative histamine metabolism with special reference to the ruminants.

As many of you might already know, the toxicity of histamine varies widely between animal species. The quantities needed to kill a guinea-pig is only 1/10th of a milligram per kilo when given intravenously, whereas the corresponding amount in the rat is about 10 thousand times higher. The lethal dose of sheep is about midway between that in the guinea-pig and that in the rat.

Table 1. Lethal dose of histamine.

	mg/kg i.v.
Guinea Pig	0.1
Pig	1.3
Sheep	10
Rat	1300

The quantities needed to obtain pharmacological responses to histamine are of course much lower than the lethal doses. In the sheep, for example, about 2 µg/kg of histamine is needed to obtain a fall in blood pressure. In many species, e.g. the cat, much less histamine has to be given to obtain a similar effect and strangely enough, even in the rat, this dose of histamine causes a marked drop in blood pressure. So there is no parallelism between the doses needed to obtain a lethal effect and those needed to get detectable pharmacological effects. It is also worth of mention that in many species, e.g. the dog and the cat, the circulatory system is most sensitive to histamine, whereas in other species,notably the guinea-pig, the respiratory system dominates the picture of histamine intoxication.

In ruminants both the respiratory and the circulatory system participate in the responses to histamine. Further the rumen contractions are inhibited by histamine and it takes less histamine to affect the rumen than to cause fall in blood pressure and to increase bronchial resistance.

The differences in the sensitivity of different species to histamine is not due to differences in the efficiency to detoxicate the substance. Guinea-pigs inactivated histamine just as rapidly as species less sensitive.

Most animal tissues produce histamine, from the precursor histidine. Most of the histamine formed is rapidly inactivated by specific enzymes, but a small fraction, about 1-2 percent, escapes inactivation and is excreted with the urine as free histamine. There is a close correlation between the amounts of histamine excreted with the urine and concentration in blood plasma. Urine analyses thus give useful indirect information as to the concentration in plasma. Until recently it has been impossible to estimate directly the concentration in plasma of healthy individuals of all species because only minute quantities are present. Recently developed enzymatic assays have made it possible to estimate the plasma levels of histamine in some species, e.g. the rat, whereas the levels in other species, e.g. man and guinea-pigs, the normal concentrations are below the detection limit even when these sensitive methods are

used. I am not aware of any attempts to estimate plasma histamine in ruminants by the enzymatic method, but considering the low levels in the urine, I think it is safe to say that the levels would be below the limit of detection.

Table 2. Urinary excretion of free histamine.

	µg/24 hr
Humans	10-30
Rats ♂	2-11
Rats ♀	65-140
Horses	80-200
Pigs	250-700
Cows	40-120
Sheep	2-12
Goats	0-5

As mentioned above most animal tissues produce histamine. Different strains of bacteria are also potent histamine producers. This makes the alimentary tract, and noteably the fore-stomach, a potential source of histamine. On a normal diet, however, the balance between the different rumen bacteria keeps histamine at a low level. When the normal balance is upset, e.g. be feeding large quantities of readily fermentable carbohydrates, the ruminal production of histamine might increase tremendously. Further, conditions favouring increased formation of histamine often inhibits the ruminal detoxication of the substance, the result being very high concentrations. A crucial question is however: To what extent does ruminal histamine gain access to the systemic circulation and thus represents a toxic potensial? The answer to this is that histamine experimentally introduced into the rumen is not toxic by itself. The substance is not absorbed by the rumen epithelium and it is normally very efficiently broken down by the rumen flora. Only 5-10 percents escape detoxication in the fore-stomach and gains access to the upper duodenum. This fraction, however, represents a toxic potensial since histamine is quite rapidly absorbed from the small intestine of ruminants. Despite the rapid absorption of histamine from the small intestine, however, very little will reach the systemic circulation, a fact that is mainly due to a very efficient detoxication in the liver.

Due to the efficient barriers dietary histamine or histamine formed in the fore-stomach have to pass before reaching the systemic circulation, it takes very large doses, that is 3-5 g, to induce toxic symptoms in a sheep. Three-five grams of histamine correspond to the amount of histamine that might be found in about 5 kg of low-quality silage.

Ruminants are thus normally well equipped to detoxicate histamine from any source and noteably histamine formed in the fore-stomach. Nevertheless, the ruminants might be more vulnerable to the toxic effects of histamine than most species from the following reason: Non-ruminants inactivate histamine by several enzyme systems. If one enzyme system should be brought out of function, the capacities of the remaining enzyme systems are large enough to maintain an efficient detoxication. In ruminants we have found that the inactivation of histamine is depending almost entirely on one single route of inactivation, namely oxidative deamination. If this enzyme system should be inhibited, the danger of histamine intoxi-

cation would increase greatly.

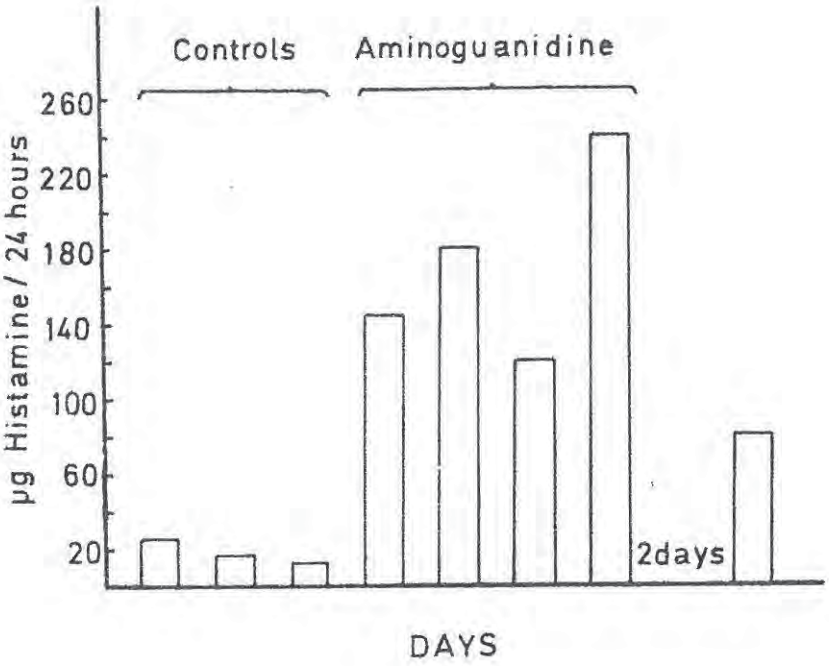

Fig. 1 shows the urinary excretion of histamine in control sheep and in sheep treated with an inhibitor of the oxidative deamination, aminoguanidine. The figures represent the fraction of endogenously formed histamine that escapes inavtivation by the tissue enzymes. Treatment with the inhibitor on an average increased urinary histamine by a factor of about 16. A similar treatment of a non-ruminat would not change urinary histamine markedly.

Table 3.

Histamine dose (g)	Amino-guanidine treatment	Urinary histamine µg/24 hrs
1.0	-	220
1.0	-	180
1.0	-	50
1.0	-	210
10.0	-	640
1.0	+	4700
1.0	+	4200
1.0	+	3800
1.0	+	4500

Table 3 gives the urinary excretion of sheep given histamine by mouth and treated with aminoguanidine. When inhibitor was given, urinary histamine increased tremendously compared to controls which received histamine only. Further, the sheep treated with the inhibtor showed signs of histamine intoxication, i.e. reduced or blocked rumen motility, tympanitis, reduced blood pressure and hyperpnoea.

To sum up: Ruminant are normally well protected against histamine. The situation may, however, be rather labile. A combination of

increased histamine formation and production of substance(s) that interfere with the breakdown of histamine might represent a threat to the ruminant.

Bovine laminitis and sequelae of it

S.A. Nilsson

In this report, the term "laminitis" or "founder" or "pododermatitis aseptica diffusa" will be used in the conventional sense to mean a diffuse, acute, subacute or chronic, aseptic pododermatitis most frequently involving the tissues of several hooves leading to local and systemic clinical signs. Obel's (1948) proposal that the disease is a dyskeratosis rather than as a pododermatitis is noticed but not quite accepted. The epithets "acute", "subacute", and "chronic" will be used in the purely clinical sense to indicate a duration less than 10 days, between 10 days and 6 weeks, or longer than 6 weeks. The earliest reference to bovine laminitis stems from around the eighteen-forties, some interest for the subject has been fitful in the ninteenth century and at the turn of the century but from 1950 onwards the interest for the disease has been very active. The most detailed descriptions of clinical appearence and treatment of bovine laminitis are published, among others, by Hess (1891 and 1904) Moser (1950), Nilsson (1958 and 1963), Maclean (1965 and 1966), Morrow (1966), Cottereau (1967), Urmas (1968), Greenough, MacCallum and Weaver (1972) and Andersson (1976). In my thesis (1963), I have pointed out that bovine laminitis occurs much more frequently and is much more important than has been called attention to in the literature. The disease has in my studies appeared as acute, subacute, chronic, and exacerbated chronic cases. Opposite to the opinion of Toussaint-Raven (1976), I will emphasize that acute laminitis is common or rather common in cattle. The disease may occur "independant" or "combined" with other disease, such as ret.sec., metritis, gastroenteritis, mastitis, internal abscesses, and acetonaemia. I will point out the often appearence in conjunction with acetonaemia. The disease appears most frequently at parturition or during the month immediately after. Acute and subacute laminitis have often been found in first-calf heifers.

Most marked symptoms are: general stiffness, tripping gait, arched back, the hind feet and sometimes the fore feet well gathered under the body. The animal would often lie flat on its side and have difficulty in rising. They often eat while lying or standing on their knees. Crossed fore feet has mostly been observed in the Swedish Red and White breed but seldom in Friesian cattle. In the acute cases an increase in pulse and respiratory rate is regularly occurring; the temperature hovers between 38,8° C and 39,1° C, when the possible combined disease do not cause a fever. Appetite and milk production may be reduced in the most acute stage but in later stages very little and not at all so much as in other diseases with great pain in the feet.

Pulsation can mostly be palpated in the lateral and medial digital artery in the fore feet but still better in the volar common digital artery. Satellite veins are distended in most animals suffering from acute and subacute diseases. The venous distension is more obvious than the pulsation on the hind feet. Tenderness to pincers is more prominent in subacute and chronic cases than in acute such ones.

In acute cases there are no changes in the hooves except for a sensation of heat on the walls. In subacute and chronic cases a paring of the sole reveals a great deal of changes - vaxy discolouration, softening of the horn along the lamellar border, and reddish brown patches. These patches, site of previous haemorrhages, are particularly common towards the toe, along the abaxial lamellar border, and at the junction between the sole and the bulb. The form of the hooves is often but not always altered in chronic cases. Flattening and widening of the hooves is common. The profile may be concave, and prominent, irregularly horizontal grooves and ridges may also be observed.

Blood pressure - tested in the aorta via the rectum - has in 77 tested animals been invariably lower in animals with laminitis than in healthy animals and extremely low in animals with acute disease. - Quantitative determinations of histamine in the blood have been carried out on a large number of cattle, about 180 cases, as well in normal animals as such ones suffering from laminitis in different stages. Determinations were carried out according to Schmitterlöws', Dunér & Pernows', and Oats' methods. Except for a very few cases much lower histamine values were obtatined in animals with acute laminitis than in healthy animals, these findings to all methods mentioned. The difference was highly significant. In animals with subacute and chronic laminitis the blood histamine levels were higher than in normal animals.

Clinically, cases of panaritium (phlegmona interdigitalis) in several feet and certain cases of ulceration of the hoof may be difficult to distinguish from laminitis. Polyarthritis, especially arthritis in the fore pedal joints, give also rise to similar symptoms. In the last disease, there will not be so strong pulsation in the digital artery as in laminitis. Stiffness and arched back are often noticed in traumatic peritonitis but in these cows, there are no pulsation at all.

Morphological findings. In acute cases external examination of the hoof revealed no changes. Upon exungulation or sagittal section a distinct hyperaemia of the front part of the sole and of the lamellar corium has been observed. Not seldom yellowish discolouration and haemorrhages have been noticable. The haemorrhages have as a rule not been so frequent and extensive as in subacute cases. Microscopically, prominent hyperaemia could be proved. Other findings were: oedema, cell infiltration, haemorrhages, necroses, and some epidermal changes with disappearence of the onychogenic subslance, changes of the cells in startum germinativum, and appearence of specific, extremely acidophilic bodies (Obel, 1948). Besides, thrombosis-like formations of fibrinoid and hyaline nature were found

frequently in the large vessels as well as the smaller, and in the arteries as well as in the veins.

In the subacute too, external hoof changes were quite rare. Sometimes sagittal section would reveal a deviation of the third phalanx. Like clinically, haemorrhages were more frequent and extensive morphologically in subacute than in acute cases. Cell infiltration with histiocytes and round cells are prominent and one can observe a tendency to sclerosis.

In chronic cases deformation of the horny hoof is common. Sagittal section often but not always reveales a deviation of the third phalanx with broadening of the area of the laminar corium distally. Haemorrhages and scarlike inflammation, often circular, one meet with most frequently in the solear corium at the "place for ulceration of the hoof". Microscopically, the oedema is less noticable. Marked sclerosis is encountered and most noticable in the stratum lamellatum of the wall. Very commonly, thick connective tissue capsules around the nerve bundles have been observed. Ample amounts of mast cells are commoner present in these cases than in other duration forms. Chronic cases with exacerbation have showed changes similar both to those discovered in acute cases and in chronic, i.e., hyperaemia, oedema, haemorrhages, cell infiltration, and sclerosis.

As a rule, no prominent changes were encountered in the pedal joints and in the fetlock joints; perhaps little more synovial fluid than in normal cases. In one case, where the clinical diagnos was polyarthritis in pedal joints, the morphological changes in these joints were much more noticable than in the corium of the hoof.

Pathogenesis. Experimental tests as well as histamine analyses of spontanous cases of laminitis speak in favour

of the belief that histamine may be involved in the pathogenesis of the disease. This agrees with Åkerblom´s (1934) conclusions about the disease in horses. Certain details in the clinical and morphological findings support this opinion. Specific epidermal changes according to Obel´s (1948) observations in horses and thrombosislike formations in the vessels have been observed in experimental cases of laminitis provoked by histamine. Whether the laminitis could be a reality be deficit from sulfuric acids, cysteine cystine, and methionine, according to Obel´s et al. (1958) and Urmas´ (1968) opinions I have no comments. Histamine may be involved as a consequence of histaminosis or through allergy. The way in which histamine activity increases in the body or tissues may be a fact by following four possibilities: 1) increased intake, 2) increased production, 3) increased liberation, and 4) decreased inactivation.

Etiology. In cases of laminitis combined with other diseases, it is fairly natural to assume that the combined ailment causes the attack of laminitis, perhaps because inflammatory processes in the body - especially purulent ones - increase the amount of histamine. There we have also the possibility, however, that the same cause brings about the combined ailment and the attack of laminitis. - In the "independent" cases, one will search for the cause in the fodder or a clinically not visible disturbance in the digestive system; in the first-mentioned instance either by some transformation of the fodder or by consumption of too large rations. Many circumstances indicate that mouldy fodder may play an important part in the onset of the disease. In some cases, which have contracted the disease in connection with consumption of mouldy hay, I have found a marked intracutaneous reaction to mouldy allergen. Abruptly feeding of folder high in protein, e.g., oil-cake concentrates, corn, heavy fresh clover, etc., may also be a cause. It is not unbelievable that abnormal rumen fluid is an etiological factor. I have carried out simple

routine tests and bacteriological examinations of the rumen contents from 100 animals, 26 of which were normal and the other suffering from laminitis or other claw diseases. In the last group, most animals had another figure of the rumen fluid than the normal cows. In ten difficult cases, I have transferred rumen fluid from normal animals to laminitis such ones, and these were healthy rather soon. Another etiological factor may be a slight or fairly slight subacute or chronic catarrh of the abomasum or of the small intestine. At autopsies of 14 animals with "independent" laminitis, such findings have microscopically been met with in 12 cases, crack-shaped gastric ulci in two.

Therapy. Hess (1891) suggested phlebotomy by bovine laminitis in animals in good general condition. This treatment is applicable also today, in cattle as well as in horses. In this therapy the animal is bled 3 - 5 litres of blood. Phlebotomy has the disadvantage of being relatively difficult to carry out in cattle. Various opinions have been put forward to explain how phlebotomy produces its effect in the disease. It shall not be used in cases combined with deficiency diseases or septic infectious diseases. Antihistamine has been used for the disease in horses as in cattle. In acute cases, not complicated, it seems me to be effective and so also in subacute cases. Antihistamine is thought to act either by preventing the release of histamine (in allergy cases) or by blocking the action of histamine on the affected organ's cells. In subacute and chronic cases, treatment with corticosterioids may be more effective than antihistamine. The corticosteroids are regarded to act either by a pure anti-inflammatory effect through cellular action or by preventing the binding of the active histamine at the sites affected. Several other substances have also been stated to have an inhibitory effect on the liberation of histamine, among others the metal ions, Cu^{++}, Pb^{++} and Zn^{++}, the sodium arsenite and a condensation product of salicylic acid. Because of it, some remedies containing these substances, especially

zinc, arsenic, and salicylic acid, may be effective in laminitis, Nilsson,(1963, p. 229) During the last years butazoloidine, 4 g. a day perorally, has been tried with some success in subacute and chronic cases. In cases, where the rumen fluid is suspected to be abnormal, i.g. cases combined with acetonaemia, a transfer of rumen contents from healthy to diseased animals has done a definite result. Urmas (1968) recommend a treatment with a remedy, Meheptin, containing methionine. This drug should act by healing a degeneration in the collagene connective fibers. I believe we have such a degeneration by laminitis but it is not visible by common staining. In U S, the veterinarians often use oidine in the therapy of laminitis.

Catamnesis and sequelae of laminitis. As regards the development of acute and subacute cases of laminitis there are the possibilities, as in inflammation in other organs, that the animal might recover completely, that it might be partially cured and that it might not at all inprove. In partial or no improvement the disease become chronic. Together with primary chronic cases these cases form the material for chronic laminitis. In cured cases it has happened that relapse has supervened and it has also happened that chronic cases have become exacerbated. This occurrence, is most common at the time of parturition or in the month following it.

In a number of cases a combination of laminitis and panaritium has been observed. In these cases it could be possible that the panaritium occurred primarily and the laminitis changes secondarily in a manner similar to that occurring in so-called metastatic laminitis in connection with mastitis, metritis and internal abscesses. The anamnesis, the clinical course and the morphological picture, in which the panaritium changes are recent and the laminitis changes older, don´t speak in favour of this development. The animals most frequently showed first symptoms of general stiffness and later severe lameness

on one or two extremities. Moreover, these combined cases mostly occurred individually with little tendency of the infection to spread from one animal to another in the herd. The majority of facts speak in favour of a primary laminitis. The possibility of secondary infection is great in laminitis cases with haemorrhages and necroses in the soft tissue. Such secondary panaritium has previously been reported in cattle by Hess (1891) and Moser (1950).

Not seldom it happens that laminitis cases which have been cured or partically cured return two or three months later as an ulceration of the hoof (pododermatitis aseptica circumscripta). These ulcerations did often not only occur on the hind feet but also, although lighter, on the fore feet in form of patches with slight blood impregnation. The morphological changes in laminitis with often occurring haemorrhages or necroses in a round or circular area on the sole at the "ulcerationplace" do it much possible that such cases result in hoof ulcers two or three months later. When laminitis is most common during the month after parturition the time for appearence of the hoof ulcers may speak for that these ulcers may be sequelaes from laminitis (cf. Nilsson, 1966). Another connection with laminitis is perhaps that we may have the same cause for laminitis and ulceration of the hoof, i.g. a catarrh in abomasum or abnormal rumen contents.

Some authors state that many cases with long hooves ("Stallklauen") are the result of an attack of laminitis. I have observed such development a few times but not so often that it would be characteristic for the disease. More often I have found secundarily high and large hooves. As previously reported it is not uncommon for the hooves to become flat and broad or deformed in incompletely cured cases. In the literature I have noticed that exungulation should be a common sequel of laminitis. I have never observed such a complication in cattle but two cases in swine.

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Subclinical laminitis in the Netherlands.

D.J. Peterse

This paper is based on results of a research project in the Netherlands with the purpose to indicate a possibility to improve the quality of the claws of the dutch cattle.
From experience it appears that in Holland the most frequent claw disorders are: phlegmona interdigitalis, dermatitis interdigitalis contagiosa and the pododermatitis group.
This project deals with the dermatitis interdigitalis contagiosa and the pododermatitis but in this paper it is limited to pododermatitis.
It is presented here with the name subclinical laminitis. Maybe it is not rational for everyone but we can discuss that.

Smedegaard (1964) and Zantinga (1971) have made a classification of severity of, what they have called, contusions respectively lesions of the sole, most times located on the junction sole/heel.
Nilsson (1963) and Maclean (1965) have mentioned the same symptoms in cases of laminitis, not only on that typical place but also in the area of the white line and the other parts of the sole.

Based on those publications I have made a classification of severity and location on the sole for the symptoms of pododermatitis, which I shall name lesions (see slides).
First the frequency of the incidence of those lesions has been surveyed and characteristics of the occurrence has been noted.
Second, the influences of the incidence of the lesions and the possibilities for selection on the trait have been analysed.
The project has been started with maiden heifers, taking the view that those animals seldom are suffering from a pododermatitis.
The material is composed of mainly Dutch Friesian animals located on
a) 14 commercial farms (160 animals)
b) 1 research farm (180 animals)
c) ca. 250 commercial farms (500 animals).
The animals on the 14 farms and the research farm have been observed 2 or 3 lactations and have been inspected systematically a few times per lactation.

The information concerns the lateral claws of the hind legs because those claws are the most affected ones in Holland.

Results

Frequency (slide). The frequency is rather high. Most animals show lesions, but it does not mean that the about 15% in class 4 has been offered as a patient to the vet.

Distribution on the sole (slide). The lesions occur on all places on the sole. Small bleedings are roughly equally distributed. If the bleeding is larger or if there is an open connection between pododerma and the outside, they are most times found on the typical place on the sole/heel junction.

It is assumed that in fact the whole pododerma is affected, like in cases of laminitis, but not so severe.

However the consequences for that typical place are the most severe caused by the construction of the hind lateral claw.

Similarity between the left and right outer claw of a cow (slide). There is a similarity in the occurrence of lesions between both hind lateral claws in

- severity
- location
- moment of appearance.

Those facts support the assumption that those lesions are not caused by a accidental trauma but that they are parts of a general disorder of the cow, which manifests itself, most times, locally in the claw.

Repeatability (slide). In relation to the possibilities for a usefull breeding on claw quality it is necessary that we can prove there exists a predisposition for sole lesions in cattle.

The table shows that 50% of the animals get the same class valuation in each lactation; a small part differs more than one class.

Twelve animals of the sixteen Dutch Friesian cows at the research farm with a severe lesion (class 4) in the first lactation have the same lesion (class 4) in the two following lactations again.

Those facts support the assumption that qualification in this way of a cow is usefull for selection on this trait.

For practical purposes it is not important whether the claw is weakened by the first lesion and is getting more "lesion prone" or the claw has a primary predisposition for lesions.

Some possible influences

Season/lactation (slide). In summer there is a lower incidence of lesions (see

paper Influences of housing). The most severe lesions are seen in the first 100 days after calving. There is a certain coincidence with the occurrence of laminitis, which most times also occurs in the period around and short after calving.
Also the typical shape deformation of the claw, that happens in cases of laminitis, are connected with the appearance of sole lesions.
A relationship between the severity of lesions and deformation has been proven but there are cases of severe deformation without lesions and severe lesions without deformation.
Stall systems (see paper Influences of housing).
Milk production (slide). It was not possible to prove a relation between the level of milk production and the predisposition for lesions.
Other claw disorders. Both other two named claw disorders have not influenced the occurrence of the lesions.
In this material lesions of the sole formed the most important claw disorder. The phlegmona interdigitalis is not considered as a big problem and the dermatitis interdigitalis contagiosa was on a rather low level because there was a prevention by foot baths with formaline.

Hereditary predisposition

In the Netherlands the dutch red and white breed (MRY) and the Holstein Friesian (HF) has a better reputation than the black and white (FH).
This research makes clear that the dutch black and white is more affected by lesions than both other breeds (slide).
Cross breeding with Holstein Friesian can improve the claw quality.
However, it is possible to show also in the dutch black and white breed differences between sires (slide).
But the level of the hereditability is rather low, so one can expect only a slow progress.

Synovial fluid in laminitic dairy cattle.

By Lennart Andersson, Veterinary Institute, Experimental Station, Skara Sweden.

Laminitis is defined as a diffuse, aseptic inflammation in the corium of the hoof. Pathoanatomically oedema, haemorrhages, infiltration of inflammatory cells, and disturbed keratinization, are seen. Depression of the hoof bone is a macroscopic finding in some cases.

The clinical symptoms vary with the intensity and duration of the disease. In some cases only a successively increasing rigidity is seen, usually in the forelegs. These are often close together or crossed. The animal shifts its body-weight from foot to foot. The process is often prolonged and in far advanced cases a heavy loss of weight is observed. Despite the loss of weight the milk production is usually unchanged.

In other cases there is a more intensive course with high degree of rigidity, elevated body temperature, elevated heart and respiratory rates, loss of appetite and sweating, Some animals with severe laminitis may be unable to rise, whereas others may stand for several days on end without lying down.

Laminitis is normally classified as acute, subacute or chronic according to the duration of the disease. In my opinion, however, it is more adequate from the clinical aspect to make a subdivision into cases with and without general symptoms as, according to the medical history, many cases without general symptoms are of very short duration. Conversely there are cases with general symptoms and longer duration. The intensity of the disease should therefore be more decisive for the clinical picture than its duration.

Material and Methods

The material consisted of 27 cows and heifers with clinical symptoms of laminitis, from which synovial fluid from the fetlock joint and blood samples were collected. Their mean age was 3 years (range 1-6 years). Most of them were primiparae. Twenty of the animals were of Swedish red-and-white, seven of Swedish Holstein Friesian breed. A normal synovial fluid material from the fetlock joint was collected from 17 clinically healthy cows. As normal material for serum 154 clinically healthy cows were used. Five animals underwent autopsy.

Total protein was determined by the biuret method.

The various protein fractions in synovial fluid were determined by means of agarose gel electrophoresis ad modum Carlström & Liberg (1975). By this method the electrophoretic pattern was differentiated into albumin, α-, interα-β, β_1, β_2 and γ-globulin.

Albumin in serum was determined spectrophotometrically with bromcresol green (Doumas et al., 1971). The total globuline concentration and the albumine/globuline ratio were calculated on the basis of the total protein and albumine values.

White blood cells in synovial fluid were counted in a Bürker chamber.

The animals were divided into cases of laminitis with general symptoms (group 1) and without general symptoms (group 2). Another subdivision was made between animals with swelling distally on the legs, chiefly round the fetlock joint (group 3), and those without this swelling (group 4). Of the seven animals in group 1 five were also in group 3.

Statistical analysis was done by means of Student's t-test.

Results

Serum. Groups 1 and 2 showed a significantly lowered concentration of albumin and raised concentration of globulin and a lowered albumin/globulin ratio compared with the healthy cows. Group 2 also showed a significantly lowered concentration of total protein. Groups 1 and 2 did not differ significantly from one another in respect of any of the measured parameters.

Nor were significant differences found between groups 3 and 4. Both groups had a lower albumin concentration, higher globulin concentration and lower albumin/globulin ratio than the healthy cows. Group 4 showed also a lower concentration of total protein.

Synovial fluid from fetlock joint. In group 1 there was a significantly larger number of white blood cells and higher absolute concentrations of total protein and total globulin. This depended mainly on increased concentrations of γ-and β_2-globulin.

Group 2 did not differ in respect of any of the measured parameters from the healthy cows.

Between groups 1 and 2 there were significant differences in the absolute concentration of total protein, total globulin γ-and β_2-globulin.

In group 3 there were significantly higher absolute concentrations of total protein, total globulin, α-and γ-globulin, and higher relative concentrations of γ-globulin .

Group 4 showed a higher relative concentration only of α -globulin.

Groups 3 and 4 differed significantly from one another in respect of absolute concentrations of all protein fractions except α-globulin.

On autopsy of five cases depression of the hoof bone was found in four. Three of these belonged to group 3.

Discussion

The aetiology of laminitis has not been fully established. Medical histories often record phenomena so different as changes of diet, retained placenta, metritis or mastitis. It seems probable that some pathogenetic factor causes the inflammatory lesions in the corium of the hoof, with clinical symptoms in consequence.

The changes in the serum protein picture found in all groups indicate the presence of a general inflammatory reaction. A remarkable finding is the very low albumin values which, dispite elevated globulin, sometimes also cause significantly lowered concentrations of total protein.

The elevated concentrations of white blood cells and of different protein fractions found in the synovial fluid from animals with swelling distally on the leg (group 3) suggest the presence of arthritis in the fetlock joint of some cows with clinical symptoms of laminitis. The swellings consisted in part of subcutaneous oedema, but manifestly derived also from pathological joints. Of the twelve animals with this swelling three were autopsied. All showed depression of the hoof bone.

In group 1 as well (laminitis with general symptoms) there were synovial changes indicative of arthritis. In cases of laminitis with high disease intensity, accordingly, there are often arthritic symptoms.

To sum up, it may be said that the changed serum protein picture, together with the clinical symptoms and autopsy findings, indicates the presence of laminitis with a general inflammatory reaction in all animals examined. The, in some animals, changed synovial fluid and the swelling around the fetlock joints suggest arthritis at least in the fetlock joint, but probably also in the pastern and hoof joints, in some cows with laminitis. This indicates the presence of a disease complex which may thus manifest itself both in the corium of the hoof and in joints. There is probably a common aetiological factor for this complex.

TABLE 1. TOTAL PROTEIN, ALBUMIN, GLOBULIN AND ALBUMIN/GLOBULIN RATIO IN SERUM OF LAMINITIC COWS WITH (GROUP 1) AND WITHOUT GENERAL SYMPTOMS (GROUP 2) AND OF HEALTHY COWS. STATISTICAL COMPARISON WITH NORMAL MATERIAL.

	GROUP 1 (N=9)		GROUP 2 (N=18)		NORMAL MATERIAL (N=154)	
	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.
TOTAL PROTEIN (G/L)	78.3	9.1	72.6^{XX}	8.6	76.7	4.7
ALBUMIN (G/L)	35.6^{XXX}	2.3	35.8^{XXX}	4.0	44.5	3.6
GLOBULIN (G/L)	42.7^{XXX}	9.8	36.7^{XX}	8.2	32.2	5.1
ALBUMIN/GLOBULIN RATIO	0.881^{XXX}	0.244	1.018^{XXX}	0.24	1.427	0.306

TABLE 2. TOTAL PROTEIN, ALBUMIN, GLOBULIN AND ALBUMIN/GLOBULIN RATIO IN SERUM OF LAMINITIC COWS WITH (GROUP 3) AND WITHOUT SWELLING DISTALLY ON THE LEGS (GROUPS 4). STATISTICAL COMPARISON WITH NORMAL MATERIAL.

	GROUP 3 (N=12)		GROUP 4 (N=15)	
	$\bar{x}$	S.D.	$\bar{x}$	S.D.
TOTAL PROTEIN (G/L)	78,1	7,8	71,6***	9,2
ALBUMIN (G/L)	36,3***	3,2	35,3***	3,7
GLOBULIN (G/L)	41,8***	8,8	36,3**	8,7
ALBUMIN/GLOBULIN RATIO	0,915***	0,239	1,018***	0,251

TABLE 3. WHITE BLOOD CELLS AND PROTEIN FRACTIONS IN SYNOVIAL FLUID FROM THE FETLOCK JOINT OF LAMINITIC COWS WITH (GROUP 1) AND WITHOUT GENERAL SYMPTOMS (GROUP 2) AND OF HEALTHY COWS. STATISTICAL COMPARISON WITH NORMAL MATERIAL.

	GROUP 1 (N=9)		GROUP 2 (N=21)		NORMAL MATERIAL (N= 17)	
	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.
WHITE BLOOD CELLS (CELLS/ L)	2695^{X}	7695	166	319	64.1	39.2
TOTAL PROTEIN (G/L)	9.8^{X}	2.5	7.3	2.4	7.7	1.7
ALBUMIN (G/L)	6.9	1.5	5.7	1.7	6.1	1.7
TOTAL GLOBULIN (G/L)	2.9^{XX}	1.4	1.7	0.9	1.5	0.8
ALBUMIN/GLOBULIN RATIO	3.022	1.598	4.052	1.711	4.32	2.08
α -GLOBULIN (REL. %)	2.86	1.85	3.38^{X}	2.19	2.07	1.12
γ -GLOBULIN (G/L)	1.40^{XX}	0.69	0.74	0.35	0.81	0.29

TABLE 4. WHITE BLOOD CELLS AND PROTEIN FRACTIONS IN SYNOVIAL FLUID FROM THE FETLOCK JOINT OF LAMINITIC COWS WITH (GROUP 3) AND WITHOUT SWELLING DISTALLY ON THE LEGS (GROUP 4). STATISTICAL COMPARISON WITH NORMAL MATERIAL.

	GROUP 3 (N=14)		GROUP 4 (N=16)	
	$\bar{X}$	S.D.	$\bar{X}$	S.D.
WHITE BLOOD CELLS (CELLS/μL)	266,5**	349,3	51,8	40,6
TOTAL PROTEIN (G/L)	9,6*	2,6	6,8	1,9
ALBUMIN (G/L)	6,9	1,4	5,3	1,6
TOTAL GLOBULIN (G/L)	2,6**	1,3	1,5	0,7
ALBUMIN/GLOBULIN RATIO	3,31	1,70	4,1	1,7
α-GLOBULIN (REL. %)	3,66*	2,64	3,05*	1,50
γ-GLOBULIN (G/L)	1,21*	0,64	0,70	0,33

SOME ASPECTS OF THE INCIDENCE OF PODODERMATITIS CIRCUMCRIPTA IN BULLS KEPT AT INSEMINATION CENTRES

A Modrakowski

INTRODUCTION

The modern breeding and rearing of cattle often leeds to diseases of the locomotive organs; among them, the most frequent are pathological conditions in the regions of digits. That is so because the aspiration of breeders for obtaining the best performance has, at the same time, created conditions favouring patholigic predisposition. The total weight of the animals body keeps increasing, while the size of claws stays same or even smaller, the structure of horn is soft, and the endurance of ligaments and tendons as well as the resistance of foot skin have not increased. These important characters, disregarded at genetic selection, and however essential for the animals health; if abnormal, they can bring about diseases of the digits. This is made still worse by the modern technology of animal breeding with too many animals kept together, force or ad libitum feeding, insufficient or no exercise, hard or uneven floors in the byres and moist litter. Another contemporary etiological factor contributing to the diseases is that no preventive and corrective chiropody is performed, and if so, it is often done improperly or not in due time. Thus, three main elements make an etiological chain: genetic conditioning, breeding technology and hygiene and trimming of the claws. An additional factor, though generally thought of as secondary, are microorganisms, which under certain circumstances can turn major in bringing about the foot disease.

Such conditions lead to environmental and overloading diseases of cattle, manifesting themselves by inflammatory conditions of suppurative and putrid character, necrosis, adaptation hyperplasia, deforming inflammations and degeneration.

One of these diseases is pododermatitis circumscripta. In bulls kept at insemination centres the latter disease is perhaps the most frequent, and yet, if followed by complications, leads to economic losses.

Material, results and discussion

The incidence of pododermatitis circumscripta was observed in bulls of black and white Fresian breed, kept at 15 insemination centres. The age of animals ranged from 2 to 10 years. The bulls were kept in standard conditions, intensively fed but with inadequate exercise.

During 10 years of observation there were found 930 cases of pododermatitis circumscripta . Generally, 10,3% of the animals were affected. The pathological changes occurred most frequently in lateral hind claws with typical localization. In the majority of cases the disease appeared bilaterally in the rear feet. The symptoms in each claw, were however different. The disease occurred most frequently in the following stages:

1. In form of discoloration of the horn of the sole which was found usually by way of trimming. In the majority of cases the discolorations disappeared after paring. It proved, that discoloration occurred as sequela of spontaneous healing of the disease, or that the process existed in latent, subclinical form.

2. As pododermatitis circumscripta purulenta with underrunning of horn of the sole and disintegration of corium. In this stage the horn of the sole was usually intact.

3. As pododermatitis circumscripta purulenta necroticans with defected horn and prolapsed corium. The clinical picture of this stage occurred in the form of defect loco dolenti, covered by disintegrated, ragged horn and suppurative exudate.

4. In form of defect filled with granulation, generally associated with disintegration and infection before. This stage is considered as further development of the disease with aspiration of the organism to recovery. The granulation tissue protruded through the horn of the sole in form of different size granulomas.

The condition was stated also in medial claws of the fore feet in 56 cases (6%). In 2 cases the disease occurred in medial claws of the hind feet.

In 109 mentioned cases (12%) developed complications in form of necrosis of the deep flexor tendon, necrosis of navicular and hoof bone, septic navicular bursitis and septic pedal arthritis. 14% of affected animals showed deformed claws or too small size of claws in relation to the body weight. 893 cases concerned bulls in age from 4 to 10 (96%), whereas only 37 cases (4%) concerned bulls 2 and 3 years old.

This proves that the incidence of the disease increased with the age of animals, obtaining at the same time increased body weight of about 900 kg on an average.

The number of complications and recurrences increased in relation to the age of the animals, too, and amounted, in per cent of the total number of cases, as follows:

age of animals	per cent of complications
4	6
5	8
6	8,5
7	13
8	19
9	20
10	20

Radiography of the digits in all typical lesions of the sole showed marked growth of the pedal bone in form of exostosis. Radiographic lesions were present in each claw of particular affected animal. Similar changes were detected in the pedal bone of claws, where horny capsel showed no changes, or only slight discoloration of the horn of the sole in the typical place. Proliferative changes, and particularly degenerative ones, were stated in non-lame bulls without elongated horn of well trimmedclaws, even showing no symptoms of claw diseases. Changes in thebones of the digits appeared in 3,5 years old bulls and then the incidence and severity of lesions increased with age and advanced the body weight due to overfeeding and inadequate exercise. X-ray examination showed that 43,5% of bulls kept at the insemination centres were affected with degenerative changes of the bones of digits, particularly of the pedal one, in latent form. Most significant was detection of lesions of the bones in bulls apparently healthy, giving no suspections of the

proceeding latent process, which prepares the animal to the apparent disease of claws.

In result of these investigations it is considered that periosteum of the pedal bone is fused with the corium and the proliferative or degenerative process can easily undergo by the way of contiguity of tissues on the corium of intact horny capsel. The lesions of the pedal bone can impair the nutrition of corium. In consequence the horn is produced less efficiently. Finally, this condition leads to a complete suppresion of horn production and to formation of empty space between the corium and up to here produced horn. The course of disintegration of the soft tissues is initially aspetic in form of degenerative changes in the blood vessels, or in form of subacute or acute inflammation, up to necrosis of the corium and complete discontinuance of hornformation. Thereby it comes to separation of the corium from the horny capsel. At the moment of opening of the horny capsel the septic process starts in specific suppurative-necrotic picture. Disturbances in the nutrition of corium express the changes in the blood vessels, revealing themselves in form of necrosis of corium under the influence of the body weight. Therefore the external (mechanical-traumatic) factor has etiological significance when it creates the lesions of the soft tissues of the pedal bone having had been prepared by the existing pathological process in latent stage. Providing this background, the compression reveals and accelerates the up-to-here pervading disease of claw. Even slight changes of bones of the digits in obese, apparently sound bulls, point to the process which under the same unchanged environmental conditions can lead to the disease of claws in form of circumscribed pododermatitis. Proliferative and degenerative changes of the bones and joints were also observed in the upper parts of limbs and in the vertebral column with concomitant pedal bone lesions of the fore and hind feet.

All these findings suggest that various segments of the skeleton, particularly the pedal bones, were affected by a primary pathologic process, probably provoked by metabolic disturbances due to overfeeding, obesity and inadequate exercise.

The rightness of the mentioned assumption seems to be also proved by the fact that the deformation of claw is fully justi-

fied only when it is accompanied with the deformation of the intrinsic bone. The horny capsel on the sound bone cannot change the shape of the pedal bone but, vice versa, the changed shape of the bones changes the shape of the claw.

All that leads to the following conclusions:

1. The incidence of pododermatitis circumscripta increased with the age of bulls and with advanced body weight in realtion to the environmental conditions, such as overfeeding and inadequate exercise.

2. The results of X-ray examinations, compared with the clinical findings, revealed that the changes of the pedal bones in bulls were primary due to lesions of the soft tissues.

3. The assumption that digital bone affections precede the changes of the corium, involves probably metabolic disorders as the main etiological factor responsible for pedal bone lesions and claw disease in bulls kept at insemination centres, intensively fed without adequate exercise.

4. Early X-ray detection of digital bone changes in subclinical form in overfed bulls is a signal to stop excessive feeding so as to prevent the development of metabolic disturbance leading to clinical manifestation of claw disease in form of pododermatitis circumscripta.

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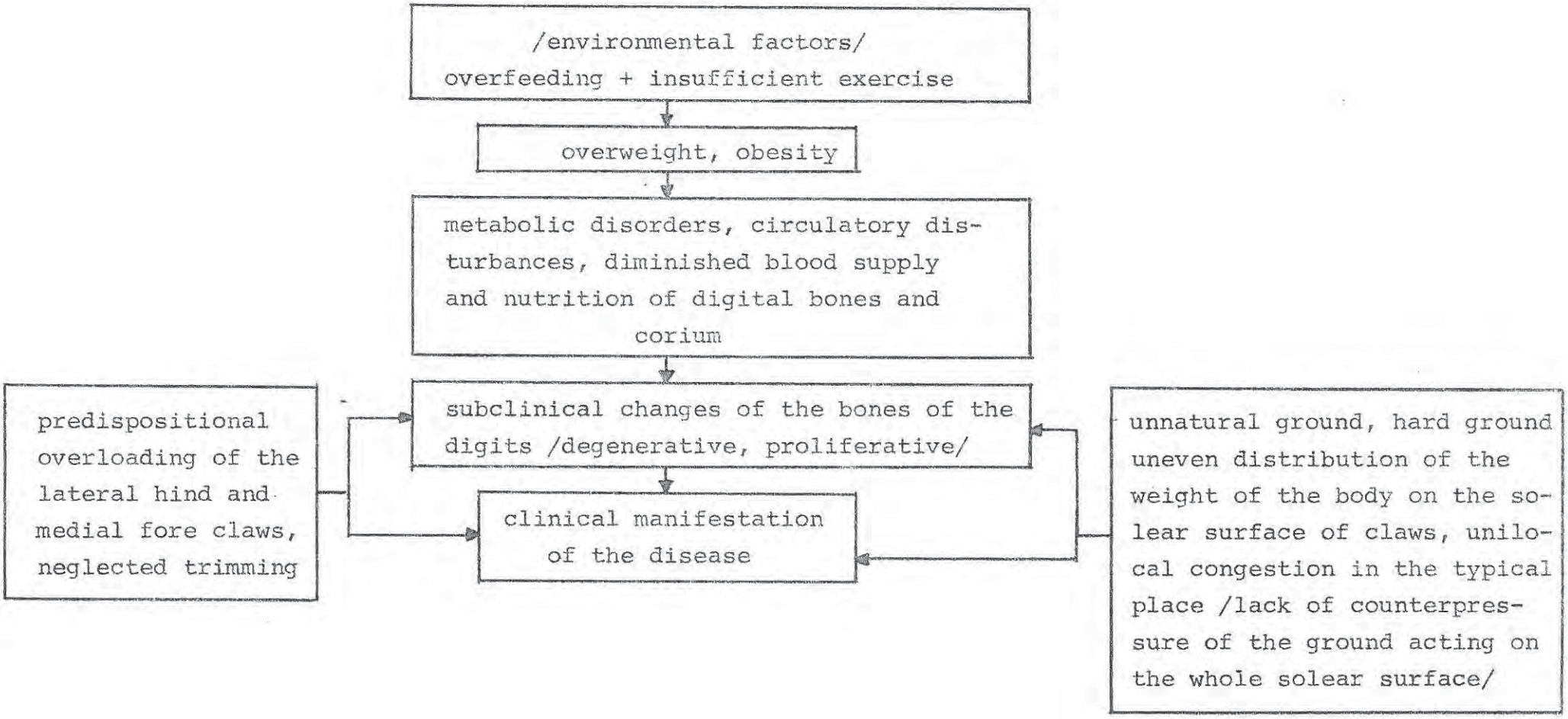
Summary

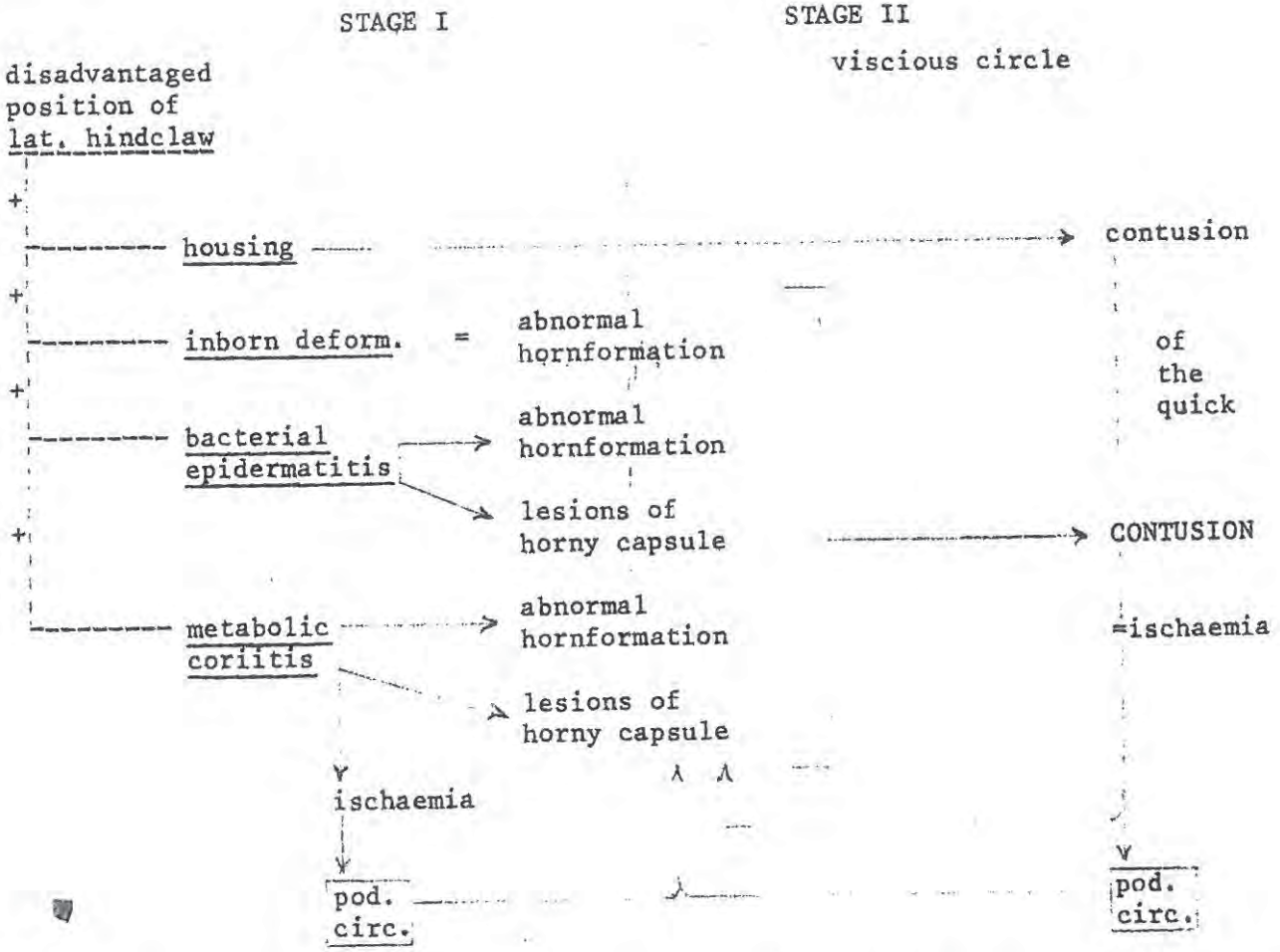
During 10 years was observed the occurance of pododermatitis circumscripta in black and white Fresian breed bulls, kept at 15 insemination centres, assuming the relationship between the pathological changes and the management of animals as environmental factor. The incidence of the disease increased with age and advanced body weight mainly in 4 years old animals. The frequency of the disease concerned 10.3% of animals. X-ray examination supported with clinical findings showed that the changes of the pedal bone preceded the lesions of the soft tissues. X-ray examination helped to detect subclinical degenerative changes of the pedal bone in 43.5% of bulls. This proves that in bulls overloading creates pathological changes in the corium of the bone, having had been prepared by degenerative process. All these findings suggest that metabolic disorders due to overfeeding, obesity and inadequate exercise are probably responsible, as the main etiological factor, for the disease of claw in bulls kept at insemination centres. Apart from selective breeding, nutrition, corrective chiropody and adequate exercise, early X-ray detection of subclinical changes of the digital bones would greatly help in prevention of the development of the disease.

Genesis of circumscribed pododermatitis in bulls of black and white Fresian breed kept at insemination centres.



Pathogenesis of circumscribed pododermatitis.
STAGE II in the patho-physiology of the quick.

E.Toussaint Raven



At different moments secondary infection may enter into the ischaemic corium and change a pododermatitis aseptica into a pododermatitis septica.

metabolic coriitis = pododermatitis aseptica diffusa

contusion / ischaemia = pododermatitis aseptica circumscripta

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On the basis of this diagram one could understand the origin, the pathogenesis, of pododermatitis circumscripta, the start of which is a local ischaemia of the corium as a result of metabolic or mechanical disturbance of the circulation.
On the basis of the same diagram one could discuss if the surgical denomination pododermatitis circumscripta is a useful diagnosis in cattle lameness control.
Pododermatitis circumscripta septica (necroticans) is the follow-up of pododermatitis a-septica (necroticans), bruising, which results from
housing (contusion - ischaemia),
nutrition (pododermatitis aseptica diffusa - ischaemia) and
bacterial invasion into the epidermis (contusion - ischaemia),
based on hereditable qualities of the animal.

Diagnosing "lamitis" or "interdigital dermatitis", subsequent pododermatitis aseptica or septica circumscripta should be regarded to as a symptom.
Too long, claw disorders in cattle have been the dominion of the veterinary surgeon. Origin and prevention belong to the science of bacterial and metabolic diseases, strongly related to animal husbandry and management.

The term 'spezifisches Trauma', introduced by RUSTERHOLZ, is of great value in the understanding of the patho-physiology of the corium of the claw, and could be translated by 'internal trauma'.
Pododermatitis circumscripta is a symptom of internal trauma.
According to ZANTINGA, the statement of RUSTERHOLZ that pododermatitis circumscripta should be due to exostosis of the claw bone, is not guilty for the problem we are dealing with to-day. Exostosis of the claw bone is not the cause, but the result of pododermatitis circumscripta.

In other words,

Defects in the horny capsule, with the exception of defects caused by external trauma, are sequel to disorders of the corium and/or germinal layer; the hornproducing tissue, the quick. This depends on the origin of the horny capsule; a concequence of which is too that sound quick means sound horn.
The concerning disorders of the hornproducing tissues can be kept under the name pododermatosis or pododermatitis. As it is difficult to decide between these two, we choose the name pododermatitis, which can be a-septic or septic.
Septic from origin could be a haematogenous bacterial invasion, which is practically unknown.
Septic from origin is a pododermatitis due to infection of the pododerma through a defect in the normal horny structure (external trauma):
a pododermatitis septica traumatica superficialis; normal claw - gray pus - various extension - favourable prognosis.

In all other casesthe first symptoms of a pododermatitis are disformation or discolouration of horn,obligatory resulting from a disintegration in the pododerma. Circumscribed perhaps, as a sequel to internal (specific) trauma, or more spread as a sequel to a more general disintegration involving the pododerma.
All defects in the horny capsule (wall - sole - white line) start as a pododermatitis aseptica circumscripta (bruising), or a pododermatitis aseptica diffusa.
All septic cases of pododermatitis, except the (external) traumatic ones, are secondarely infected by surrounding microorganisms.

Two remarks:

- It is difficult, in certain cases, to decide if the infection is mere traumatic,or if inferior hornstructure made infection possible.
Fact is, that inferior horn is easily traumatised.
Fact is too, that the prognosis in a secondarely infected pododerma is less favourable than in an infection of mere traumatic origin, the disintegrated pododerma being more susceptible to bacterial invasion than an originally sound pododerma.

- It seems to be impossible to distinguish sharply between pododermatitis aseptica circumscripta and diffusa!

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IS ULCERATION OF THE HOOF ALWAYS CAUSED BY TRAUMA?

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Several authors have worked with and described the disease "ulceration of the hoof" and discussed the etiology. All the authors are of the opinion that the anatomical reason for the hoof ulcer is a local damage in the sole corium. This local injury may be an haemorrhage, a necrosis or a local inflammatory spot which causes a poor function of the keratogenic membrane of epidermis and local area of bad horn. However, there are different opinions about the cause of the local corium injury. Most of the authors, among others Rusterholz, Fritzböger, Smedegaard, Greenough, Zantinga and Toussaint-Raven, consider the corium injury beeing a traumatic fact depending on mechanical pressure or on overtension in the flexor tendons. This fact may be a reality throught abnormal posture of the hind legs and formation of exostosis on the posterior edge of the third phalanx, abnormal length of the hoof by inadequate trimming, or by uneven hanging of the pedal bone. A few authors (Hess and Meser) mention the corium injury beeing a sequel of an infection by B. necrophorus or C. pyogenes by a crack in the horn or metastatically. Other authors (Bouckaert, Merces and Nilsson) have put forward that there may be a local circulatory disturbance as cause to the haemorrhage or the necrosis either by immobile standing or by thrombo-embolic formation in the branches of the digital arteries.

In my studies of bovine laminitis when I found at section a "laminitis-picture" in the fore hooves, in the hind hooves I often observed a local injury in the solear corium at the place for spontaneous hoof ulcer. This damage had in this cases a round, oval, or circular form with a distinct limitation. This form and limitation is difficult to explain arising from mechanical pressure or a flexer tension but easier from a circulatory disturbance in the vessels of

the solear corium. In my practice, I have also found, that the disease most often encounter good milk cows and happens about 3 - 4 months after parturition. Not seldom it meets with in cows which have suffered from laminitis in connection with parturition or on the month after it. By section in my laminitis cases, I have microscopically often found several thromboses in the vessels and circularly necroses. Because of these facts, the time for the appearence, by occurrence in the same animals, the form of the sole injury, and specific microscopical findings, I will devine that the etiology of laminitis and ulceration of the hoof in cattle may be related or perhaps the same. I will not contest that we often or most often have a traumatic cause to the hoof ulcer but I will emphasize that we must count on a primary circulary disturbance.

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The Compton Survey of Bovine Lameness 1977

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INTRODUCTION

In view of the paucity of information about the incidence and type of lameness encountered in dairy cattle in the United Kingdom, members of the British Cattle Veterinary Association during 1977 recorded all cases of lameness in dairy cattle over 8 months of age. A total of 146 veterinarians in 48 practices participated and the geographical spread was comparable to that of the distribution of dairy cattle, and one practitioner in Eire also participated. A complex one-sheet form was devised and the results was analysed by the help of a computer. The factors examined included the management system, distance walked, the month of lameness, wetness of feet, and herd size as well as the relationship to calving, heart girth, age, breed and origin (home bred or purchased). In the limb lesions the cause, tissue and the site in the leg were required to be entered on the form and in the foot lameness cases, the claw, the identity of the foot lesion and the site in the claw were recorded as well as the condition of the claw.

The foot lesions were named as follows: Sole ulcer, white line separation, white line abscess, punctured sole and pus, foreign body in sole, overworn sole, foul in the foot, interdigital hyperplasia, interdigital foreign body, under-run heel, sand crack, aseptic laminitis, deep sepsis and other. The areas of the claw were divided into five and the condition of the claw was classified as normal, overgrown, axial rotation or unequal size.

RESULTS

There were 7,528 cases of lameness involving 9,130 lesions originating in 1,823 herds containing 136,931 cows. This total of cows represents approximately 3% of the national dairy herd. The incidence rate per annum of dairy cow lameness in this survey was 5,5%.

About 88% of all lesions occurred in the feet and 12% in the re-

mainder of the limb. The percentage of the total lesions of different types was as follows: foul in the foot 15%, white line abscess 14%, sole ulcer 12%, punctured sole and pus 9%, under-run heel 8%. These five lesions account therefore 58% of all lesions. Aseptic laminitis accounted for 5% of all lesions and the final category of "other foot lesions" for 7%.

The distribution by month showed that the peak months were January, March, February followed by November. The lowest incidence was in July followed by August and June. Analysis by age showed that lameness was commonest in five and six year old cows (31%of foot lesions, 29% of leg lesions) and that leg lesions occurred in a slightly younger age group than foot lesions. Thus 3% of the foot lesions were found in animals aged 8 months to 2 years (most of these animals would not have calved), while 13% of leg lesions were in this category.

The relationship to calving indicated that the foot lesions were found primarly in the period post partum of high production with 28% of lesions recorded in days 1-50 post partum, 19% 50-100 days post partum and 15% 101-150 days post partum. This represents 62% of cases in the first five months post partum.

Division of the total foot lesions into fore feet and hind feet gave a ratio of 16:84. This ratio was most markes for sole ulcer with 98% of lesions in the hind feet and in order of decreasing frequency was followed by interdigital hyperplasia (94%), under-run heel (92%), punctured sole and pus (80%), while only interdigital foreign body was more common in the forefeet (51%). The outer claw was more frequently involved than the inner claw in almost all foot lesions including sole ulcer, white line separation, white line abscess, deep sepsis, and solar foreign body. Overall, 75% of the footlesions occurred in the outer claw. If the total foot lesions are divided into fore and hind feet, inner and outer claws, the distribution is as follows: front inner claw 8%, front outer claw 7%, hind inner claw 13% and hind outer claw 73%. This particular analysis was based on 5,966 lesions (not all veterinary surgeons filled in all parts of the form for each case).

Analysis of the factor of claw condition showed that 31% of the

feet lesions were associated with overgrowth, 6% with axial rotation and 5% with unequal size, leaving 58% regarded as normal condition. In comparison 88% of the claws of the animals with a leg condition were considered normal and 9% were thought overgrown.

Examination of the factor of breeding (home-bred or bought-in) showed little difference in the distribution, with 72% of the foot lesions being in home-bred animals and 78% of the leg lesions being in home-bred stock.

The management system factor was found to show that 49% of the lesions occurred with the animals at pasture (this percentage will correspond with the average period which UK dairy cattle spend at grass, in other words about half the year) while 39% of the lesions occurred in cubicles or concrete yards. Straw yards accounted for 4%, cowsheds for 7% and other management systems for 1%.

Analysis of the distance walked from the pasture to the parlour showed that 72,4% of the cases of lameness walked up to quarter of a mile (approximately 400 m) a figure which would have to be multiplied by 4 to give the total distance walked per day. Most of the remaining cattle (20,2%) walked a quarter to half a mile (400-800 m). Wetness of the feet was recorded as the number of hours per day that the feet were wet and 30% of the lesions fell into the category of 0-3 hpurs per day, 29% into the category 18-24 hoyrs while the remainder rather evenly distributed in the periods 3-6, 6-12, and 12-18 hours. Thus lesions tend to be associated either with relatively dry or very wet conditions.

When the country was divided into four regions, namely the south-west, the south and east, the midlands and north-west, the north and Scotland, the south-west was found to have 41% of the lesions, 41% of the cows and 38% of the herds, the corresponding figures for the other regions being 10, 14 and 11, for the south and south-east, 32, 30 and 29 for the midlands and north-west and 11, .2 and 11 for the north and Scotland. These figures tend to indicate that the south-west and the midlands and north-west are particularly affected by the problem of lameness in dairy cattle.

Relationships were found between several other environmental and animal factors and are being subjected to statistical analysis. These relationships included time of the year, (corrected for the calving date) management system (corrected for time of year), herd size, wetness of feet (corrected for the time of the year) and management system (claw condition), time relative to calving and breed, origin, age and heart girth of the animal.

It has been calculated that the economic cost of the lameness due to dairy cattle, based on a calculation from this data is approximately £10,000,000 per annum and the total, when it is realised that a proportion of the lameness is not seen by veterinarians but is treated by the farmer alone is calculated at approximately £15,000,000 per annum.

Breed comparison on claw and leg traits

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A long term experiment is being carried out at the department of Animal Breeding and Genetics. The purpose of the experiment is to compare the Swedish dairy breeds concerning their growth rate, feed efficiency and milkproduction as well as in a number of secondary traits such as fertility including hormone studies of progesterone and prostaglandins, claw and leg tratis, udder and udderhealth, ease of milking, blood-parameters and skeletal development.

Four breed groups are represented in the experiment, the Swedish Red and White (SRB), the Swedish Friesian breed (SLB), the Swedish Jersey breed (SJB) and crosses SLBxSRB. In the SRB-group are monozygous twins included. The experiment are going to include 150 cows which are to be studied in five lactations.

Some of the purposes of the investigations on claw and leg traits are summarized in the following paragraphs.

1. Compare the breedgroups and the phenotypic variation within breeds.
2. Develop new and/or improved methods for calculation of breeding values on claw and leg traits in dairy production.
3. To study the interaction between claw and leg traits and other traits as for example milkproduction, growthrate etc.

Short description of the methods:

- Every month are legs and feet on every animal clinically investigated by veterinar.
- Every heifer are trimmed once before calving and the cows are trimmed twice during lactation.

During the trimmings several measurements are made on the claws such as length of toe, the height of the heels and the growth of the claws. A sample of the horn is taken to study the hardiness of the claws. The legs are judged to compare the stance of the animals.

- To study the skeletal development X-rays-photos are made on carpus, tarsus and the phalanxes every third month and two times during lactation.
- The content of minerals in the skeleton is determined by dichromatic photos absorptionetry.
- Also the content of minerals in the blood (Ca,P,Mg) are analysed regularly.

It should be stressed that the experiments are ongoing and preliminary results are going to be published in the coming years.