Roger Blowey

EIGHTH INTERNATIONAL SYMPOSIUM ON DISORDERS OF THE RUMINANT DIGIT

and

INTERNATIONAL CONFERENCE ON BOVINE LAMENESS

Program
Proceedings and Abstracts

Banff, Canada

1994

A Continuing Veterinary Education Program
of
The University of Saskatchewan
Saskatoon, Saskatchewan, Canada

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ABOUT THE INTERNATIONAL CONFERENCE AND 8TH SYMPOSIUM

The First Symposium of Disorders of the Ruminant Digit was held in Utrecht in 1976. Other symposia have followed at intervals of two years. An important function of the symposia has been to create international agreement on such matters as terminology and anatomic descriptors. During the last decade the organisers of symposia have taken the opportunity to arrange for sessions to be held that would be of interest to the practitioners in the host country. The 8th Symposium and the International Conference, held in Banff, Canada, are the first to take place in North America.

The papers presented at the International Conference and the papers and abstracts presented in the 8th Symposium of the Ruminant Digit have been combined in these Proceedings. Papers do not appear in the order presented at the meetings but have been grouped under several headings which should facilitate the exploration of specific topics. Many of the manuscripts arrived in a form that required retyping. We apologize in advance for any errors. The name shown in relation to the program lists only the individual presenting the paper. The table of contents lists the names of all of the authors. Finally, the names and addresses of the authors form the preface to each paper.

Please note that it is important to adhere closely to the schedule. In the International Conference speakers must allow time if they wish to have their papers discussed. They must make their wishes clear to the session chairman. In the case of the Symposium the speaker will be allowed 12 minutes for the presentation and 8 minutes will be devoted to discussion. Any member of the audience may speak only once and comments or questions must be brief.

I would like to express my appreciation to my wife Sharon who has been entirely responsible for typing, collating and compiling these proceedings. I wish to express my gratitude to Dr. R.S. Butler who has so ably managed the fiscal arrangements for the conference and to Mrs. Anne Ruholl for her contribution in helping to arrange the scientific program. Special thanks should go to the Zinpro Corporation for their financial assistance. Finally, I would like to thank my friends and colleagues from around the world who made presentations at the Conference.

Paul R. Greenough
Editor

INFORMATION FOR DELEGATES

LUNCHES and REFRESHMENT BREAKS

The location of the lunch service will be displayed at the ***Registration Desk.*** *Served from 12:00 to 1:15 from Monday, June 27 to Thursday, June 30, (inclusive).*

Refreshment breaks will be served in the reception area that is adjacent to the Max Bell Auditorium and Room 253.

WELCOMING RECEPTION — *Sunday June 26*

Sponsored by the ZINPRO Corporation

Bourgeau Lounge, Sixth Floor, Lloyd Hall from 7:30 to 10:00 p.m.

COUNTRY BARBECUE — *Monday June 27*

Brewster "Donut Tent", located adjacent to the Rocky Mountain Resort on the East side of Banff, from 6:15 to 10:00 p.m.

** Bus service 6:00 to 10:30 p.m.*

MEDIEVAL DINNER — *Thursday June 30*

Banff Springs Hotel

Reception ***Mt. Stephen Room*** *7:00 to 8:00 p.m.*

Dinner ***Alhambra Room*** *8:00 to 10:00 p.m.*

** Bus service 6:30 to 10:30 p.m.*

** **Bus service will be available to and from the Conference Centre calling (on request) at conference motels along Banff Avenue.***

POSTER SESSION

Located in ***Room 251*** *and will be available all hours from Monday through Thursday. For details see pages 397 to 400.*

BUSINESS MEETING

Max Bell Auditorium - 17:15 - Tuesday June 28

Chairperson: ***P.R.Greenough***

Agenda

1. *Location for the 9th Symposium 1996*

2. *Recommended International Standards*

   a) *Expanded terminology (Computer coding)*
   b) *Lameness scoring*
   c) *Lesion severity scoring*
   d) *Conformation evaluation: Anatomical landmarks*
   e) *Claw measurements and characteristics*

3. *Discussion on future collaborative research*

4. *Other business*

The business meeting has been a forum for discussions that has led to the establishment of internationally agreed guidelines. These guidelines have had an important influence on facilitating scientific investigation of lameness problems. Progress is reflected in the many excellent papers appearing in these proceedings and it therefore seems an appropriate time to revisit, review and explore guidelines again.

INTERNATIONAL CONFERENCE

Max Bell Auditorium

Monday 27 June

08:15 Opening Remarks — ***R.S. Butler***

Session One

Diagnosis of Lameness

Chairperson: K. Mortensen

08:25 International terminology of digital diseases — ***A.D. Weaver***

08:40 Structure and function of the digit — ***P.R. Greenough***

09:15 Treatment of bone and joint infections — ***A.M. Trent***

10:15 Refreshment Break

10:40 Diagnostic radiology of the bovine foot — ***U. Bargai***

- The state of the art today
- The aging of the distal phalanx: Radiographic changes

12:00 Lunch Break

INTERNATIONAL CONFERENCE

Max Bell Auditorium

Monday 27 June

Session Two

Interdigital Diseases

Chairperson: L.C. Allenstein

13:00	**Digital dermatitis**	***C.M. Mortellaro***
13:30	**Interdigital causes of lameness**	***R.W. Blowey***
14:15	**Treatment of specific digital lesions**	***C. Bergsten***
15:15	**Refreshment Break**	
15:45	**The pathology of digital disease**	***P. Ossent***
16:15	**The impact of a lameness management programme**	***J.J. Vermunt***
17:15	**Sessions Adjourn**	

INTERNATIONAL CONFERENCE

Max Bell Auditorium

Tuesday 28 June

Session Three

Surgical Treatment and Other Therapies

Chairperson: A.D. Weaver

08:15	**Responsible pain management**	***A. Livingston***
08:45	**Alternatives to amputation in the bovine digit**	***J.G. Ferguson***
09:30	**Alternatives to amputation**	***Ch. Stanek***
10:30	**Refreshment Break**	
11:00	**Predisposing causes of laminitis**	***J.J. Vermunt***
12:00	**Lunch Break**	

8th SYMPOSIUM Room 253

Digital Dermatitis Chairperson: C.M. Mortellaro **Tuesday 28 June**

8:30	Risk factors in the development of digital dermatitis in dairies in Tehran area ***I. Nowrouzian***
8:50	Papillomatous digital dermatitis of dairy cattle in California: clinical characteristics ***D.H. Read***
9:10	Current investigations into the cause of dermatitis digitalis in cattle ***B. Zemljic***
9:30	Studies on the pathogenesis and control of digital dermatitis ***R.W. Blowey***
9:50	Digital dermatitis: further contributions on clinical and pathological aspects in some herds in Northern Italy ***G. Scavia***
10:10	Preliminary report on the onset and evolution of digital skin diseases in a group of 32 heifers ***C.M. Mortellaro***
10:30	Papillomatous digital dermatitis and associated lesions of dairy cattle in California: pathologic findings ***D.H. Read***
10:50	Epidemiological investigations of digital dermatitis in Dutch dairy cattle ***D. Dōpfer***
11:10	Preliminary results from a spray application of oxytetracycline to treat, control and prevent digital dermatitis in dairy herds ***J.K. Shearer***
11:30	A survey of digital dermatitis treatment regimes used by veterinarians in England and Wales ***P.D. Graham***

INTERNATIONAL CONFERENCE

Max Bell Auditorium

Tuesday 28 June

Session Four

Genetic Considerations

Chairperson: A.M. Trent

13:00	Genetic improvement of claw and leg traits ***O. Distl***
13:30	Feet and leg traits of dairy cattle ***B.T. McDaniel***
14:30	Conformation of beef cattle ***P.R. Greenough***
15:00	Refreshment Break

Session Five

Epidemiology of Lameness

Chairperson: J.J. Vermunt

15:30	Recent studies on the epidemiology of lameness ***W.R. Ward***
16:15	In search of an epidemiologic approach to investigating bovine lameness problems ***P.R. Greenough***
17:15	***BUSINESS MEETING***

8th SYMPOSIUM Room 253

Laminitis Chairperson: J.K. Shearer **Tuesday 28 June**

13:30 Prevalence of lesions of subclinical laminitis in first lactation cows from high production Ohio Holstein herds
R.H. Smilie

13:50 A scoring system to evaluate lesions associated with subclinical laminitis in high production Ohio Holstein herds
R.H. Smilie

14:10 Prevalence and severity of lesions associated with subclinical laminitis in heifers and cows in confinement and pastured Ohio Holstein herds
R.H. Smilie

14:30 Pathophysiological studies in dairy cattle affected with subclinical laminitis
Ch. Stanek

14:50 Lesions of the hoof in first-calving dairy heifers
D.N. Logue

15:10 Relationship of diet, hoof type and locomotion score with lesions of the sole and white line in dairy cattle
D.N. Logue

15:30 Lesions of the foot and ultrastructure of the white line in relation to lameness in dairy cattle
D.N. Logue

15:50 Environmental control of laminitis in dairy cows
L.C. Allenstein

16:10 Bovine toe abscesses
D.W. Miskimins

INTERNATIONAL CONFERENCE

Max Bell Auditorium

Wednesday 29 June

Session Six

Pathogenesis of Laminitis

Chairperson: W.R. Ward

08:30 Theories on the pathogenesis of bovine laminitis
P. Ossent

09:00 Bovine laminitis
(diffuse aseptic pododermatitis)
clinical and pathological findings
K. Mortensen

10:00 Refreshment Break

10:30 Correlation of laminitis and fertility
D.W. Collick

11:00 Some housing and management considerations relevant to dairy cow welfare and stress related lameness
W.G. Bickert

12:00 Lunch Break

8th SYMPOSIUM Room 253

Diagnosis and Therapy Chairperson: Ch. Stanek **Wednesday 29 June**

8:30	The diagnostic value of ultrasonography in bovine limb disorders	***J. Kofler***
8:50	Effect of long-term administration of bovine somatotropin on lameness and limb lesions in dairy cows	***A.M. Trent***
9:10	Lameness in dairy cows: incidence in Argentina	***B. Rutter***
9:50	Treatment of bovine lameness with metacresolsulphonic acid	***B. Rutter***
10:10	Toxic and infectious causes of lameness in cattle and game species in Southern Africa	***S.R. van Amstel***
10:30	Eco-pathological study of lameness in dairies in Tehran area, Iran	***I. Nowrouzian***
10:30	Frequency of claw diseases in appraently healthy animals	***B. Zemljic***
10:50	Preliminary observations on the application of cowslips as adjunct to treatment of lameness in dairy cows	***J.K. Shearer***
11:10	Bacterial etiology of diseases in the foot rot complex: recent research and nomenclature changes	***J.N. Berg***
11:30	Evaluation of diclofenac sodium and synovial fluid transplant for treatment of aseptic arthritis in bovines	***M. Singh***
11:50	Pharmacokinetics of cefazolin in bovine synovial fluid following intravenous regional injection	***J.G. Ferguson***

INTERNATIONAL CONFERENCE

Max Bell Auditorium

Wednesday 29 June

Session Seven

Nutritional Involvement in Lameness

Chairperson: D.W. Collick

13:00	Nutritional factors associated with lameness	***W.R. Ward***
13:45	The role of trace minerals in bovine lameness	***L.M. Schugel***
14:15	Mineral and selected vitamin nutrition related to lameness	***M.E. Smart***
14:45	Refreshment Break	
15:15	Nutrition, rumen environment and laminitis	***R.D. Shaver***

16:15 ***Panel Discussion: Diagnosis, Treatment and Control of Digital Lesions***

Chairperson: J.G. Ferguson

Panelists to be selected from among the registrants

17:30 Session Adjourns

8th SYMPOSIUM Room 253

Management Chairperson: C. Bergsten **Wednesday 29 June**

~~13:30~~	Trauma induced lameness in feedlot cattle ***E.K. Leitch***
13:50	Does the claw trimming procedure affect milk yield and milk quality factors? ***Ch. Stanek***
14:10	Excessive dietary protein as the cause of herd outbreaks of "Mortellaro disease" ***U. Bargai***
14:30	Effect of overcrowded housing conditions on foot lesion developments in first-calved Friesian heifers ***F. Leonard***
14:50	Biomechanics of dairy cows: effects of housing and grazing ***A.H. Herlin***
15:10	The role of stockmanship in foot lameness in UK dairy cattle ***W.R. Ward***
14:30	The measurement of behaviour of UK dairy cattle by 24-hour observations ***W.R. Ward***
14:50	The minimal solution footbath - an aid to treatment of digital dermatitis ***W.R. Ward***
16:15	***Panel Discussion:*** ***Diagnosis, Treatment and Control of Digital Lesions*** Chairperson: J.G. Ferguson **Panelists to be selected from among the registrants**

INTERNATIONAL CONFERENCE

Max Bell Auditorium

Thursday 30 June

Session Eight

Hoof Care

Chairperson: R.W. Blowey

08:30	Pathogenesis of sole ulcers	***E. Toussaint Raven***
09:15	Functional trimming	***E. Toussaint Raven***
10:15	Refreshment Break	
10:40	Claw trimming and claw lesions	***A. Brizzi***
11:00	Restraint and equipment	***A. Brizzi***
11:30	General management of claw lameness	***A. Brizzi***
12:00	Lunch	

Session Nine

13:30	***Panel Discussion: Etiology of Laminitis*** Chairperson: P. Ossent
15:00	Refreshment Break
15:30	***Panel Discussion: Control of Lameness*** Chairperson: A.D. Weaver

8th SYMPOSIUM Room 253

Research Forum Chairperson: J.N. Berg **Thursday 30 June**

8:30 Use of image analysis in studies of lesions of the sole and white line in cattle
K.A. Leach

8:50 Hock conformation of dairy heifers in two management systems
J.J. Vermunt

9:10 Correlations of locomotion and body and claw traits with regard to production in dairy cattle
D. Boelling

9:30 Bovine lameness - a cell culture approach
K.A.K. Hendry

9:50 Breed differences in pressure distributions underneath claws of dairy cattle
O. Distl

12:00 Lunch

13:30 ***Panel Discussion: Etiology of Laminitis***

Chairperson: P. Ossent
Panelists to be selected from among the registrants

15:00 Refreshment Break

15:30 ***Panel Discussion: Control of Lameness***

Chairperson: A.D. Weaver
Panelists to be selected from among the registrants

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INTERNATIONAL TERMINOLOGY OF DIGITAL DISEASE

A David Weaver
Charlton Mackrell Court
Somerton, Somerset, TA11 7AL, England

Terminology has often confused our understanding of different digital problems of cattle. In Paris, at the fourth international meeting on diseases of the ruminant digit (1982), ten bovine and five ovine digital terms were agreed. The bovine terms, in latin, were:

1. Dermatitis interdigitalis
2. Erosio ungulae
3. Hyperplasia interdigitalis
4. Dermatitis verrucosa
5. Phlegmona interdigitalis
6. Dermatitis digitalis
7. Pododermatitis circumscripta
8. Pododermatitis septica (traumatica)
9. Fissura ungulae (longitudinalis et transversalis)
10. Pododermatitis aseptica diffusa

A definition could not be agreed for overgrown feet (Ungulae deformans), covering all physical deformities of the horny capsule.

These terms had initially been discussed at the first international meeting in Utrecht (1976), at which a series of about 50 slides, illustrating these terms, had been selected. At intervening meetings (Skara 1978; Vienna 1980) the criteria for selection, as well as definitions were refined. Definitions, in 3 languages (English, French, Spanish) were placed alongside 23 selected illustrations, together with brief discussion in a small colour atlas published after the Paris meeting (Espinasse et al 1984).

The justification for the list was the confusion about existing terms which were frequently colloquial, eg. "corns",frequently general, eg. "panaritium" (German) or "panaris" (French) or "footrot" or "foul" (American English or English English).

Having outlined this effort made to facilitate the uniform evaluation and comparison of different studies subsequently carried out, what is the current position of these terms today?

Members of this bovine digital study group have accepted and generally used many of these terms. Interdigital(ID) dermatitis, ID hyperplasia, heel horn erosion and septic traumatic pododermatitis are used in English language journals. Verrucose dermatitis was defined as a "chronic proliferation of the dorsal and, or plantar/palmar skin, initially moist, and later developing into wart-like proliferations" and today one manifestation is as a well-recognised late stage of digital dermatitis.

Digital dermatitis has been extensively investigated on the farm in numerous countries and to a limited extent in laboratories (including US, UK and Slovenia), and is, in a tribute to the original observer, Mortellaro, often called Mortellaro disease. A recent issue of Index Veterinarius (March 1994, 62, 3, 52) listed a title which graphically illustrated the current confusion: "Mortellaro - a very unpleasant claw disease found in many dairy herds" (Dieckhoff 1993).

The awkward phrase pododermatitis aseptica diffusa is occasionally seen in parentheses after the term laminitis. This latter term is likely to persist but we would do well, later in this meeting when its pathogenesis is discussed to confirm the appropriate latin term.

Pododermatitis circumscripta, being a contusion

of the sole, is another term where adoption of the latin phrase is difficult due to the habitual acceptance of "sole ulcer". Yet sole ulcer remains a misleading term, suggesting incorrectly that the pathological process starts on the bearing surface of the sole or sole-heel junction.

Few references have been found in veterinary literature of the past 10 years to horn fissures or fractures, either horizontal or vertical. Such references usually refer to vertical "sandcracks" as in the horse.

Index Veterinarius, a primary reference and indexing journal, also has problems. In 1985-90 it listed Foot Diseases as "see Hoof & Claw diseases". In 1991 they returned to Foot Diseases, giving up on anatomical accuracy! Let us at least agree that we are concerned with digital or claw diseases!

What should be done with these terms? Should they be abandoned or retained? We should welcome critical discussion. My personal suggestions are:

1. The terms, with the exception of pododermatitis verrucosa, should be retained.

2. They should be more widely publicised in appropriate journals; (Hataya 1991, Burtan, Morosanu & Cirlan 1985), being placed in parentheses after the proper name in that specific country.

3. They should be inserted, in parentheses, into the title and introductory sentences of papers concerning bovine digital disease.

Burtan I, Morosanu N & Cirlan M (1985). Contributions to the new nomenclature of bovine digital diseases. Lucr. Stiint. Inst. Agron. "Ion Ionescu de la Brad" Iasi Zootehn. - Med Vet 29, 105-106.

Dieckhoff H J (1993). Mortellaro: eine sehr unangenehme Klauenerkrankung in vielen Milchviehbeständen. Milchpraxis 31(8), 8, 10-12.

Espinasse J, Savey M, Thorley C M, Toussaint Raven E & Weaver A D (1984). Colour atlas on disorders of cattle and sheep digit. Point Vétérinaire & Société Française de Buiatrie. Maisons-Alfort (ISBN 286326 039 1).

Hataya M (1991). Terminology of the bovine foot and its diseases. J Vet Med Japan 44(6), 393-396 and 44(7), 453-457.

TRAUMA INDUCED LAMENESS IN FEEDLOT CATTLE

E. Keith Leitch, D.V.M.

Wainwright Veterinary Clinic (1990) Ltd.
Wainwright, Alberta, Canada, T0B 4P0

Lameness of wild range cattle in Western Canadian feedlots can result in significant economic losses. The incidence of lameness can be as high as 10-25% of animals from a particular feedlot. The handling of wild range cattle on slippery abrasive surfaces of runways, chutes, cattle liners and cargo ships causes trauma to the hoof wall and sole of the foot. Severe lameness, usually of the hind feet, results from separation of the hoof wall from the sole at the toe of the foot. Infection of the soft and bony tissues of the digit cause significant pain to the animal. Many go off feed, lose condition, become downers and die, or are destroyed as a sequellae of the trauma and lameness. Examination of the feet after thorough cleaning while the animal is secured on a tip table is required for diagnosis and treatment. Treatment options are limited, and involve establishing drainage at the toe, blocking up non-affected toes, antibiotics and analgesics. Maintaining affected animals in clean dry surroundings with good footing is mandatory although may be difficult in most feedlot situations. Prevention is difficult: footing for cattle must be non-abrasive yet secure and non-slip, and wild cattle must be handled as calmly as possible. This requires excellent livestock handling facilities and experienced cattlemen.

In the analysis of feedlot records the failure to gain weight, the increased time in the feedlot, the increased care demands and drug costs, and the eventual loss of some animals as a result of trauma-induced lameness are significant economic losses to feedlot operations.

THE PATHOLOGY OF DIGITAL DISEASE

P.Ossent and C.J.Lischer*.
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Most structures of the digit are readily accessible or at least depictable and the disease conditions may be diagnosed satisfactorily at clinical examination. However, once the soft tissues encapsuled within the horn shoe are involved, the situation gets complicated.
Pododermatitis diffusa, or laminitis, is a processes which manifests in the soft tissues within the hoof. It has been recognized as one of the more important claw diseases and causes for lameness. The clinical signs may be most severe but the nature of the lesions is not visible to the eye or demonstrable by any other means. It is a major complication in the clinical recording of lesions in the hoof that changes within the vital tissues take weeks after the initial insult to emerge at the surface of the horn shoe. It is precisely with this problem in mind that the pathologist may make a useful contribution by demonstrating exactly why the cow was off its feed, why it was loosing weight or why it was lame. The post mortem examination may disclose lesions in different parts of the corium or inner surface of the horn shoe immediately after the onset of clinical signs.
The method of examination demonstrated here is of such simplicity that it is not restricted to the necropsy room but may easily be carried out on the farm yard on feet returned from the slaughterhouse; as feedback for the veterinarian and a useful demonstration for the farmer.
After the foot is immersed in hot water at 65°C for 30 minutes, the horn shoes are removed whole by clamping them in a vice and using the metacarpal or metatarsal bone as a lever. Hot water facilitates the procedure and substantially reduces the otherwise encountered mechanical and autolytic artefacts. The tissues are sufficiently well preserved to allow samples to be taken for histology.
Not only is the normally inaccessable complete surface of the corium exposed for inspection but also all the remainining structures within the horn shoe such as the deeper layers of the dermis, the bone surfaces, tendons, ligaments, bursa podotrochlearis and joints. The inspection of the innermost epidermal layers of the shoe is important for the estimation of the significance and age of lesions encountered in the vital tissues since this zone suffers alteration as soon as any process impedes the production of horn.
A spectrum of lesions which may be encountered within the foot at post mortem examination will be presented, whereby emphasis will be put on cases which presented with severe clinical signs leading to slaughter but where no outer changes were to be seen.

USE OF IMAGE ANALYSIS IN STUDIES OF LESIONS OF THE SOLE AND WHITE LINE IN CATTLE

K.A. Leach[1], *S.A. Kempson*[1], *D.N. Logue*[2], *and J.M. Randall*[3]

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Summerhall, Edinburgh EH9 1QH, Scotland

[2] The Scottish Agricultural College
Auchincruive, Ayr KA6 5HW, Scotland

[3] Silsoe Research Institute, Wrest Park
Silsoe, Beds., U.K.

A technique using image analysis of photographs has been developed to add objectivity to the assessment of sole and white line lesions. This method enables, first, accurate measurement of the extent of lesions on the distal surface of the claw, and second, standardisation of their allocation to different regions. At present severity of lesions can still be best assessed visually, and we consider that this subjective aspect of assessment is most representative when carried out on the animal, rather than from photographs. Various scoring methods incorporating lesion size and severity have been compared and used to monitor lesion development during the first lactation. The tendency for severe lesions to be relatively small means that severity must be weighted if it is to be combined with size into a score reflecting clinical significance. Haemorrhages of the sole and white line have shown different patterns of development between two and three months post-calving, suggesting that the timing of insults and/or responses may differ in the two regions.

Diagnostic Radiology of the Bovine Foot - The state of the art today.

Uri Bargai
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Introduction: The use of Radiology in Bovine Medicine is strongly connected to the following factors:

1) The type of Bovine medicine practiced in the specific herd. Bovine medicine,unlike equine or small animal medicine,could orientate itself to either herd medicine or individual cow medicine or both.In those practices or countries where Bovine medicine is herd medicine,the use of radiology for diagnosis of individual cow's problem is rarely if ever resorted to.
2) The size of the herds in the practice area.In smaller herds ,the individual cow has much more objective and subjective value to the farmer,and he will be more receptive to the offer by his attending veterinarian to use radiology for the diagnosis of his cows lameness problems.
3)The management of the herd. low level of management will resort very little or relatively little to veterinary assistance, and if will resort to it- only at the minimum possible cost.
4)The standard of the professional education of the veterinarian.It is only natural that a veterinarian will push in his practice the use of radiology in his diagnostic work if he himself was exposed to radiology techniques in bovine medicine when he was in school, and would not do so if not expose to it.

It is because of these factors that the use of bovine radiology is limited mostly to small and medium size herds which are found in countries with a high level veterinary education and to herds of good management and high production to justify the additional expense to diagnose and treat the lame cow. Bovine radiology is therefor seen in countries in western and central Europe , Israel, Canada and some of the states in U.S.A where the family herds are still predominant.

Nevertheless,with the increase awareness of the economical effect of lameness in the cow is ever on the increase. ,the use of radiology to diagnose the exact cause will increase. It is in view of this ,that radiology of the foot of the cow is an integral part of any symposium on the subject of bovine lameness.

Equipment:

All portable x -ray machines are powerful enough to produce a diagnostic radiograph of the bovine foot.The exposure range is 60 -75 kVp and 5-15 mAs. Metal cassettes containing rare earth intensifying screens are highly recommended, but normal fast (par) screen will do. processing could be done manually or in an automatic processor in a hospital ,if accessible.
needless to say that aprons and gloves are essential to all people involved in the procedure.

Procedures:

Although the bovine patient is mechanically restrained in a stanchion during radiography. the animal is less used to the handling of its feet than the horse.
Radiography of front feet, however could still be done without any sedation. Hind feet radiography usually requires a small amount of sedation which could be achieved by injecting Xylazin IV. A 2 cc dose will usually produce enough cooperation on behalf of the cow to enable radiography of the hind feet.

The examination of the bovine digit involves three standard views:
Anteroposterior designated as dorsopalmar or dorsoplantar according to the foot, straight lateral,and cranio caudal oblique either lateral or medial.This third standard view essential because of the overlapping of the two digits in the lateral view.

Indications:

Clinically,lameness originating from the foot of the cow can be either associated with or without swelling .Conditions associated with a non swollen foot lameness will nessecitate radiography more than the swollen foot lameness.These are usually fractures of P3, foreign body in the early stage,solar abscesses and hoof remodelling . Conditions associated with swollen foot lameness may be either digital cushion abscess, paronychia,septic arthritis ,osteomyelitis , fractures and complications due to foreign body.

Radiological examination of the lame foot is essential first and foremost for a proper evaluation of the case ,weather it is

treatable or not and if treatable -is it a medical or a surgical case, and if surgical- where is the best surgical approach in the affected part. **Because in cattle the decision on treatment of a patient depends always on comparison of the cost of it with the alternative value of the animal- radiology is indispensable.**

Proper evaluation of a radiograph must be based on a good knowledge of the anatomy of the foot.Good references for the normal radiographic anatomy are available in form of text books and articles.

A review of the normal radiological anatomy and radiography procedures will be presented, followed by selected cases of radiographic diagnoses of clinical cases of foot lameness.

THE AGING OF THE DISTAL PHALANX (PIII) - RADIOGRAPHIC CHANGES.

URI BARGAI
THE HEBREW UNIVERSITY OF JERUSALEM
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The distasl phalanx of the cow is the anatomical part which is subjected to trauma,concussion, préssure and infection more than any other part of the bovine animal. It is this bone that is most frequently radiographed for the diagnosis of lameness.Of great importence is to learn to recognize the changes that result of aging and "wear and tear" in this bone, in order to be able to distinguish properly between a diseased bone and normal aging one.

The following are the radiographic changes that are seen in Piii as the cow approaches 9-10 years of age:

1) Increase in size of the extensor process on the dorsal anterior aspect of the bone.
2) Periosteal proliferation on the dorsal edge of the extensor process.
3) Remodelling of the solar aspects of the bone and formation of bony irregularities along the lateral and medial margins of the bone.
4) Increased diameter of the vascular channels.
5) Calcification of tendons and ligamentous attachments to the bone.

These radiographic findings should be considered normal when radiographs of the lower bovine digit are examined.

THE DIAGNOSTIC VALUE OF ULTRASONOGRAPHY IN BOVINE LIMB DISORDERS

Dr.med.vet. Johann Kofler

Clinic of Orthopedics in Ungulates, University of Veterinary Medicine Vienna, Linke Bahngasse 11, A-1030 VIENNA; AUSTRIA
Head: O.Univ.Prof.Dr.P.F. Knezevic

In this report the use of sonography as an additional and very helpful method in the examination of locomotory system disorders in bovines is presented.
The classical examination of orthopedic bovine diseases up to the e present is based primarily on clinical examination, on exploring lesions with a probe, on centesis of diseased synovial cavities and other fluid filled swellings with followed by macroscopic and bacteriological examination of aspirated fluid samples. In soft tissue disorders radiographic findings are frequently insufficient. By centesis only fluent synovial content can be aspirated, on advanced septic arthritis and tenosynovitis in bovines, synovial content lose his liquid character and become thick due to the production of flocculent debris, coagulated fibrin masses, high viscous purulent exudate and necrotic masses.
The used real-time ultrasonic unit (Sonoscope 3®, Kranzbühler, Germany) is equipped with a linear- (7,5 MHz) and a sector-scan (5 MHz) and stand-off pads. Ultrasound scans were made in both transverse and sagittal planes of the region of interest. Ultrasonography was applied in various diseased limb structures in cattle and allowed a more definite diagnosis in disorders of:
- carpal-, tarsal-, stifle region (their joints, tendon sheaths and bursae) and pelvic region,
- digital flexor tendon sheath, metacarpo-/ metatarsophalangeal joint, proximal and distal interphalangeal joint. Suspected hematomas, abscesses and covered muscle-lesions of traumatic origin were further indications.

In consideration of the different echogenicity (anechoic, hypoechoic, hyperechoic) of synovial

inflammation products and of trauma induced fluid accumulations, they could be classified as slight viscous fluid (edema, sero-fibrinous synovial fluid, hemorrage), as highly viscous fluid (fibrino-purulent fluid, older hemorrage) or as semisolid or solid masses (coagulated fibrin-masses, adhesions, mature fibrous tissue).
By producing flow phenomena by moving the transducer, the different characters of viscosity (liquid, highly viscous, solid) of synovial content could be determined as well as by assessing the presence or absence of dorsal enhancement.
The diagnostic value of sonography results from the possibilty to obtain important additional information about the structure and composition of diseased soft tissue:
* helps to identify specific soft tissue structures,
* provides some appreciation of the extent and composition of fluid accumulations (edema, hemorrage, synovial fluid, purulent exudation, coagulated fibrin masses...),
* helps to differentiate rapidly between affected and adjoining unaffected structures (joints, tendon sheaths, bursae, muscles),
* allows a more appropriate centesis in some specific conditions,
* is more informative than often insufficient radiographic findings in soft tissue disorders,
* the procedure is quick, noninvasive and harmless to the patient and the operator.

The use of sonographic examination in bovine lameness is documented with typical examples of the above mentioned orthopedic disorders. Sonography is the imaging method of choice to visualize pathological involvement of limb soft tissue structures also in bovines.

LAMENESS IN DAIRY COWS - INCIDENCE IN ARGENTINA

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The findings during 1992, 1993 on 25 farms in the Provinces of Buenos Aires, Santa Fe and Cordoba (Argentina) with a total population of 4580 Argentine Friesian cows were reported.

The different parameters investigated were:

Incidence: 1071 (23.4%) in the first visit; decreasing in subsequent visits to 4.5%.

Season: the most frequent incidence of lameness in the herds studied was seen during May, June and July (end of autumn and beginning of winter) about two to three months post-parturition.

No. of calving/cow: 1st calving 45.1%; 2nd calving 19.0%, 3rd calving 12.8%, 4 or more calvings 23.2%.

Distribution of lameness: forelimb 136 (12.7%) and hind limb 935 (87.3%).

Diagnosis: Dermatitis digitalis 39.4%; Dermatitis interdigitalis 26.3%, Erosio ungulae 12.0%, Laminitis 10.0%, Sole ulcer 5.3%, Hyperplasia interdigitalis 3.2%, Pododermatitis septica 2.1%, Phlegmona interdigitalis 0.9% and Fisura ungulae 0.6%.

Culled cows: 3.5%.

TOXIC AND INFECTIOUS CAUSES OF LAMENESS IN CATTLE AND GAME SPECIES IN SOUTHERN AFRICA

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The toxic and infectious conditions described are restricted to those which can produce lameness by affecting one or more digits (part of the limb below the fetlock joint). Only those conditions which have been positively identified in Southern Africa will be mentioned. A list of these conditions are shown in Table 1.

Table 1. List of toxic and infectious causes of lameness found in Southern Africa

Cause	Agent involved
Toxic	Crotalaria spp
	Sweating sickness
	Pithomycotoxicosis
	Fluorosis
	Ergotism
Infectious	Foot and mouth disease
	Interdigital dermatitis
	Footrot
	Heel erosion
	Bovine virus diarrhoea/Mucosal disease

TOXIC CAUSES

Crotalaria spp.

C. burkeana and other *Crotalaria spp.* are responsible for outbreaks of acute laminitis particularly in cattle but sheep, goats, donkeys and wild antelope can also be affected. Based on the clinical signs the condition is also known as "Stiffsickness". This term has also been coined for ephemeral fever and aphosphorosus. The clinical signs are typically those of acute

laminitis, the claws being painful and warm with reddish discoloration of the unpigmented parts. Affected animals adopt a typical laminitic stance. The acute stage of the disease lasts a few weeks before becoming chronic. During this phase the pain decreases and the claws grow out abnormally becoming flat, elongated and turn up. Similar abnormal horn growth can be seen in cattle and game species suffering from foot and mouth disease.

Stiffsickness resulting from *Crotalaria spp.* has been described to occur in South Africa, Botswana, Namibia and Zimbabwe. It flourishes in wooded grassland or open sandy areas and spreads rapidly in old lands, trampled veld and disturbed soil. Under the latter conditions the disease can take on alarming proportions and it has been reported that up to 50% of cattle in such regions can become affected.

The toxin of *C. burkeana* is not known and the disease differs markedly from that caused by other *Crotalaria spp.* the majority of which contain the pyrrolizidine alkaloids.

Sweating sickness
Sweating sickness is a condition particularly seen in calves caused by a salivary protein ("toxin") carried by some of the strains of the tick, *Hyaloma truncatum*. The toxin leads to a severe inflammatory response especially of the skin with exudation hence the name "Sweating sickness". This inflammatory response is caused by a localised disseminated intravascular coagulopathy (DIC) which also affects the claws leading to clinical signs associated with acute laminitis. Affected animals treated with non-steroidal anti-inflammatory drugs and a specific hyperimmune serum recover without any complications.

Fluorosis
In Southern Africa drinking water from deep wells and the feeding of phosphatic rock supplements are mainly responsible for the development of fluorosis. Fluorosis occurs naturally in rock in association with phosphate. This can lead to toxic levels of fluorine in associated soils and water.

Chronic intoxication (Fluorosis) results in lesions of the teeth and bones leading to lameness, stiffness and a painful gait. Long bones are painful on pressure and may be palpably and visibly enlarged. Metacarpal, and metarsal bones and the phalanges are involved. Well defined exostoses results.

Pithomycotoxicosis
Pithomycotoxicosis has been incriminated in two syndromes which cause hepatogenous photosensitivity. These syndromes include facial eczema and "geeldikkop" (yellow thick head). However, in the latter condition it has now been shown that sapponins contained in the plant *Tribulus terrestris* are the main cause of the hepatic involvement leading to photosensitivity. The incriminating fungus *Pithomyces chartarum* is found in a wide range of conditions of temperature, moisture and substrate which include various pastures like rye grass, panicum and clover. Pithomycotoxicosis produce a photosensitivity induced coronitis which can cause lameness.

Ergotism
Ergotism is characterized by dry gangrene and sloughing of the skin of the feet, muzzle, ears and tail. It occurs particularly in cattle leading to lameness among other signs.

The disease is caused by *Claviceps purpurea*. In South Africa the fungus has been demonstrated to

grow on oats, barley and annual rye grass (*Lolium multiflorum*). The sclerotia of the fungus contain the alkaloids, ergotamine, ergometrine and ergotoxin which stimulate adrenergic nerves leading to vasoconstriction, thrombosis and infarction of the skin.

Endophytes causing "Fescue foot" and summer syndrome (marked by a high body temperature) have also been found on annual rye grass (*Lolium multiflorum*) and *Cynodon spp.*

INFECTIOUS CAUSES

Conditions of the feet of cattle and game species caused by *Fusobacterium necrophorum* and/or Dichelobacter (*Bacteroides*) *nodosus*

1. Infectious pododermatitis (Footrot)
A condition yet unnamed but similar to footrot in cattle and from which *Fusobacterium necrophorum* has been isolated (Dr V de Vos; Kruger National Park, personal communication), has been recognised in Elephants. Typically the condition is seen in old heavy bulls. Affected animals are recognised because of a single leg lameness. The lesion consists of a sole ulceration of various extent which may penetrate deep into the digital pad. One such case in a young orphaned elephant in captivity treated by the author responded well to treatment with topical antiseptic dressings and systemic antibiotics.
Footrot in cattle usually affects only one foot, most commonly that of the hind leg.
Mild to severe lameness and fever are commonly seen. Footrot extends from a interdigital dermatitis to form a cellulitis which cause swelling of the interdigital tissues and the heels and may extend up to the fetlock. Discharging sinus tracts may be present. Septic arthritis, tenovaginitis and osteomyelitis of the digital bones may result.

2. Interdigital dermatitis
Interdigital dermatitis is characterised by erosion and hyperkeratosis of the interdigital skin usually without fissure formation or extension into the deeper tissues and structures. The lesion is obvious at the heels and separation of the horn on the inner aspects of the heels occur facilitating entry of foreign material. In complicated cases animals may show mild lameness. Footbaths are used to control the condition.

3. Heel erosion
Characterised by lines of erosions that appear as black marks, circular craters or deep fissures on the plantar/palmar convexity of the heels. Lines of erosions can form V shaped clefts with the apex of the V pointing dorsally. Heel erosion is unimportant as a direct cause of lameness but can predispose to claw conditions eg. sole ulcer and laminitis.

Bovine virus diarrhoea/Mucosal disease
Lameness occurs in cattle suffering from Mucosal disease due to the presence of erosive lesions on the skin-horn junction, around the dewclaws and in the interdigital cleft commonly affecting all four feet. Coronitis and hoof deformities occur.

Foot and mouth disease
All cloven-hoofed domestic and game species are susceptible. Lesions on the feet result in lameness and affected animals tend to lie down. All four feet are usually affected where lesions develop in the interdigital space, bulbs of the heel and around the coronet. Secondary infection of ruptured vesicles on the feet occur commonly. Such infection may involve the deeper structures of the digit resulting in septic arthritis and other complications. Interruption in horn growth results in chronic claw deformities.

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ECO - PATHOLOGICAL STUDY OF LAMENESS IN DAIRIES IN TEHRAN AREA , IRAN

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Abstract:

During a period of 10 years (1980-89) clinical and environmental records from 7620 cases of lameness in 383 dairies (out of a total of 130475 cows) with obtained meteorological data were analyzed statistically and the seasonal patterns of the prevalence of lameness were calculated using time series procedure. The over all prevalence rate of lameness among all cows was 5.84 and the annual prevalence ranged from 3.90 to 7.94 percent. Three months moving average revealed the prevalence of lameness is significantly high in spring at each 10 successive years of study. Significant correlation between the rainfall and the prevalence of lameness was apparent. Digital lesions were responsible for 96.30 percent of all lameness. Through manipulating data the importance of nutrition, housing system in accordance with the occurrance of digital disorders were noticed. The specific seasonal distribution of lameness and the pattern of lesions under different nutritional management and housing system in dairies in Tehran area suggested that the approach to prevention and control could be achieved in dairies confronting with the lameness dilema.

FREQUENCY OF CLAW DISEASES IN APPARENTLY HEALTHY ANIMALS

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In 1993, 227 dairy cows and heifers on 21 farms in the Ormoz commune were examined for the purpose of establishing the frequency of claw diseases and disorders in apparently healthy animals. Our objective was to establish if pododermatitis aseptica was present in our commune. Because "extensive" dairy production is practiced in our commune, it was previously believed that this condition was not present.

We found in our investigation that 86 animals of 227 (37.89%) had some form of pododermatitis aseptica. In 20 animals (8.82%) we found typical changes for pododermatitis aseptica diffusa chronica. In all other cases we found different types of haemorrhages in the sole and, therefore, we concluded that all these animals fall into the category of pododermatitis aseptica diffusa.

Surprisingly, we found that 13.65% of the animals were in different stages of pododermatitis circumscripta. Most lesions were superficial. Only in two cases did we find the typical changes of profound pododermatitis, well known as ulcus Rusterholzi.

In 13.65% dairy cows and pregnant heifers we diagnosed erosio ungulae. In another 20.71% of the animals we established that early stages of erosio ungulae existed.

In some cases we found that the same animal had several different types of changes or disorders. Therefore, the claws of 57.71% (131 animals) of cattle under investigation showed pathological changes of clinical significance. We also evaluated the frequency of claw deformities in our population. Deformities were observed in 84.56% of the cattle under investigation.

The proportion between the frequency of diseases in forelimbs and hindlimbs was approximately 15:85. In the case of deformities the proportion was 60:40.

The statistical analysis demonstrated a positive correlation between inapparent claw diseases and care and age of the animal, as well as between deformities and the age of the cattle. Surprisingly, a negative correlation was established between deformities and claw care. It should, however, be noted that the relationship between the type of cubicle and disorders or deformities was hardly perceptible. This may have been because no simple and exact criteria by which to estimate cubicles have been elaborated. Despite this, inapparent disorders of the claw showed some relationship between frequency of the occurrence to the type of cubicles while deformities did not. It has been proved that the frequency of claw deformations increases significantly with aging of cattle (^{2} = 90,6448). No striking significance, however, has been found in other instances.

Summary

Our objective was to demonstrate the incidence of pododermatitis aseptica diffusa. In our investigation we found a high incidence of this disorder. The high incidence (37.88%) was a little disturbing, because our dairy herds are made up of 100% Simmentals with an average milk yield of about 4500 kg milk in a standard lactation. Because most cases of aseptic pododermatitis occurred around parturation, we think that under our circumstances this is the result of inadequate feeding during the dry period.

Apparently healthy animals were those that the owner described as being healthy.

We have established that under our circumstances we have various types of pododermatitis aseptica, many of which during the past few years we have diagnosed as being acute cases. This shows that during recent years, in our breed, because of selection and different type of feeding and higher milk production some claw diseases of which we were not previously aware are now being observed.

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BACTERIAL ETIOLOGY OF DISEASES IN THE FOOT ROT COMPLEX: RECENT RESEARCH AND NOMENCLATURE CHANGES

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Cultural studies were conducted on clinical cases of acute interdigital phlegmon (acute foot rot) in beef cattle and on clinical cases of interdigital dermatitis in beef and dairy cattle. As originally described by Berg and Loan (Am. J. Vet. Res. 36:1115, 1976) the etiology of interdigital phlegmon was a synergistic infection between *Fusobacterium necrophorum* and *Bacteroides melaninogenicus*. Since the time of the original report both species have been subdivided into three new species. Cultural studies of recent cases and of the original isolates indicate that the etiology should now be described as a synergistic infection between *Fusobacterium necrophorum* and *Porphyromonas asaccharolytica*.

Dichelobacter (Bacteroides) nodosus was isolated from the feet of cattle in seven beef and dairy herds in five states in the United States. The clinical diagnosis prior to culture was interdigital dermatitis. Serotyping of the *D. nodosus* isolates showed a diversity of serotypes. Concurrent culturing for *F. necrophorum* was conducted in the herds from two states (four herds) with recovery of the bacteria occurring from all feet cultured.

LAMENESS, A CONSTRAINT TO SMALL HOLDER DAIRY CATTLE PRODUCTION IN DEVELOPING COUNTRIES: AN OVERVIEW ON EAST AFRICA

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Lameness has become an important constraint to small holder dairy cattle production systems in East Africa. Digital diseases observed to be the major cause of lameness, include: Dermatitis interdigitalis, erosio ungulae, verucose dermatitis, laminitis and whiteline disease. Preliminary surveys indicate that the increase in lameness has coincided with the recently introduced "Zero grazing" and confinement management by small holder farmers. The farmers own 1 to 5 imported dairy breeds which are confined indoors due to lack of grazing space in urban and peri-urban centers and are fed on cut grass, crop residues and at parturition supplemented with concentrates. The aim is to supply wholesome milk to the homestead and the surplus is sold as a source of income to the family. The factors ascribed to the increase in digital diseases include poor housing, faulty feeding, nutritional deficiencies, lack of hygiene and drainage. Other factors include lack of knowledge on claw care and poor management. The economic losses incurred include reduced milk production, infertility and premature culling. Suggestions on development of sustainable systems aimed at increasing the availability of wholesome milk and reducing suffering caused by lameness in small holder dairy farms in urban and peri-urban areas in East Africa are made. This is necessary in order to improve the human health as well as national economy in the developing world.

BOVINE LAMENESS - A CELL CULTURE APPROACH

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The mechanical strength of the bovine hoof arises from keratinization of cells in the germinal layers of the epidermis. Histological examination of hoof tissues in calves and young heifers has identified occasional disturbances in this keratinization process which would result in ineffective hoof development, and may precipitate lameness when these animals come into lactation. We have developed a system for short-term culture of bovine hoof tissue which allows the investigation of epidermal keratinization. We have used this culture system to look at rates of protein synthesis by incorporation of [^{35}S]-methionine, and cell turnover by [^{3}H]-thymidine incorporation. Keratin has been identified by SDS-PAGE and western blotting. Fluorography of separated proteins has determined that keratin is being synthesized by the tissue in culture. Keratin was located by immunohistochemistry principally in the germinal epidermal layers; this coincides with the major site of protein synthesis as determined by microautoradiography. Preliminary experiments involving the addition of epidermal growth factor to the cultures have indicated that addition of this stimulus can alter the rates of protein synthesis in this cultured tissue.

The results suggest that hoof tissues cultured under these conditions provide a useful system for studying the acute regulation of epidermal keratinization.

BOVINE TOE ABSCESSES

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Summary

Toe abscesses were diagnosed in five Midwestern feedlot lameness outbreaks submitted to the Animal Disease Research and Diagnostic Laboratory during the 1992-93 winter. Affected cattle developed severe lameness from 3 days to 3 weeks after feedlot arrival. Close examination of feet revealed abnormal hoof wear, separation of the hoof wall from the sole, and drainage and swelling of affected feet. Treatment of the problem included corrective foot trimming to allow drainage and antibiotic therapy. Causes of the problem included abrasive and traumatic injuries which allowed bacteria to infect the foot. Hooves were softer and more prone to damage because of unusually wet weather conditions the previous summer and fall. Prevention tips include bedding rough surfaces and preventing traumatic foot injuries.

Key Words: Lameness, Toe Abscess, Infection

Introduction

An unusual lameness problem was observed in scattered Midwestern feedlots during the winter of 1992-93. Severe lameness developed several days to three weeks postarrival. Hind feet were usually affected, but front feet could also be involved in severe cases. Affected calves were gaunt and reluctant to move. Response to treatment was poor and some animals eventually died. Calves or tissues were submitted to the Animal Disease Research and Diagnostic Laboratory, Brookings, SD, for diagnostic assistance from five feedlots.

Materials and Methods

Calves and/or tissues with toe abscesses were received from five different feedlots with complaints of lameness problems during the winter of 1992-93

(Table 1). The calves were necropsied and affected feet were split on a band saw. Various tissues were collected for bacteriology, virology, histopathology, parasitology, hematology, and toxicology exams according to the decisions of the pathologist on duty. Cases selected for the study demonstrated variable degrees of abnormal hoof wear, separation of the sole from the hoof wall, and inflammation of the corium (vascular layer between the hoof wall and third phalanx [coffin bone]).

Results and Discussion

Toe abscesses have not been widely described in the literature. One previous report was found in the popular press describing toe abscesses in Kansas feedlots and a second report was found in a veterinary journal (VM/SAC 77:1385-1387, 1982). Cattle examined in this study came from different feedlots in the region served by the lab (Table 1). The origins of the affected calves included South Dakota and Montana. Various breeds were affected. Lameness developed from a few days to three weeks after feedlot arrival. Weights ranged from 500-700 lbs. The cases were presented to the lab between December and March. Morbidity ranged from a few animals up to 75%. Mortality was 7% in the worst group. Affected calves failed to gain and often finished behind penmates.

Clinical symptoms included severe lameness in affected legs. The lateral claws of the hind feet were most commonly affected, but medial hind claws and front feet also had lesions in some cases. The calves were usually gaunt and reluctant to move. Early examination of affected animals revealed abnormal wear of the hoof, extreme tenderness of affected digits, and elevated temperatures. As the problem developed, swelling developed at the coronary band and separation of the hoof wall and sole at the white line occurred. Untreated calves sometimes sloughed toes. Infection spread up the legs causing arthritis and cellulitis in some cases. Additional spread of infection to internal sites occurred in three of five cases.

Splitting the affected digits on a band saw revealed internal lesions including laminitis, osteomyelitis of second and third phalanges, arthritis, tendinitis, cellulitis, necrosis and abscessation of the third phalanx (P3), and sole abscesses.

Of the three cases cultured, *Actinomyces pyogenes* was found in affected digits, and *Bacteroides melaninogenicus* was found in two of the three cases. *A. pyogenes* and *B. melaninogenicus*, spread from infected feet, were isolated from the lung of one calf. Two cases were not cultured. These bacterial isolates are commonly found in suppurative processes of cattle. It is interesting to note that *Fusobacterium necrophorum*, a common isolate in footrot, was not identified.

No viral agents were identified in the tissues submitted. Liver selenium in one case was high, but not in the toxic range.

Weather conditions were unusually wet in the region in 1992. These conditions tended to soften hoof walls. When cattle were sorted, processed, or on rough abrasive surfaces, the hooves were quickly rasped away. As the wall of the hoof was worn away, the vascular area was exposed, providing an ideal portal for bacteria to enter the foot. Bacteria sometimes ascended the leg, following along vessels causing abscesses and cellulitis along the way. The sudden turning movements used by cattle when sorted may lead to tearing and separation of the hoof wall from the sole and further white line abscessation. Standing for excessive periods (during trucking) and other traumatic events will lead to softening of solar horn and solar hemorrhage. The hemorrhages in the horn form a point of weakness which can lead to solar penetration, sole ulcers, or white line abscessation. Rough, uneven concrete surfaces may also traumatize the feet leading to infection and abscessation.

Treatment of affected animals may include trimming toes to assist in drainage of exudate and antibiotic therapy. Early treatment is imperative because chronic infections respond poorly to treatment. Foot injuries can be reduced by handling cattle as quietly as possible, by sorting and processing cattle on dirt or deep sand, by replacing damaged surfaces, and by getting an accurate diagnosis for lameness problems.

Table 1. Toe abscess cases, 1992-1993

Case	Tissues/animals received	Feedlot location	Morbidity, %	Mortality, no.
1	1 live calf	SD	30	12
2	1 dead calf/amputated toe	IA	75	8
3	2 live calves	SD	1	2
4	3 dead calves	SD	1	3
5	2 feet	NE	5	2

Case	Bacteria isolated	Other lesions
1	*Actinomyces pyogenes*	Cellulitis, lung abscesses
2	*A. pyogenes/Bacteroides melaninogenicus*	Arthritis, tendinitis
3	*A. pyogenes/B. melaninogenicus*	Osteomyelitis, arthritis, lung abscesses
4		Sloughed hoof, osteomyelitis
5		Osteomyelitis,, nephritis

TREATMENT OF SPECIFIC DIGITAL LESIONS

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Lameness is a considerable problem in intensive dairy production all over the world. It is often a herd problem and the incidence may reach 100 percent. Nine out of ten lame cows have the causative lesion in the digital region (Russel et al. 1982). Clinicaly obvious claw diseases often account for only a portion of lameness problem because subclinical cases can be very substantial in number. Subclinical conditions can be identified and properly treated if there is program for regular functional claw trimming. However, due to lack of knowledge and experience, and to the nature of the problem, early treatment of digital diseases is often neglected or delayed. When the lameness is not detected early, the underlying process may advance to a more serious or chronic stage. Highly skilled professional treatment is then urgently needed. Advanced digital affections are very painful and, generally, animal welfare considerations must be evaluated in order to assess if the animal should be treated or culled.

A good anamnesis and careful clinical examination are important prerequisites for a correct diagnosis and subsequently for an adequate therapy and prognosis. In field practice the examination and treatment may be difficult due to insufficient restraint of the animal, lack of assistance and a miserable working environment. A functional crate or, preferably, a specially designed trimming box or table is a necessity for professional handling of most claw diseases. With such equipment the work will be safe both for the animal and for the veterinarian. Instruments for successful

treatment of claw disorders must up-to-date and well maintained. For painful, surgical treatment the veterinarian must be highly skilled in the application of a regional anaesthesia.

Regional intravenous anaesthesia

When a digital disease requires painful incisions or surgery, the claw has to be properly anaesthetized. Regional intravenous anaesthesia is effective and easy to perform. A tourniquet consisting of an approx. 50 cm long rubber tube or twisted rubber cord is tied firmly below the carpus of the front leg or below the tarsus of the hind leg. The hair over the digital vein is shaved with a disposable shaver so that the vein can be easily palpated. The vein is entered with a needle (1,0 - 1,2 mm) and after the haemostatic blood has drained, 20-30 ml of local anaestethic without adrenaline is infused. The needle should then be removed. While waiting for anaesthesia, 5-10 min, the leg is restrained and washed for surgery.

Specific digital lesions of the skin

The following lesions are chronic conditions of the digital or the interdigital skin. When the animal shows lameness or discomfort, surgical removal of the affection may be the best or only way of recovery.

Verrucose dematitis (digital dermatitis, interdigital papillomatosis) is a chronic proliferative process of the digital skin of which topical or parenteral medical treatment is insufficient (Rebhun 1980). The circular growth is most often located in the plantar aspect of the hind legs adjacent to the interdigital space. The size can vary from 0,5 - 10 cm in diameter with a thickness up to 4 cm. In large growths and if more than one claw is affected, the convalescense can be prolonged. Culling

instead of surgery has to be considered in severe cases.

Anaesthesia, restraint, and preoperative wash are performed. The whole affected skin area has to be completely removed. Do not "shave" away the top warts only. There is a potential risk of reinfection or recurrence if the growth is not completely removed. Small vessels can be recognized and ligated. However, for general haemostasis most commonly the whole area is cauterized. The adjacent area may be treated topically with tetracycline aerosole. The wound is covered with an antibiotic gauze or an antiseptic dressing. A compression bandage consisting of a thick gauze pad and an elastic gauze bandage is applied. The tourniquet is then released. The bandage should be exchanged next day and removed after another 3 to 4 days. During the convalescense of normally two to three weeks, the area shall be kept clean and topical antiseptic dressing should be applied regularly.

Interdigital hyperplasia (corns, fibrom) is a fibrous protrusion of the interdigital space. It is a result of chronic irritation of the interdigital skin causing inflammation of the soft tissue and splaying of the digits. Digital diseases which can be involved are; interdigital dermatitis, digital dermatitis, heel horn erosion, interdigital phlegmon and sole ulcer. Interdigital hyperplasia can also be provoked by incorrect claw conformation, which can be inherited or acquired from insufficient wear and absent or incorrect claw trimming. Moreover, a slippery uneven flooring (ie old slatts) is another potential risk factor.

After anaesthesia and preoperative measures, the protrusion is cut away in one piece, with a scalpel. The blade is most easily inserted from one end through the base, with the top of the blade first and the blunt part against the axial

wall of the digit. The hyperplasia is not well vascularized and the wound will have no large vessels in contrast to that of *verrucose dermatitis*. However, cauterization can be recommended for haemostasis. An antibiotic gauze or antiseptic dressing is covered with a compression bandage. The tourniquet is then released. The bandage is applied for about five days. Depending on the aetiology in the specific case, there is a risk for recurrence if the predisposing factors are not excluded. In chronic cases in which the distal interphalangeal ligament (cruciate) has been stretched, the digits have to be approximated for an even longer period than would be required for wound healing. A light antispetic bandage wrapped around the digits and/or a wire inserted through holes drilled in the axial walls of the toe of each claw will keep the digits together.

Specific digital lesions in the claw horn

Horn lesions can be related to defective horn formation or accidental trauma.

In laminitis, many histological changes have been demonstrated in the corium and epidermis of the affected digits (Andersson and Bergman 1981). The changes result in the growth of poor quality horn and in lesions appearing in the horn of the claws (Kempson and Logue 1993). Several of the most common digital lesions are associated with laminitis: sole haemorrhages, double sole, sole ulcer, white line lesions, heel horn erosion, abscesses, laminitic ring or band, horisontal fissures, etc. (Greenough 1985) The course of laminitic symptoms can most often be assigned to calving time and the debut of horn lesions are normally seen 2-3 months after the calving. Lesions discovered at even later period still have their etiology around calving. The weight distribution on the digits determines partly the localization and severeness of the lesion. Body temperature, the glutaraldehyde

test and the formol gel test can give an excellent prediction of the chronicity and the degree of inflammation and infection.

In treatment and prevention of these horn lesions functional claw trimming is of greatest importance. More chronic and severe lesions call for a more specific treatment, in addition to claw trimming.

Sole haemorrhages are most often found at claw trimming and considered as signs of subclinical laminitis. If no clinical symtoms are evident the operator should be cautious not to cut away too much changed horn. Functional trimming will be enough. However, if the animal is lame, or if fluid is exuding from fissures, the lesion must be explored further.

Sole ulcer, white line lesions, abscess in the white line or sole and heel horn erosion are more severe ditigal lesions which are the most common causes of lameness in dairy cattle and need special attention.

In more complicated cases with severe lameness the application of a torniquet and anaesthesia will relieve pain, give haemostasis and faciliate treatement.

Diseased horn is pared away until healthy horn appears. All undermined horn shall be explored and most often cut away. Attempts should be made to salvage as much of the outer as possible in order to sustain support for the claw. Healthy corium must not be damaged and the sharp hoof knife should be handled with the blunt top pressing down corium and cutting outwards. It is important to attempt to maintain the height and anglulation of the contralateral "healthy" digit.

Protruding granulation tissue, which most commonly occurs in sole ulcers, should be excised at the base. Necrotic and purulent tisssue must be completely resected.

If the animal, in addition to the local lesion shows general symptoms of infection, parenteral antibiotic and antiinflammatory therapy is indicated.

Blocks

In laminitis with complications, frequently one digit is considerably more affected than the the other; the medial digits in front legs, the lateral digits in hind legs. The healthy digit can be used as support to relieve the weight from the affected one. There are of course different ways to maintain load relief.

The oldest used block for load relief is a *wooden block* (thickness ≈ 20 mm) which is fixed with methy; methacrolate which is a two component acrylic (Technovit, Pedikit, Demotec). The healthy digit is trimmed to a correct angle and defective horn and foreign material is trimmed away. Note that the lateral wall must be clean. If the horn is soft and moist it must be dried before gluing. A hair dryer can be used. The components of the acrylic are mixed in accordance with the manufacturers instructions. A thin layer of the unmixed fluid is then brushed onto the surface of the sole. The mixed acrylic is then applied either on the digit or on the block. Then the block is pressed carefully to the right position. The toe of the block and that of the claw should match. The acrylic is moulded over the abaxial wall and a thin layer can also be puttied over the sole of the block to reduce wear. The hardening time is about 5 minutes at +20°C. At low temperatures below +10°C the technique is not recommended without external heating. Depending on humidity of the environment the block can stay in place for weeks or even months, if it does not wear down. Otherwise it can easily be trimmed off with a knife and hammer when desired.

The "Cow slip" (Giltspur Sci. Ltd) is a new

type of *hard plastic slipper* (thickness 13 mm). The slipper is fixed on the claw with a resin similar to that described in the technique above. It is made in one size with a left and right model, and the sole of the block is patterned. The advantage of the "Cow slip" is that the two component resin is mixed directly in the slipper, which is then applied. The toe of the claw has to be trimmed otherwise a digit with an abnormal shape will not fit into the slipper. It will stay for about 6 weeks before the resin fails.

Rubber blocks have been used for a long time. Prefabricated blocks (thickness 20 mm) have a number of holes at the toe and along the outer border. The block is nailed into the white line as in horse shoeing and the end of the nails is clinched into the wall. Nailing a block is independent of the temperature and humidity of the claw horn. The rubber block is elastic and will stay on for weeks until the rubber is partly broken or the block accidentally breaks off. If or when the block drops off it should be remembered that there will be danger to other animals from the nails that remain in the shoe. If nails remain attatched to the claw of the treated animal this is also a further hazard.

"Shoof"(Shoof Int. Ltd) is a *plastic shoe* which has a wedged heel (0.3-20 mm) and is tied to the claws. It is made in four sizes with three models of each; a left and right elevated and a normal. The elevated model acts as a block. The shoe will also relieve pain from the rear part of claw by the wedged heel. The claw must be in a correct shape to fit in the shoe. An enclosed bag with copper sulphate is placed on the lesion and an enclosed elastic gauze bandage is wrapped around the lesion and around the pastern up to the dew claws. It is important to use the bandage to prevent galling. The piece

of string can then be tied fairly tight and it is self securing. The shoe can be used several times. The piece of string, elastic bandage and copper sulphate bag can be replaced and are commercially available in a kit. The shoe acts as a protective bandage and can be kept on for 1-3 weeks under good conditions. It can be used in early stages of clinical laminitis when visible changes is not yet seen in the sole but the animal shows marked tenderness. It should not be used in more advanced cases of any digital disorder when the soft tissue above the coronary band is swollen.

With all types of blocks which transfer weight to a single digit, there is a potential risk for overloading. Despite this risk the technique to relieve pain from an affected digit by using a block seems to be the superior method for rapid recovery.

Bandaging

Bandaging of claws in field practice has been disputed (White et al. 1981). The objectives with bandaging are to;

- protect the lesions from contamination with microorganisms
- absorb serous or purulent exudate,
- maintain correct humidity and temperature,
- make air exchange possible,
- desinfect by applied topical dressing,
- compress for haemostasis.

If pus or other exudates are evident the bandage has to be changed before its capacity for absorbtion is exhausted. Failure to change a contaminated or wet bandage can result in complications or cause a new lesions. The difficulty is to make a durable bandage which is easy to apply, is waterproof, and at the same time ventilates. New types of rubber boots will

protect the bandage from outside contamination but will easily get humid inside. Older concepts where the bandage is protected with an impregnated sac of jute will still work satisfactory.

In less complicated cases there is no need for a bandage when the cow is kept in a dry location and the lesion is regularly checked.

The use and choice of topical dressing or ointment varies among practices. Copper sulphate and pine tar are often used and have very good qualities of impregnating horn and as an antiseptic.

Convalescence

The management and the environment are of great importance during convalescence. Many times in field practice, besides the primary lesion, the animal will develop decubital injuries resulting from recumbency. In order to prevent these injuries the animal must be kept on a dry soft foundation with space for free movement. Depending on climate and weather, pasturing should be considered. When the animal has to be stalled, the optimal location is a box with dry deep straw. For animals walking on concrete, manure contaminated alleys, banished to uncomfortable cubicles or tied under similar conditions, the recovery can be considerably delayed or fail.

Summary

With an appropriate treatment and good aftercare most specific digital disorders can be brought to recovery. However, when treatment is delayed and if deeper structures has got involved the prognosis is more uncertain; the convalescence period is prolonged, healing will be defective and a primarily less serious lesion may end up in bacteriaemia, septicaemia and death.

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EFFECT OF LONG-TERM ADMINISTRATION OF BOVINE SOMATOTROPIN ON LAMENESS AND LIMB LESIONS IN DAIRY COWS

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A matched case-control study was performed to assess associations between administration of a prolonged release formulation of bovine somatotropin (bST) and clinical lameness and limb lesions in dairy cows. Cows treated with bST for at least 2 lactations (cases) and nontreated dairy cows matched by herd, age, parity, and stage of lactation (controls) in 8 herds were evaluated for clinical lameness and limb lesions by two observers, using standardized scoring procedures. While a high proportion of the study cows were clinically lame (43%), no association was detected between long-term administration of sometribove and lameness. Of more than 20 types of limb lesions identified, 2 were positively associated with long-term bST use including superficial laceration of the tarsus and superficial swelling of the metatarsophalangeal joint. Femoral lesions and superficial lacerations of the femur were negatively associated with sometribove treatment.

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TREATMENT OF BOVINE LAMENESS WITH METACRESOLSULPHONIC ACID

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Treatment with metacresolsulphonic acid in a 25% water solution was evaluated in a clinical trial comprising different lameness infections in dairy cows.

1,480 cases were registered and classified as: Dermatitis digitalis, Dermatitis interdigitalis, Dermatitis verrucosa and Hyperplasia interdigitalis.

The following results were obtained from the clinical trials:

Dermatitis digitalis: over 678 cases, 522 (76.9%) were cured with only one treatment, and 116 (17.1%) cases needed a second treatment. Effectivity: 94.1%.
Dermatitis interdigitalis: over 424 cases, 363 (85.6%) cured with only one treatment and 42 cases (9.9%) needed a second treatment. Effectivity: 95.5%.
Dermatitis verrucosa: over 285 cases, 250 (87.7%) cured with only one treatment and 22 (17.7%) needed a second treatment. Effectivity: 95.4%.
Hyperplasia interdigitalis: a bandage with gauze soaked in metacresolsulphonic acid was applied over the surgical wound. This was repeated three times and a better healing of the wound was obtained.

From these results, it can be considered that metacresolsulphonic acid is a great help as a complement in the treatment of the different bovine foot pathologies, due to its hemostatic, antimycotic and antibacterial action and due to its stimulating the healing of wounds.

EVALUATION OF DICLOFENAC SODIUM AND SYNOVIAL FLUID TRANSPLANT FOR TREATMENT OF ASEPTIC ARTHRITIS IN BOVINES

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The study was conducted in 6 male calves of 9-12 months of age and weighing 75-100 kg. Acute arthritis of the carpal joint was induced in all the animals by intra-articular administration of 1 ml turpentine oil. Two animals served as control and in the remaining 4 animals intra-articular treatment of Diclofenac sodium (50 mg) in combination with fresh homogenous synovia (2 ml) was carried out on 5th and 12th post-induction days. Typical clinical signs such as lameness, joint effusion, arthralgia, reduced joint mobility, positive flexion response, increased knee circumference and loss of weight bearing persisted throughout the observation period of 3 weeks in untreated control, but these symptoms subsided gradually in treated animals. Altered synovial fluid constituents such as mucin clot quality, relative viscosity, total leucocytic count, glucose and total proteins returned to the base value in treated animals, however, normalisation in these parameters was not achieved in untreated control.

PRELIMINARY OBSERVATIONS ON THE APPLICATION OF COWSLIPS AS ADJUNCT TO TREATMENT OF LAMENESS IN DAIRY COWS

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Cowslips are orthopedic shoes developed as an aid in the treatment of lameness in cattle. They are fitted to the healthy claw of the affected foot and thereby remove weight from the diseased or injured claw. A major advantage of cowslips over wooden blocks is speed of application due to a specially developed methylmethacrylate resin that sets up much more rapidly even in cool weather conditions. The unique hoof-like design of the cowslip increases the surface area for the adhesive material. Thus, when the hoof sole and wall are properly prepared prior to application, cowslips will remain in place for several weeks. Preliminary data from 15 observations of cowslips used as an adjunct to therapy of lame cows in a Florida dairy demonstrated an improvement in milk production (over a 7-day period) of 16.8 lb/day for cows in early lactation and 7.2 lb/day for cows in late lactation.

TREATMENT OF BONE AND JOINT INFECTIONS

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Diseases of bone and joint are commonly encountered in cattle of all ages. By making appropriate choices among available treatment options, the veterinarian can often make the difference between complete restoration of function, resolution of disease with a tolerable decrease in function, and progressive disease and/or disfunction leading to loss of use. Aside from fractures, infection is the disease which places the greatest demands on the attending veterinarian for rapid and effective selection among treatment options.

Infections of bone and joint occur as a result of tissue invasion by pathogenic organisms, followed by microbial proliferation and tissue destruction. The tissue destruction occurs as a direct result of microbial toxins and byproducts, and as a result of the host inflammatory response to the invading organisms. Effective treatment must both eliminate inciting organisms and minimize deleterious tissue destruction. An understanding of the pathophysiology of osteomyelitis and infectious arthritis is important if this goal is to be achieved.

Bone and joint infections may be caused by bacteria, spirochetes, chlamydia, fungi and viruses. "Septic" arthritis or osteomyelitis refers to infections by pyogenic bacteria, the most common causative agent in bone and joint infections. Infectious agents gain access to bone and joint by one of 3 main routes; the circulation (hematogenous), extension from an adjacent infection, and direct inoculation. Knowledge of the route of contamination is useful in predicting the types of organisms involved, the likelihood of multiple sites of infection, the amount of structural damage to expect, and

the need for ancillary treatment.

Hematogenous spread of bacteria typically occurs in young calves, reflecting a combination of the immature immune system, more permeable mucosal barriers, and a uniquely susceptible vascular anatomy. As the physes and joints develop, hairpin turns with sluggish flow and limited phagocytic ability combine in immature calves to promote localization and growth of any bacteria which have gained access to the circulation. Hematogenous infections are often multifocal, particularly in calves less than 1 month of age. Therefore, identification of one site of infection in neonatal calves should prompt close examination of all joints and bones for additional sites of infection, as well as a thorough evaluation for a source of the septicemia (including lungs, intestine and umbilical remnants). Hematogenous infections are typically monomicrobial in nature, and a limited number of organisms are commonly encountered. *Salmonella spp.* and *Actinomyces pyogenes* are the two most common organisms identified in association with hematogenous bone and joint infections in calves, with *Salmonella spp.* most commonly isolated in calves less than 12 weeks of age and *A. pyogenes* more commonly responsible for infections in older calves. Other organisms commonly recognized in association with hematogenous infections include *Streptococcal species*, *E. coli*, *Klebsiella*, *Proteus*, *Fusobacterium necrophorum*, and *Mycoplasma bovis*. Less commonly implicated organisms include *A. bovis*, *Staphylococcus spp.*, *Erysipelothrix spp.*, *Brucella spp.*, *Haemophilus spp.*, *Bacteroides spp.*, *Chlamydia spp.*, *B. burgdorferi*, and rare viral agents.

Bone and joint infections secondary to spread from a contiguous infection or direct inoculation can occur in any age ruminant. Such infections are commonly solitary in nature and are often associated with loss of structural

integrity of bone and or joint. Infections developing by extension from adjacent infection will typically be monomicrobial or involved synergistic organisms. Treatment must not only deal with the local bone and joint infection, but must deal with the adjacent infection and try to restore the integrity of the joint capsule and or periosteum. With the exception of infections resulting from accidental contamination during arthrocentesis, direct inoculation often involves major tissue damage (fracture, laceration into the joint) and involves multiple organisms and foreign material, with similar treatment considerations.

Treatment of infectious osteomyelitis and arthritis should focus on 3 goals: 1) elimination of causative agents; 2) elimination of inflammatory cells and debris; and 3) prevention of further damage. The main tools in treatment are antibiotics, drainage and immobilization/stabilization. While antibiotics are an essential part of treatment for any non-viral bone or joint infection, it is crucial to remember that the infectious agents is responsible for only a limited amount of the damage cause to osseous and articular structures. Therefore, antimicrobial therapy should never be considered sufficient as the sole method of treatment. Attention to drainage and stabilization are equally important in therapy and failure to address these areas effectively can result in a costly and potentially needless treatment failure. In addition, the importance of early treatment can not be overemphasized. Irreversible and irreparable tissue damage occurs within 48-72 hours of joint infection, and any delay in initiation of the components of treatment can drastically decrease the likelihood and quality of recovery.

Effective antimicrobial therapy depends on selection of an antibiotic which is effective against the organisms involved, penetrates

effectively into the tissues affected and is active in the environment of the infection, and on maintenance of antimicrobial levels for long enough to allow complete elimination of all involved organisms.

The first step in effective treatment is to select an antibiotic which has an effective spectrum of activity. While initial antibiotic selection must often be made before knowledge of the causative agent is available, continued antibiotic selection should, whenever possible, be based on results of a culture and sensitivity or, at least a Gram-stain. On occasion, identification of the causative agent is not possible due to inability to obtain a representative sample or lack of organism growth in culture, often due to prior initiation of antibiotics. When specific information on the causative agent is lacking, an intelligent choice can be made by recognition of the typical organisms identified based on knowledge of the route of contamination and age of the animal as described above. For infections involving mixed infections or multiple possible organisms, broad spectrum coverage is indicated.

Selection of an effective spectrum is only the first step in selecting an appropriate agent. The antibiotic must then be able to reach the microorganisms and maintain their efficacy at the site of infection. In general, most antibiotics which achieve high circulating levels will also cross the synovial membrane, with or without inflammation, will enter the joint in effective levels. This is not necessarily true for infection of bone. Penicillins, cephalosporins, aminoglycosides, lincosamides, fluoroquinolones and rifampin will generally attain levels in bone which exceed minimum inhibitory concentrations for susceptible organisms. Accumulations of fibrin may present a formidable obstacle to adequate drug-organism access. Most antibiotics have decreased penetration into areas surrounded

by fibrin, although rifampin and the quinolones are known to penetrate into abscesses in effective levels and to remain effective in the abscess environment. The local tissue environment also can present an obstacle to effective drug-organism interaction. Many drugs are less active in the presence of necrotic debris and the acidic environment associated with tissue necrosis. Gentomycin, for example, is most effective in an alkaline environment and can be expected to be relatively ineffective in the inside of an acidic environment. For many of the reasons described above, drainage should be a primary treatment goal for treatment of infections with localized necrosis and abscesses whenever possible.

The routes and timing of antibiotic administration are also an important consideration. In order to achieve tissue levels rapidly and to maintain them at a high level, agents should be administered by the IV route during the initial treatment period. Due to the somewhat protected environment and potentially restrictions in drug-organism contact, organisms frequently persist in sites of bone and joint infection for extended periods of time. Treatment of either bone or joint infection is routinely continued for a minimum of 4-6 weeks, with IV therapy continued for at least 2 weeks, and often for the entire period. Prolonged IV treatment is often impractical in food animals, but initial treatment by the intravenous route for at least a week should be considered if at all possible for the best possible outcome. Intra-articular infusion of antibiotics has gained favor in some circles based on the theoretical advantage of improved local antibiotic levels and the potential for use of an effective but potentially toxic or expensive agent with less risk of systemic toxicity or at a lower dose than would be required if administered systemically. Potential

disadvantages include increased local tissue irritation and limited penetration of subsynovial tissues. While intra-articular administration of antibiotics may prove to have some advantage as an adjunct to systemic antibiotic therapy, the agent should be selected with recognition of the potential for synovial irritation and used in conjunction with a compatible systemic agent.

Ultimately, the principles of appropriate pharmacologic therapy must be combined with practical management and economic considerations in selection of drug therapy for bone and joint therapy. This often results in a conflict in choices. As an example, the relatively inexpensive aminoglycosides are considered to have excellent *in vitro* efficacy against Gram-negative organisms but have poor activity in the presence of the necrotic debris and acidic environment encountered in the septic environment. Similarly, the economically favored procaine penicillin has good spectrum against Gram-positive organisms and has a low enough cost to be continued for the required time for effective treatment, but the procaine form achieves less effective levels in bone and joint than do the more expensive sodium and potassium salt forms. Initial broad spectrum activity is indicated pending results of culture and sensitivity. Cephalosporins (eg., ceftiofur) and fluoroquinolones (eg., mycotil) may provide the best combination of efficacy, penetration and cost, although *in vivo* efficacy has not been confirmed in treatment of bone and joint infection in cattle. Alternatively (recognizing some limitations), a combination of a Beta-lactam antibiotic (penicillin or ampicillin) with an aminoglycoside, oxytetracycline, or potentiated sulfas have been used with reported clinical success.

Control of inflammatory damage involves use of effective anti-inflammatory therapy and drainage. While use of non-steroidal

antiinflammatory drugs (NSAIDs) such as aspirin and phenylbutazone are somewhat controversial, they have a number of distinct advantages in treatment of both bone and joint infection. Not only do they improve comfort and decrease inflammation, they specifically decrease prostaglandin mediated bone lysis, potentially decreasing the amount of early bone destruction. Caution should be used in instituting NSAID therapy in prior to effective stabilization of unstable fractures. Debridement and/or drainage/lavage are extremely important components in treatment of almost all bone and joint infections to relieve pressure and remove potentially destructive inflammatory debris. One exception would by for treatment of acute diffuse osteomyelitic lesions which have not yet localized. Attempted debridement at this stage is unlikely to completely remove all affected tissue and may disrupt developing host localization. The second exception occurs in periarticular bone infections in which debridement is mechanically impossible without risking entry into the joint.

The final consideration in treatment of bone and joint infection is prevention of further mechanical injury. If the infection is associated with a fracture or ligamentous injury, mechanical stabilization is an essential part of treatment. Immobilization may play an important role in stabilization, although prolonged immobilization can have detrimental effects in treatment of infected joints. While immobilization can decrease the amount of mechanical trauma to joint surfaces, it also impairs venous and lymphatic drainage from the joint and can promote formation of mechanically limiting fibrous adhesions. As a thumb rule, controlled mobilization should be encouraged as soon as possible after definite improvement in local inflammation and pain can be demonstrated. If mobilization results in an increase in pain or

swelling, then immobilization should be resumed.

Successful treatment of bone and joint infection in cattle depends on early recognition, accurate identification of the organisms and tissues involved, rapid initiation of aggressive therapy addressing the 3 therapeutic goals described, and continuation of therapy for long enough to completely resolve the lesion. As veterinarians, we do not always see affected animals in time to prevent permanent damage or even, in some cases, to overcome progressive damage. Nonetheless, recognition of the pathophysiology of infection and attention to the therapeutic goals can lead to successful management in many cases.

PHARMACOKINETICS OF CEFAZOLIN IN BOVINE SYNOVIAL FLUID FOLLOWING INTRAVENOUS REGIONAL INJECTION

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The technique of intravenous regional administration of drugs has been utilized in man and animals for many years to produce regional anesthesia, or combat sepsis in an extremity. The potential advantages for the use of this modality include the distribution of drug in high concentrations within a limited area in the vicinity of the infection, the avoidance of detrimental effects of certain drugs upon the synovial tissues of a joint, reduction of cost related to the use of smaller amounts of antibiotic utilized, and the potential for minimizing withdrawal times relative to lower dosages of drugs being used to treat the infection. Previous studies have not addressed the pharmacokinetis of a single dosages calculated to meet the antibiotic requirements of an isolated limb. This study was designed to provide information on antibiotic pharmacokinetics of synovial fluid following the administration of a single, calculated dose of drug given intravenously distal to a tourniquet applied to the hind limb of cattle.

Ten healthy Hereford cross cows were randomly assigned in a crossover design for trials 1 and 2. A catheter was placed in the tibiotarsal joint for serial sampling of synovial fluid and a catheter was placed in the lateral saphenous vein to facilitate the administration of the antibiotic. A pneumatic tourniquet was applied proximal to the tarsus and monitored to ensure its function. 250 mg of cefazolin was injected into the saphenous vein, samples were collected

from the joint catheter, and stored at -20°C until assayed. In trial 1, samples were collected at 0, 0.25, 0.5, 1.0, 1.5, 3.0, 5.0, 8.0, and 12 hours after injection, the tourniquet remained in place for the duration of the sampling period. In trial 2, samples were collected at time 0 and 2.0 hours following antibiotic injection whereupon the tourniquet was removed and samples collected at 0, 0.25, 0.5, 1.0, 1.5, 3.0, 5.0, 8.0, and 12 hours after tourniquet removal.

In trial 1, the cefazolin concentration increased for the first 0.5 hour and then was maintained between 54.7 μg/ml and 73.2 μg/ml. In trial 2, the cefazolin concentrations decreased similar to first-order, one compartment model elimination. Following tourniquet, the synovial concentration rose to 142.4 μg/ml and remained above 8 μg/ml for 4 hours and reached undetectable concentrations by 8 hours. The average elimination half-life was 0.82 hours.

STRUCTURE AND FUNCTION OF THE DIGIT

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THE CLAW

The claw comprises the capsule (hoof or epidermis) and everything it contains. This includes the distal phalanx, the distal part of the middle phalanx, the distal sesamoid bone, the podotrochlear bursa, the joint ligaments, the terminal parts of the extensor and flexor tendons. The capsule also embraces the vascular corium as well as the subcutis which is modified at specific locations to form the coronary and digital cushions.

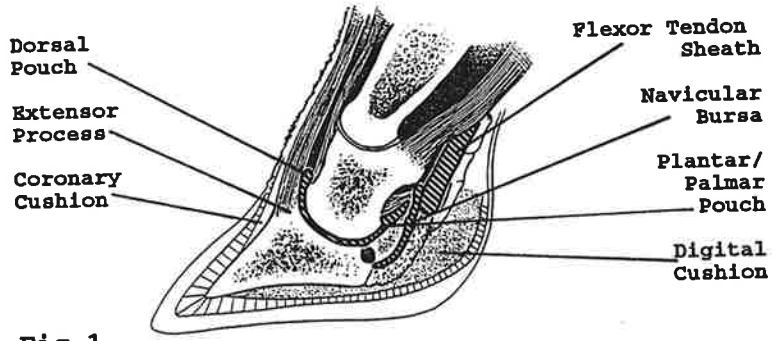

Fig.1

The Distal Interphalangeal Joint

The distal interphalangeal joint (DIP joint) is almost totally embedded in the claw capsule. The joint comprises the distal and intermediate phalanges.
The distal phalanx should not be referred to as the P3 or coffin bone. The anatomical

relationships of the synovial spaces are important to understanding the pathogenesis of infection of the DIP joint. The dorsal pouch of the joint capsule is protected dorsally by the extensor process and its tendon (Fig 1). However, it can be seen that the dorsal pouch is vulnerable axially through spaces between the dorsal elastic ligament and the distal interphalangeal ligament (Fig 2).

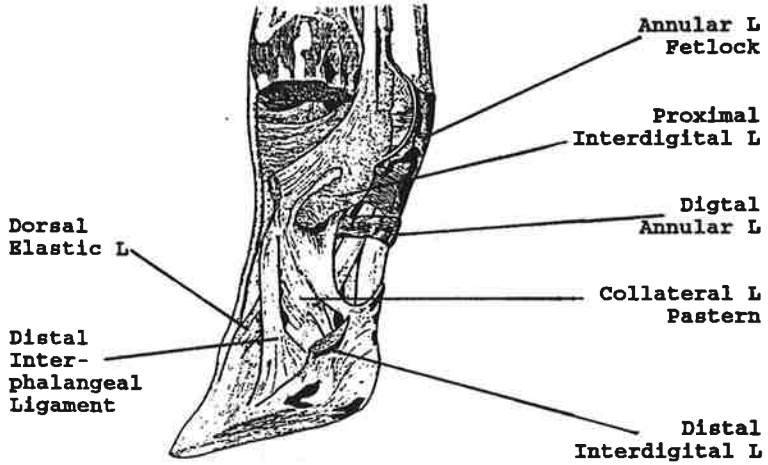

Fig.2

Complicating infections that are sequels to Interdigital Phlegmon enter the joint via this route.

Similarly, on the abaxial surface of the joint, the dorsal pouch is vulnerable between abaxial collateral ligaments and the insertion of the lateral digital extensor (Fig.3).

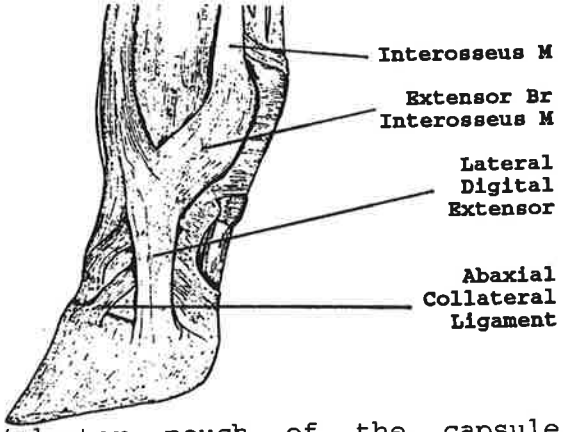

Fig.3

The palmar/plantar pouch of the capsule extends into the ***Retroarticular Space.*** This space is deep inside the digit but is the crossroad for infection either coming from the joint or the bursa. This is the location of the retroarticular abscess which is a common complication of Avulsion of the Zona Alba (white line disease). The third serous structure in the region is the sheath of the deep flexor tendon which can also become involved in deep-seated infections.

The abaxial collateral ligament and the insertion of the lateral digital extensor of the lateral hind DIP joint of some cows respond to mechanical stress by the deposition of periarticular exostoses. The depositions cause sufficient pressure on the coronary corium to promote accelerated growth of the abaxial wall and the development of a corkscrew claw.

The distal interphalangeal ligament (cruciate ligament) can also be subjected to great tension in heavy animals. On radiological examination bone proliferation can be observed

at the various insertions of this ligament in the distal and intermediate phalanges as well as the distal sesamoid. These changes are observed in cases of interdigital fibroma in beef breeds.

The Claw Capsule (Epidermis)

a) The Coronary Segment

The claw capsule is continuous with the epidermis of the skin above the coronet. The coronary band and part of the hoof wall distal to it is covered by the stratum externum or periople. The periople is generated at the skin horn junction. Although normally soft and pliable, the texture and appearance of the layer will alter with age or as the result of a disturbance in horn growth. A rough frayed periople may be an indicator of a chronic metabolic disturbance.

Beneath the coronary band is the coronary cushion which is a network of elastic tissue and veins. The cushion may function as a pump when the intermediate phalanx squeezes the structure during locomotion and aids perfusion of blood through the corium. This may explain the importance of exercise in maintaining good claw health, particularly in growing animals.

b) The Parietal Segment (hoof wall)

The distal border of abaxial wall of the hoof capsule is the true bearing surface of the claw. The bearing surface at the abaxial bulb/wall junction receives the first impact of each step and consequently wears more rapidly than other areas of the true bearing surface. The abaxial wall merges with the

axial wall at the dorsal flexure of the capsule. The axial wall is much thinner than the abaxial wall and plays no part in weight bearing.

The modified epidermis of the claw wall is generated at the coronary band at a rate of 0.5 cm (0.3 to 0.7 cm) per month and moves distally to be worn away at the bearing surface. Faint ridges (rugae) in the claw wall run, more or less, parallel to the skin/claw junction (limbus). These ridges diverge slightly towards the heel reflecting a more rapid rate of growth/wear in this region. Changes in the quality of the ridges occur as the result of changes in the metabolism of the animal. These changes may be associated with alterations in nutrition or related to stress or a disease process.

Temporary reduction in horn production results in the appearance of a groove running more or less parallel to the coronary band. The stress of weaning and associated procedures, particularly of beef calves, produces such a groove. The groove may be referred to as a 'hardship groove'. The groove grows out at the average rate of 0.5 cm per month. Therefore, it is possible to calculate the approximate date at which the animal was subjected to the stress that caused the groove. This is an extremely valuable diagnostic tool.

c) **The solear and heel segments**

- **The Heel (Torus)** The horn of the rounded bulb is soft and flexible. The heel is attached to the wall at the axial and abaxial grooves. It covers the digital

cushion which is a fibro-elastic complex that functions as part of the digital shock absorbing system. The horn may become overgrown (overburdened) due to lack of wear associated with the pain in the digit. It is also subject to erosion which disrupts the balance of the claw which in turn may lead to mechanical damage to the sole and zona alba.

- **The Sole** The bovine sole is leaf-shaped and merges imperceptibly with the bulb. The periphery of the sole adheres to the wall by means of the zona alba (white line). Change of color to yellow or pink is an indication that laminitis may be present.

The tubules of the sole are fewer in number than in the wall (about 40 per mm^2) and run parallel to the dorsal wall of the claw. If the tubules become filled with blood it will have a striated (paint brush) appearance. This is usually indicative of a lamanitic event.

In the normal claw the horn is thicker at the sole heel junction than it is at the apex of the sole. Excessive wear or inappropriate hoof trimming may reduce the thickness at the heel/sole junction to such an extent that mechanical damage can occur in the area. It should be noted (Fig.1) that the distal surface of the distal phalanx is concave. The plantar/palmar process is relatively close to the sole. If the sole in this region becomes thin a sole ulcer can result.

The Corium

The corium forms the germinative bed place of the claw which consists of strata

granulosum, lucidum, spinosum and corneum. The characteristics of the cells in these strata vary significantly depending on the region of the corium of the claw. The corium forms papillae which interdigitate with the openings of the tubules.

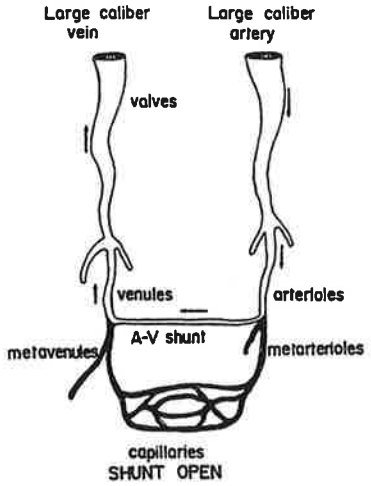

Fig.4

The corium is extremely vascular. Arterio-venous shunts (bridges) which are operated by smooth muscle provide control to the flow of blood into the capillary bed (Fig.4). This mechanism may function to equalize pressure inside the claw during weight bearing. It may also have a role to play in controlling the temperature of the claw.

A second pressure control mechanism is provided by the glomus bodies. These structures are also bridges between the arterioles and venules but they are capable of considerable dilation and are under the control of smooth muscle. It has been hypothesised that the smooth muscles in the AV-shunts and glomus bodies may be made inoperative by vasoactive toxins. This may initiate a cascade of events that cause permanent damage to the tissues of the corium.

The Sub-cutis

The sub-cutis is a network of fibro-elastic tissues that function as a supporting structure for the corium. The periostium is absent on the distal phalanx which acts as the base from which the fibroelastic network is suspended. The sub-cutis is specially modified in two regions.

BLOOD SUPPLY TO THE DIGITAL REGION

Arteries

The digits of the forelimb (thoracic limb) receive the bulk of their blood supply from the median artery which flows into the palmar common artery before dividing into the palmar proper axial digital arteries II & IV. The palmar common artery lies on the medial tendon groove in close proximity to the medial metatarsal nerve. Because this vessel is substantial and superficial, particularly in the distal portion of the medial tendon groove, extreme caution should be taken in placing needles for regional nerve blocks.

The palmar proper axial arteries enter the axial face of the distal phalanx to form the terminal arch which curves around in the depth of the bone to emerge and anastomose with the corresponding palmar proper abaxial arteries. Small vessels radiate from the terminal arch and those exiting at the distal border of the bone form the marginal artery (circumflex artery) which lies in the angle between the sole and the wall. The corium of the sole and a large portion of the wall are supplied from this artery. Widened vascular channels and a tortuous course of the terminal arch were present in the digits of the front limbs of barley fed beef cattle (MacLean,

1970). Constrictions in the arteries radiating from the terminal arch were found by Morcos (1960) to be present in dairy cattle suffering from sole ulcers. Angiographic studies of hooves of horses affected with chronic (Ackerman et al, 1975) or acute laminitis (Coffman et al., 1970 and Hood et al.,(1978) showed irregularities in the appearance of the terminal arch. Boosman (1989) postulates that mural thrombosis may occur during episodes of sub-clinical laminitis and that organisation of this mural thrombus could be considered as a possible cause of intimal proliferation and arteriosclerosis.

The digits of the hind limb (pelvic limb) are supplied mainly by the dorsal metatarsal artery which anastomoses with plantar common digital arteries of III and IV before bifurcating to form the plantar proper axial digital arteries of the digits. The latter arteries enter the distal phalanges and are distributed as described for the forelimbs. Care should be taken in introducing a needle into the proximal interdigital space because the risk of entering the arterial complex at this point is quite significant.

Veins

In each digit the veins are situated more superficially than the arteries; that of the pes draining into the lateral saphenous vein; that of the manus to the palmar common digital vein which drains into the cephalic vein. Although not constant in location the palmar and plantar proper digital veins run subcutaneously dorsal to the dew claws; the dorsal common digital vein is located more or less on the axis of the limb. The saphenous

vein is subcutaneous as it crosses the hock. These superficial veins are ideal sites for intravenous regional nerve blocks or intrevenous antimicrobial regional therapy.

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RESPONSIBLE PAIN MANAGEMENT

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There have been many developments in the knowledge of the generation and control of pain over the last few years. These developments have been of utmost importance, because although we have a range of drugs which can provide adequate analgesia, it is the knowledge of how and why pain occurs which allows us to utilize these drugs to the best advantage. There have also been developments in our understanding of pain in animals. The main difference in the perception of pain in man and animals does not seem to be in the generation or perception of the pain, but in the behavioral response. What this means is that animals feel pain as much and in a similar manner to humans, but they just don't jump up and down and make such as big a fuss about it as we do. The bottom line on these studies of pain in animals is that, if in our opinion a procedure would be painful if done on us, then as veterinarians it is our duty to provide adequate analgesia to the patient. Where then does this fit in with the program on bovine lameness? Well the first thing is that the pain perception involving the bovine foot is quite complex, mainly because of the insensitive nature of the horny outside layers of the hoof, compared to the very high sensitivity of the inner parts of the foot or the interdigital region. The various regions of intermediate sensitivity give an enormous range of pain perception within a relatively small area, and in the majority of cases a mixture of these sensitivities will be involved. Basically what this means is that two similar but slightly different procedures could give rise to two very different pain intensities. What we can do is to look at the range of agents we have available and look at how they work. Then we can consider how pain is produced under different circumstances and try to match the pain to the analgesic for the best effect.

The range of agents which can be considered for analgesia under the circumstances of bovine lameness fall into three main groups. These are agents which work

locally, the local anaesthetics; agents which work peripherally, mainly the non-steroidal anti-inflammatory drugs, and finally, agents which work centrally and are mainly the opioids and the alpha two adrenergic agonists. Each of these groups of drugs have particular advantages and disadvantages and we can try to relate their use to the type of pain encountered.

If we now consider the pathogenesis of pain, perhaps we can make some useful connections with the various analgesic drugs available. Firstly, let us consider what we mean when we refer to 'pain'. There are really two main divisions in the term 'pain'. These can be called physiological pain and pathological pain. The first is the sort of pain which serves as a sensory warning that damage has just occurred, which we are all familiar with, and hence we can apply the term physiological. It is a process which helps an animal survive and thus it could be regarded as advantageous. The second, or pathological pain, can arise as a result of some traumatic incident or disease process within the body, but sometimes, as we know from human studies, it can occur in the absence of any tissue damage. This latter form is known as neuropathic pain and can be very difficult to treat. There are several differences in the two types of pain, in that physiological pain will often disappear shortly after the stimulus is removed, whereas pathological pain normally continues and even increases even though the damage is constant; also physiological pain is often directly associated with the location of the stimulus whereas pathological pain is often diffuse or referred to another area.

This leads to the question, if pain exists do we want to eliminate it totally or should we be trying to eliminate the pathological pain while leaving the physiological pain mechanisms intact so that we can get the best of both worlds. Clearly this could be a useful aim; the problem is, it is almost impossible, with the drugs available, to draw this fine line in animals.

When we are considering clinical cases such as lameness, we first must ask ourselves how much pain is there and where it is coming from. For instance, if a foot has a grossly infected and inflamed lesion, then the nature and pathogenesis will be different from either a chronic low grade arthritis or a bad cut on the heel from

broken glass. This is because when damage first occurs, the pain can generally be classed as acute and physiological, and correction of the lesion and short term analgesia will suffice. However, if damage is allowed to continue then the damaged tissues release chemicals such as prostaglandins and kinins, which in turn increase the sensitivity of the pain receptors around them, causing an increase in the area from which pain is felt. In addition, these chemicals can cause receptors which normally respond to touch to become pain receptors. This process is called hypersensitivity or hyperalgesia.

The second and really fascinating process which can take place in the presence of on-going pain is the development of central hypersensitivity. Changes take place within the spinal cord and brain which make the nerve cells more responsive to a given pain signal from the peripheral tissues. Again this means that a touch might be perceived as pain. The stimulus for these changes are not known, but it is very possible that the sending of high rate barrages of pain signals might stimulate this change in pain sensitivity. One interesting corollary from these theories, which is supported by clinical studies in both man and animals is that if you suffer from chronic pain, you are more sensitive to an acute pain stimulus. Thus as far as our patients with chronic lameness go, they will be more sensitive to any acute pain - possibly associated with a clinical examination of the area - and hence may display an increased difficulty with handling or restraint or examination. Basically they may be struggling because you are hurting them and not just because they do not like your face. This also means that animals in chronic pain will require a larger dose of an analgesic to produce the same pain deadening effect. These factors are also attracting a lot of attention in elective surgery where there is little or no pre-existing pain. Studies in both man and animals have shown that if you prevent the release of prostaglandins from damaged tissues by pretreatment with non-steroidal anti-inflammatory drugs, and then prevent the firing-off of impulses from cut nerves with local anaesthetics or opioids during surgery, then people or animals feel significantly less pain post-operatively and require

significantly less post-operative pain killing drugs.

This will be of limited value in most cases of bovine lameness, because tissue damage is normally long standing and the sensitization will already be there. But we can remember a few things - there are some good non-steroidal, anti-inflammatory drugs out there but they should be kept to a short term use because of their side effects. The local anaesthetics work every time as long as we put them in the right place and remember that infected tissues can lessen their activity (so clear up the infection first if you can). The fact that they block motor and sensory inputs is not a major problem when we are dealing with feet, and finally, they are not very expensive. The centrally acting drugs such as the opioids are not very popular for use in cattle but the alpha two agonists such as xylazine work really well for sedation as well as being as potent an analgesic as morphine in cattle. It is also worth remembering that the tranquilizers like acepromazine have no pain killing activity at all.

In summary, remember that animals feel pain just as we do and that lesions of the hoof and foot can be very painful. By using drugs such as the non-steroidal anti-inflammatories, the local anaesthetics and the alpha two agonists, we can provide reasonable pain management and make the whole thing a lot easier on our patients and ourselves.

ALTERNATIVES TO AMPUTATION IN THE BOVINE DIGIT

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When considering preserving limb function and minimizing lameness caused by diseases of the distal limb, digit sparing procedures effecting the distal components of the digit can provide practical alternatives to amputation or emergency slaughter, thus ensuring continued productivity for the remaining lifetime of the animal.

Before selection of appropriate alternative procedures, it is essential to have a thorough understanding of the condition, its etiology, and an appreciation of the time over which the condition has developed. It is also imperative for purposes of prognostication and post-operative care, that as much information of the condition as possible be considered in the decision making process. The etiology of the primary condition and the pathologic processes involved in any secondary problems will effect the prognosis and treatment regimens since hematogenous, traumatic, developmental, or degenerative conditions will all affect the healing and recovery process. The duration and rate of progression of clinical signs may reflect the seriousness of the problem and dictate the choice of a conservative or more radical treatment modality. Since fore and hind limbs function differently and medial and lateral claws have distinct roles and characteristics, it is important to bear in mind the implications of the specific claw which is affected. Since medial claws of the forelimbs and lateral claws of the hind limbs are the most severely stressed during normal activities and are thus more critical to the well-being of the animal, digit sparing procedures play a particularly important role

whenever these digits are affected. This aspect is further emphasized in breeding bulls which are expected to perform under field conditions. Future function, housing, and management are factors which will play a part in the selection of the appropriate therapy as will the inherent value of the specific animal involved.

A list of conditions affecting the distal limbs of cattle which may be treated by digital amputation includes lesions of the claw, skin, and soft tissues, conditions of the distal phalanges, interphalangeal joints, synovial cavities, and tendinous structures, which can result from infectious, traumatic, or other factors. Treatment of any such conditions by means other than amputation or slaughter salvage may be considered as treatment alternatives to amputation. This presentation will address only arthrodesis of the distal interphalangeal joint as an alternative to amputation for those conditions associated with tissues in the immediate vicinity of the joint, namely retroarticular abcesses, osteitis of the navicular bone, and septic arthritis of the distal interphalangeal joint and associated involvement of the distal and middle phalanges.

The time required for recovery from surgical or conservative therapy varies with the procedure as well as each animal and the degree of tissue involvement. Some surgical alternatives are associated with extended post-operative healing periods which must be considered and discussed with the owner prior to treatment. It is advisable to review the advantages and disadvantages of both amputation and the alternatives to amputation with special emphasis on long term prognosis, post-operative management, and potential complications with the client early in the stage of treating the animal.

Amputation, generally regarded as a rapid, and economical, albeit short-term solution to selected digital conditions has been advocated for specific conditions of the bovine claw, sole, integument, bones and joints of the distal digit as well as problems involving the tendons and tendon sheaths of the distal limb.

Alternatives to claw amputation usually involve medical and / or surgical intervention of one digit while allowing the other digit of the same limb to bear the full forces normally applied to both. The protection of the affected and treated limb from significant stress is thought to reduce pain, and facilitate the reparative process and is accomplished by application of a wooden block to the unaffected digit by means of polymethylmethacrylate or via a metal plate attached to the hoof by nails or other devices. The block thus elevates the affected claw and protects it from ground forces and minimizes dynamic forces acting through the tendons and ligaments of the distal limb.

Infection of the distal interphalangeal joint is a relatively common occurrence in cattle. The etiology is usually related to a septic process beginning in the sole, white line or interdigital area, and spreading by direct invasion into the joint or periarticular tissues. The tissues in this region provide little physical barrier to pathologic organisms once they become established in the area. The vulnerability of this site and its proximity to other synovial cavities such as the navicular bursa and flexor tendon sheath, make infections of this joint particularly threatening. Septic arthritis of the distal interphalangeal joint is the most common condition associated with diseases of the digital flexor tendon sheath in cattle (Stanek, 1988).

Traditionally, sepsis at this site has been treated by antibiotic therapy when the condition was diagnosed at an early stage. The more advanced infections with excessive bony and soft tissue proliferation were more likely to be treated by amputation of the distal half of the digit. Drawbacks to simple anti microbial therapy were primarily lack of consistent success. Surgical removal of the affected part provided, on average, a two year respite before the remaining digit failed due to chronic overloading. Untreated animals have been known to form a large bony mass around the distal joint and become relatively sound after a prolonged healing phase. Such animals do not become completely sound but are capable of moving around without major pain. The physical deformity readily visible for the remaining life of the animal.

Conservative treatment of septic arthritis of the distal interphalangeal joint has consisted of administration of local and systemic antibiotics over varying periods of time with variable and usually unrewarding results when the process has been well advanced at the time of initiation of treatment. The somewhat more aggressive modalities of joint lavage and drainage have provided a better success rate as a result of removing the infected and reactive fluids within the joint cavity but are not effective at removing infected and devitalized soft and hard tissues which serve to harbor organisms and interfere with the normal healing processes in the region of the joint. Arthrodesis (surgically facilitated fusion) of the joint serves to remove infected and devitalized tissue from the site and allow for preparation of the boney surfaces for optimal healing. The process minimizes pain and the production of large callus reactions which normally occurs in an attempt to combat infection and immobilize the joint.

The first sign observed is a progressively increasing lameness followed by swelling around the distal limb just above the later or anterior wall of the claw. The enlargement continues to expand usually regardless of antibiotic treatment. A fistulous tract is frequently seen to exit from the joint just above the coronary band. Radiographic examination in the early stages may reveal no obvious abnormalities or only slight widening of the joint space. With time there is further widening of the space and destruction of the cartilage and subchondral bone resulting in an obvious destruction of the joint. Concurrent with the bone and cartilage destruction is the production of new bone at the periphery of the joint in what appears to be an attempt to stabilize the articulation. As the disease process develops from its early stages, the affected animal prefers to spend more time in recumbency and reduces its food intake as well as milk or meat production. In early stages of the disease, conservative treatment with antibiotics may effect a cure or at least stop progress of the process. In more advanced stages a surgical approach is recommended.

Long-term success is better achieved by selecting a surgical procedure which removes the infected tissues and supports the body's natural attempts to fuse the joint and provide pain-free, functional movement. A number of techniques have been advocated which involve an approach to the joint through the sole. The following method is proposed as an effective means of creating a surgical arthrodesis of the joint by an approach through the heel bulb in a transverse plane. It is critical to discuss the prolonged recovery period (approximately three months) with the owner and make certain that it is understood that the animal will loose condition and undergo some significant pain during the healing process. Antibiotic therapy is begun before surgery is initiated.

Anesthesia may be readily achieved by means of local intravenous regional injection of lidocaine distal to a tourniquet. Following routine aseptic preparation of the digit, a transverse incision is made from the axial to the abaxial borders for almost 360^{o}. A wedge of tissue is then removed to allow a posterior approach to the affected joint. The tissues removed in this wedge are the deep flexor tendon, the sesamoid bone, and all fibrous material in the dissection plane. Once the joint is entered and drained, the cartilage and all affected subchondral bone is removed by manual or mechanical curettage to the level of healthy tissue as evaluated by digital palpation and visualization. A drain is then placed into the joint cavity and the heel incision closed using non-absorbable interrupted sutures. The limb is bandaged and maintained in flexion to reduce tension on the skin suture. A wooden block is applied using polymethylmethacrylate and the drain is removed in three to five days.

Post-operative care consists of stall rest, antibiotics for 10 to 14 days and radiographic monitoring of the fusion process. Extensive production of periosteal new bone is expected following an initial "lag" period. There is clinical fusion of the joint before radiographic evidence of complete bony union is seen. The prognosis for return to milking and breeding performance is good.

FEET AND LEG TRAITS OF DAIRY CATTLE

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Differences among breeds and cows within breeds have shown that genetics has important effects on feet and leg traits of dairy cows. Systems of scoring feet and legs have been developed that are accurate enough to recognize genetic variation yet simple and inexpensive so that large numbers of breeding animals can be evaluated. Genetic evaluations on eye-scored measures of these traits are available on most dairy bulls in AI in North America and Western Europe. Evidence to be presented will show that selection based on genetic evaluations of bulls for feet and leg traits will improve longevity, presumably through improved foot health.

DESCRIPTION OF TRAITS OF FEET AND LEGS WIDELY SCORED

Traits involved with locomotion that are widely scored in dairy cattle are foot angle, legs side view and legs rear view. Foot angle is based on the angle of the claws from the periople line to the ground. Legs side is a score of the hock angle as viewed from the side. These two traits are evaluated by all breeds and AI units. Scores for legs rear, when used, are higher for those that are straighter and lowest for those that are close at the hocks. Generally all traits are scored on a 1-to-9 scale except for the Holstein-Friesian Association of America that scores on a 1-to-50 scale. A summary is as follows:

Trait	Scoring	Desirable
Foot Angle	Low(1) to High(50)	High to 60 deg.
Rear Legs, Side	Posty(1) to Sickled(50)	Intermediate
Rear Leg, Rear	Close(1) to Straight(50)	Straight at hocks

Through careful training of the persons doing the scoring, the scores are accurate enough to be the base data in effective genetic evaluations of feet and leg traits. Bull evaluations are reported separately as foot angle and legs side view in the United States and a few other countries. In others these and other traits are combined into an overall "feet and legs" measure. Genetic evaluations for "legs rear view" are less widely used and only rarely reported separately.

A different score used in the Netherlands is that of foot diagonal. This is an eye score of the distance from the top of the heel to the end of the claws. As scored, it includes both claw angle and length of claws. Analyses of Dutch data for diagonal does show that the eye scores of it are adequately heritable for accurate sire evaluations. In many publications, the Dutch do combine such scores in an overall index with legs before reporting them to breeders.

Although research has shown value for length of claws when measured (Choi and McDaniel, 1993; Smit et al., 1986), dairy breeding organizations have been reluctant to score claw length because of the potential bias from trimming. Little data are available on the accuracy with which length can be eye-scored, but limited experience indicates it can be scored at least as accurately as claw angle.

HERITABILITIES OF FEET AND LEG TRAITS

Heritability estimates for a single eye-scored foot angle average about 0.10 with the highest estimate no more then .15. This means that single scores on an individual cow are not a reliable measure of her genetic merit for the trait although they may be unbiased. Yet, a heritability of 0.10 is adequate to obtain a reliable estimate of the breeding value of a bull or cow when scores on many offspring are available. A composite of recent heritability values based on eye scores is in Table 1. Heritabilities for legs rear are slightly lower than those for legs side. Values obtained by the Holstein-Friesian Association of America (1994) are .16 for side view and .08 for rear view. Slightly higher estimates were obtained from British Holsteins by Brotherstone and Hill (1991).

The underlying genetic differences among cows for leg traits, especially when scored from the rear, seem to be larger than those observed by even trained evaluators. The major contributor to low heritabilities for leg traits appears to be variation in the stance a cow is in when she is scored. Scores or even actual measures on individual cows often show large changes when they are observed after the cow moves a few steps (Te Plate and McDaniel, 1990). Again, these result show the need to use breeding values from a progeny test of bulls with little emphasis on scores of individual cows when selecting to improve locomotion traits.

The heritabilities of feet and leg scores on individual cows in Table 1 illustrate the low accuracy of selection on cows. To be successful in making genetic improvement, selection must be based almost exclusively on progeny

TABLE 1. Heritabilities of Claw and Leg Traits

Trait	North America[1]	Britain[2]
Foot or Claw Angle	.08 to .10	.18
Rear Leg, Side View	.12 to .16	.15
Rear Leg, Rear View	.08 to .10	.12

[1] Holstein-Friesian Association of America, 1994.
[2] Brotherstone et. al. 1990

tests of bulls. Relative selection accuracies of individual and progeny tests for different heritabilities are in Table 2. These show that accurate breeding values on bulls for low heritability traits are possible when adequate numbers of progeny are available. The general rule is that six progeny are needed to equal the accuracy of individual selection for the same trait and heritability.

TABLE 2. Accuracies of breeding values for individuals and progeny tests at different heritabilities.

Herit-ability	1 Record on cow	Number of progeny 10	20	50	100	200
.05	.22	.33	.45	.62	.75	.85
.10	.31	.45	.58	.75	.85	.91
.20	.44	.59	.71	.85	.91	.95

Practically all scoring for conformation of claw and leg traits is based only on the rear. Characteristics of front legs and claws are generally ignored because variation in them is not considered to be a cause of many locomotive disorders. Genetic variation in front claws seems as large as that in back claws(Hahn et al., 1984; Baumgartner and Distl, 1990). Judgments of front legs were also more heritable than those of rear legs in the one study where they were scored (Baumgartner and Distl, 1990). In the latter research four of the six front leg or claw traits were more heritable than their rear counterpart.

If and when it is important to have more accurate breeding values for claw traits for individual cows, they may be obtained by combining the cow values with those for their sires. Actually other related animals also may contribute to the more accurate breeding values. Use of an "animal model" method of genetic evaluation that includes the genetic relationships among all animals evaluated will provide more reliable genetic values for individual

females as well as bulls. Even with the extra information provided by relatives, the reliability of the information on a cow's claws and legs is of limited value to predict what she will transmit to her offspring. However, cow values are unbiased when computed with an animal model and often may be all that is available.

Heritabilities based on actual measurements of front claws have been higher than those based on measurements of rear claws of the same cows (Hahn et al.,1984; Baumgartner and Distl, 1990). Because few problems have been observed in front claws, they have not been scored in most evaluation programs. Their scores, when added to those for rear claws, might make it easier to recognize genetic differences among individual cows.

RELATION OF LINEAR TRAITS TO FOOT PROBLEMS AND SURVIVAL

Progeny tests of bulls for conformation of feet and legs have been favorably associated with longevity of daughters in both North America and Europe. This has been especially true where claws and legs were scored independently. Correlations of genetic values of sires for claw angles have been more closely related to survival than those of leg traits. Because breeding values are unbiased measures of bulls' true genetic values, they should be the selection criteria rather than the actual progeny averages so often used. It is imperative that genetic values for feet and leg traits be computed as accurately as possible on bulls.

Breeding values for feet traits scored in first lactation have generally been negatively correlated with those for milk production (Foster et al., 1989; Brotherstone and Hill,1991b; Short and Lawlor, 1992). Actual measurements have shown similar trends (Choi and McDaniel,1993; Reurink and Van Arendonk, 1987). These results mean that positive selection pressure must be placed on feet traits or they will deteriorate when selection is strong for milk or protein yields.

The most extensive studies of the relations of foot and leg linear scores with survival are those of Boldman et al.(1992); Brotherstone and Hill (1991a and 1991b); Burke and Funk(1993); Dekkers et al.(1994); Foster et. al.(1989); Rogers et al.(1989) ; McDaniel et al.(1993); Short and Lawlor, (1992). Sire evaluations for survival and those for linear traits of claws and legs were in the desirable direction in all studies. Exceptions were claw angle and rear legs rear view in the study by Boldman et al.(1992). Although survival rates were defined somewhat differently in each of the investigations, all studies showed higher claw angles were positively correlated with

increased survival(Table 3). This was especially true when milk was included as a covariate to remove the effects of early culling of low yielding first lactation cows.

Much of the value of claw angle seems to be differences in survival of cows with extremely high or low angles. Foster et al. (1989) found little difference in longevities of cows with claws scored for 11 through 33 on a 50-point scale, but those with scores of 34 to 50 lived 162 days longer. Conversely, cows with low scores of 1 to 10 lived 54 days less then those with intermediate scores.

Results indicated that legs straighter from the side than considered optimum by the various agencies doing the scoring were associated with longer lives. In most studies the degree of straightness that predicted the longest lives still were legs with considerable set to the hock. Actually, the optimum seemed legs that were only about 0.5 standard deviation straighter than that thought best. Legs were less correlated with longevity than foot angle in most studies.

Generally scores of rear legs rear view have been more highly correlated with survival than those of rear legs side. In these same studies sire evaluations of bulls transmitting straighter legs from the rear view, less "hocking in", were positively associated with higher survival rates.

Only Burke and Funk (1993) addressed the relative importance of feet and legs to predict survival for different housing types and foot trimming routines. They found that the regression of herdlife on foot angle was higher in tie stalls than in free stalls or loose housing. Also the association of claw angle and herd life was lower in herds that never trimmed than those that did routinely. Perhaps the herds that never trimmed claws had an environment that did not stress feet. Effects of legs did not differ except in loose housing where they had only half as much impact as in free or tie stalls. This finding may be somewhat suspect because there were less than 25 % as many observations in loose housing as in the other types. Time on concrete, bedding type, heifer housing, amount of exercise, or use of footbaths did not affect the relationships.

All investigators except McDaniel et al. (1993) found that sire breeding values for udder traits were slightly more highly correlated to survival than were claw and leg traits. In this study claw angle was the best predictor of survival rate. The data of McDaniel et al. (1993) were based on 389,000 cow lifetimes in the Southeastern U.S.A., an area where most cows are housed in free stalls or

outside on dirt lots for much of the year. Also, a high percentage of the cows were non-pedigree and milked and cared for by hired workers rather than the owner. Whether claws and legs will become more important for predicting survival in other areas as herd sizes increase and free stalls become more common is a matter of speculation.

TABLE 3. Summary of Associations of Scores of Locomotion Traits and Survival

Trait	Relation to Survival
Foot or Claw Angle	Higher angles, Longer survival
Rear Leg, Side View	Mildly straight leg, Longer survival
Rear Leg, Rear View	Straighter from rear, Longer survival

Studies of relationships of measured claw traits and survival have given similar results as those of scores even though they were based on much smaller samples of data. The genetic correlation of average claw angle and age at culling was .87 in the research of Choi and McDaniel (1993). Findings of Reurink and Van Arendonk (1987) were in the same direction but smaller. In both investigations first lactation cows with shorter claws lived longer.

The relation of claw diagonal with survival has not been determined with scored data. However the difference in the survival to third calving of first lactation cows in the shortest quartile for measured claw diagonal and those in the highest was over 8% (Reurink and Van Arendonk, 1987). Differences in survival of cows in the highest and lowest quartiles for claw angle exceeded 3% while those for claw length differed by more than 2%. Additional research is needed to determine the value of scored claw diagonal to predict survival rates.

GENETIC BASIS OF CLAW DISORDERS

Several claw disorders seem to have a partially genetic basis. The heritability of laminitis has been reported to vary from .14 (Huang and Shanks,1993) to .22 (Reurink and Van Arendonk, 1987). The two estimates for the heritability of erosion of heel horn have been consistent, .13 (Huang and Shanks,1993) and .15 (Baumgartner and Distl,1990). Values for interdigital dermatitis have been variable: .04 (Huang and Shanks,1993), .09 (Reurink and Van Arendonk, 1987), .13 (Baumgartner and Distl, 1990) and .27 (Petersen et al, 1982). Only single estimates of .21

for sole contusion and .31 for hyperplasia interdigitalis are available from Baumgartner and Distl(1990). The heritability of sole ulcer has varied from .03 to 0.39 depending on how it was scored and the stage of lactation observations were taken. The heritability for white line separation has varied from .08 (Huang and Shanks, 1993) to .17 (Baumgartner and Distl, 1990). It seems unlikely that an adequate number of cows will be measured or scored for these traits to compute useful genetic evaluations of bulls in AI.

Genetic correlations between claw measurements and claw disorders have been moderate (Distl et al., 1990). As angle of the dorsal wall (foot angle) increased, laminitis, dermatis digitalis, and sole contusion decreased. These values suggest that selection for higher claw angles should decrease the frequency of these disorders. Correlations of foot angle with heel horn erosion and hyperplasia interdigitalis were low but favorable.

CONCLUSIONS AND RECOMMENDATIONS

Selection to improve foot angle seems to be the most practical way to improve locomotion in dairy cattle. Not only are genetic estimates widely available on bulls in AI, but research in several countries also shows that bulls siring steeper foot angle have daughters that live longer. This is after considering effects of other traits including yields.

Data on the effects of genetic variation in leg structure are not as consistent but do suggest an impact on longevity. Legs that are neither too straight nor too sickled seem the best. Selection for an intermediate optimum is difficult, but suggests that mating to maintain an intermediate is worthwhile. Although not as easily or widely scored, leg structure from the rear may be more useful than legs scored from the side.

Research in some countries suggests that scores for foot angle and legs can be combined effectively into a single value that may be used to improve locomotion. These results do need more verification before they are widely recommended.

Many other traits of feet and legs do show substantial amounts of genetic variation. Because of the expense of obtaining accurate measures of them on large numbers of dairy cattle, these additional traits are unlikely to be of practical value in the near future.

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CONFORMATION OF BEEF CATTLE

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Definition

The dimensions and shape of an animal are referred to collectively as its conformation. The proportional dimensions may be determined objectively by measuring bone lengths and the distances between fixed points on bones. Angularity, particularly that of the limbs and pelvis, is another factor that is extremely important in making an assessment of conformation. Body angles are closely related to functional efficiency (Bonsma, 1973).

Functional efficiency may be defined as 'an animal's ability to perform the functions for which it was intended for a prolonged period'. Functional efficiency is therefore linked to productivity as well as to the following factors:

a) Fertility (see below **'effect of sexuality on conformation**,)
b) Calving Ease (size and shape of pelvis)
c) Longevity (usually refers to the length of useful life)
d) Carcass Merit
e) Frame Score
f) Freedom from diseases of the musculoskeletal system.

Correlation of conformation with functional efficiency is cost effective to the livestock industry. An increasing number of research reports demonstrate a correlation between objective measurements and a desired characteristic. However, conformation has

been judged traditionally based on aesthetic qualities or on the anecdotal association of a given trait with performance. These aesthetic qualities are influenced by the muscularity of the animal and the distribution and quantity of subcutaneous fat. Thus it may be argued that the show ring perpetuates an unscientific and purely subjective system. Judgement based only on fashion, tradition, or the personal bias of a judge is contrary to the interests of the commercial producer.

The objective of this paper is to clarify some of the misunderstandings that exist in the evaluation of conformation and to dispel some of the mystique associated with show judging. Veterinarians do have significant contributions to make in helping to evaluate functional efficiency as part of herd health programs.

Literature

The importance of the scientific study of conformation is recognized by the cattle industry, as evidenced by the many hundreds of research reports on the subject published in the literature. Although the objectivity of some of these studies is questionable, in general they indicate that a better understanding of conformation and its heritability is of great economic importance (Kempster et al. 1982; Lopez de la Torre and Benito 1979; Brooks and Harrington 1960; Qureshi et al. 1980; Hand et al. 1986; Foster et al. 1989). However, in many of these reports the anatomic criteria for measurements are not specified, while in others they are vague. It is, therefore, fully justfied to argue that the measurements used in research should be precisely defined and thus comparable between workers.

There are numerous relationships between conformation and disease. Several workers (Bartels 1975; Van pelt 1975; Féher et al. 1968; Greenough 1980; Bailey 1985) have reported that animals with poor conformation are susceptible to arthritis. Serous tarsitis (bog spavin) is another condition that has been observed in cattle with poor hind limb conformation, and is considered to be heritable (Sittmann and Kendrick 1964; Howlett 1972). Straight hocks (post leg) are often associated with these conditions; some believe this condition to be hereditary as well.

The increase in the inclination of the hock in beef cattle has occurred as a result of selection for height at the hip. However, Bonsma (1973) demonstrates very convincingly that bone growth is controlled by sex hormones, and argues that unqualified selection for size can produce animals with low fertility. Other evidence suggests selection for size could increase the risk of gigantism (Greenough 1991). Some of the evidence linking conformation to health problems is anecdotal; hence it would be profitable to re-explore some of the alleged relationships using precise methodology.

The methods used to study the shape and size of claws are much more advanced and are used more uniformly in research than those used for body measurements. The relationship between claw characteristics and predisposition to disease has been studied. (Andersson and Lunström 1981; Smit et al. 1986 a,b; Politiek et al. 1986). Precise criteria for measuring claws have also been described (Gilmore 1978; Fessl 1982; Huber et al. 1983; Distl et al. 1984; Peterse 1986; Smit et al. 1986a,b). The coefficient of variation for subjective foot scores as defined by Morris et al,(1985) can be quite high while objective measurements of claw traits can be low.

White skin above the coronary band "white socks" is a trait preferred by breeders of Holstein cattle; however, this characteristic is usually associated with light coloured claw horn which is softer than dark-coloured horn and more prone to damage (Dietz and Prietz 1981; Chesterton et al. 1989). This provides a good example of fashion conflicting with considerations of health.

Anatomical Landmarks

A major goal in the study of conformation is to reach international agreement on the most appropriate anatomic body landmarks to use as reference points between which measurements can be taken. These points have neither been described with adequate anatomical exactitude, nor used consistently between workers.

Magnusson suggests that the following criteria should determine the choice of reference points:

1) The points must be easy to identify through palpation and must be situated primarily on the skeleton in order to avoid the influence of muscles, fat tissue, skin and hair thickness.

2) The points must be situated as near the ends of bones as possible in order to mark the length of the bones. They must also be near the moving centre of the actual joint for angle measurement.

3) The points and distances between them must, if possible, coincide with the outlines and axes used in subjective judging of conformation. This fact is important if objective and subjective methods are to be translated into each other.

The following 11 anatomic points are suggested as being most appropriate for objectively measuring conformation or body

Anatomical Landmarks of the Claw

Side View
i. The skin-horn junction at the heel
ii. The skin-horn junction on the dorsal surface of the digit
iii. The apex of the claw
iv. Junction of the abaxial wall with the heel, ie: The distal end of the abaxial groove

Rear View
i. Abaxial wall of the lateral claw
ii. Axial wall of the lateral claw
iii. Abaxial wall of the medial claw
iv. Axial wall of the medial claw

Frame Size

Usually proportional dimensions are referred to by the beef industry as "frame size". Height at the hip is generally seen as a major indictor of this; however, such a system fails to recognize the importance of body length and girth. Body length is not defined accurately or consistently in the literature.

Frame size may be viewed as one component of conformation. Muscle and fat are to some extent reflected in body weight, therefore, one method of roughly classifying conformation is by hip height and body weight. It has been said that "at best, frame score is used as a descriptive measure of height and maturity type; at worst it becomes a standard of excellence which is fanatically sought".

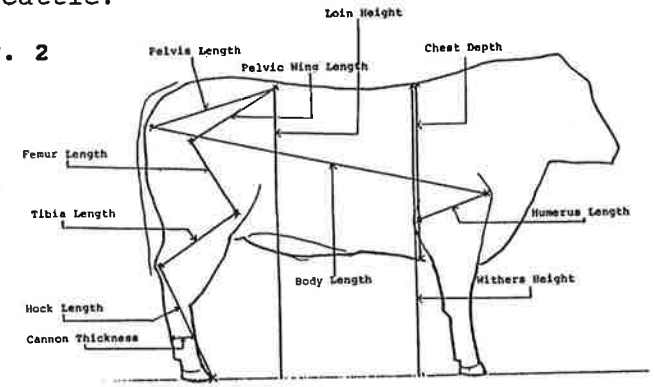
It is worth noting that the term "hip height" does not refer to the height of the coxo-femoral joint (thurl), but to the height of the tuber coxae. Unfortunately, the position of the tuber coxae relative to the dorsal surface of the animal is variable.

This variation is increased by the large differences in the size of the tuber coxae which exist among animals. A more consistent landmark is provided by the lower external tubercle which should be used not as a measure of height but to determine pelvic length and external angles of the pelvis. The true height should be referred to as 'loin height', which is the distance from the floor to the level of the lumbo-sacral junction.

In dairy cattle, stature is measured as the height to the withers (or, as some say, 'shoulders'). Stature is reported to be a highly heritable characteristic.

Figure 2, shows some of the measurements that may be used to describe the conformation of cattle.

Fig. 2



Conformation Traits (Traits Other than Production [TOP])

Traits are distinguishing physical characteristics, many of which have a strong tendency to be heritable. Most traits are 'descriptive', that is to say, they are described in qualitative terms. Defining a trait can be quite picturesque and meaningless in a scientific sense.

For example:
"The hocks should be cleanly moulded with the bone flat, strong and flinty".
Such a description can be interpreted in various ways by different observers.

Some descriptive traits can be evaluated relatively accurately. Claws may vary in color from black to white. On the other hand, a descriptive trait such as 'feet and legs' may contain so many variables that an accurate general assessment is not possible. Nevertheless, this trait is used extensively by research workers who report that 'feet and legs' have low heritabilty.

Effect of sexuality on conformation

Long bones increase in length from growth plates (epiphyses) that are located across the shaft at either end of the bone. When sex hormones (estrogen and testosterone) are present in the blood, the activity of the plates gradually slows, and the plate eventually fuses with the rest of the bone.

Usually the closing of the growth plate takes place at puberty. In the case of steers, sex hormones are much reduced and the animal grows taller and bigger. Similarly, if a cow or bull is subfertile, it will tend to be taller at the withers and deeper in the brisket. In the past this conformation was considered desirable, and as a result instances have been recorded of bulls winning show championships only to be found later to be sterile or subfertile. Such bulls tend to lose their masculine characteristics and are referred to as 'eunuchoidal' (Bonsma, 1973). It follows that selection for height at the withers (stature or size) can be risky unless the selection is balanced and the trend moderated.

Selection for large size poses other risks as well. Large animals with high average daily weight gains may be predisposed to gigantism. Moreover, if a breeder selects over-vigorously for a set of physical characteristics, there is a risk that some desirable characteristics will be lost.

Straight Hind Limbs

Particularly in beef breeds, greater 'height at the hips' is regarded as a desirable characteristic. The logic behind this preference is not clear. It may be that some judges mistakenly associate hip height with meatiness or carcass size.

Be this as it may, breeding to increase hip height is invariably achieved by selecting for straight hind legs. A straight hind limb has no advantage in terms of carcass yield because the meat-to-bone ratio is constant irrespective of the angles of the joint (Berg and Butterfield, 1976). On the other hand, straight legs have been associated with a high incidence of arthritis. Straight legs may also predispose the animal to spastic paresis; they also function poorly in absorbing the mechanical stresses of weight bearing, which places greater strain on the bearing surface of the claw. If the breeder is unaware of this fact and fails to select for large claw size, the animal's longevity may well be reduced as a result.

Body Length

Body length is a frequently but loosely used term. It is not defined in the literature using anatomical landmarks.

Nygaard (1983) measures body length from a hypothetical point taken vertically over the most posterior part of the tuber ischiadicum

(pin) to the spine of the third thoracic vertebra. The Canadian Simmental Association uses a similar system. However, it is impossible to feel the spines of the thoracic veretebrae in a heavily muscled bull.

The majority of workers use the term 'body length' to describe the distance from the pin to the point of the shoulder. However, the pin is a very large structure, so to produce a consistent and accurate measurement the exact part of the pin must be described. The point that is recommended is the most lateral and lowest part of the bone.

South African workers have reported that: "Highly significant correlations were established between shoulder height and body length with average daily gain, average daily gain per day of age and final mass. Partial correlations showed that body length exercised greater influence on performance traits than shoulder height" (Swanepoel and Heyns, 1986)

Claw characteristics

It may be logical to assume that the size of a claw is important, but to date no work has provided objective evidence that this assumption is correct. Hypothetically, there must be a biomechanical relationship between the weight of an animal, the angulation of the limb joints, the size and quality of the claw and the degree to which the latter is affected by disease such as heel erosion. The components of this relationship are subject to objective measurement. Claw size may have an important part to play in the predisposition to certain diseases. The size of an animal's claws seems to be a factor overlooked by the cattle industry.

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HOCK CONFORMATION OF DAIRY HEIFERS IN TWO MANAGEMENT SYSTEMS

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General conformation refers to body weight, shape of body and limbs (in particular hock angulation). Characteristics of conformation are known to be heritable and there has been a universal move in the cattle industry to select animals on the basis of straight hocks. Little explicit information is available in the literature as to the degree of angulation desired in the hock joint of cattle, in spite of the emphasis placed on this point in judging. Excessively straight legs ("post-legged") make the animal vulnerable to joint injury and claw problems. Increased angulation of the hock, although regarded as unsightly and a conformation weakness, thereby handicapping the animal in the show ring, never has been associated with lameness.

The main purpose of this study was to test, under field conditions, a system that provides an objective evaluation of conformation. This research tool was then used to determine the hock conformation (hock angle [°]) in a group of Holstein heifers at various ages. Thirty heifers, the replacements of the University of Saskatchewan dairy herd, were used for this 14-months-long study. The heifers were managed in two different ways. Indoor-housed heifers joined the dry cows in a free-stall facility with alleyways that were partly solid concrete and partly slatted. Outdoor-housed heifers were maintained on an earthen and gravel-surfaced corral. Fifteen heifers were allocated randomly to each group.

Hock conformation was determined by using a computerized Conformation Determination System (CDS) (Greenough PR, Berg PA. 1989. Western College of Veterinary Medicine, University of Saskatchewan, Saskatoon, Sask., S7N 0W0, Canada). Measurements were made every 4 weeks, starting at 12-13 months of age until two months after calving at 24-28 months of age.

Overall, the heifers studied had straight limbs; the mean value of the hock angle and its standard

error was 167.3 ± 0.7 (range 154.3-177.4). Although hock angles decreased with age in both groups, the differences between first and last examinations were not significant. At the first examination mean hock angles were not significantly different between the two groups (170.1 ± 1.6 vs 167.5 ± 1.6), but at the last examination indoor-housed heifers had significantly greater mean hock angles (167.4 ± 1.0 vs 164.2 ± 1.3; $p<0.05$). Apparently, cattle on slats adopt a stilted gait which is reflected in their hock angles. The question of whether certain deviations from an arbitrary norm actually interfere materially with the efficiency of the dairy cow is up for debate. The straight or upright hocks of the modern Holstein may have a reduction in their shock-absorbing function and, therefore, are likely to accentuate the impact and friction forces received by the hind claws. Such forces will have exaggerated effects if the claws are damaged by laminitic change.

GENETIC IMPROVEMENT OF CLAW AND LEG TRAITS

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1 Introduction

Claw and leg problems are considered as one of the most important reasons for involuntary culling of cows. Figures from the milk recording organisations in West-Germany indicate that cullings due to claw and leg problems were nearly doubled from about 4-5% to 7-9% within a ten year period from 1983. Therefore, the economic importance of good claw and leg health is quite evident for longevity. Surveys on lameness suggested an annual incidence ranging from 5% to 30% (Politiek et al., 1986). Peterse (1982) quoted 10-25% of Dutch cows needing veterinary treatments for lameness. Reurink and Van Arendonk (1987) found that 21% of 1,141 Holstein Friesian cows from the Netherlands were lame. Another Dutch study by Smits et al. (1992) in 2,121 Holstein Friesian and Dutch Friesian cows stated that 75% of the cows were affected by claw lesions. Dermatitis interdigitalis was prevalent in 83% of the cows. Similar estimates were given by Philipot et al. (1990) from a French study comprising 160 herds and 4,896 cows. 8.2% of the cows were lame and at least 25% of the cows were affected by heelhorn erosion, haemorrhages of the sole, dorsal concavity of the wall and yellowish colourings of the sole. Baumgartner et al. (1990) found in a random sample of 1,938 first lactating German Simmental cows a prevalence for heelhorn erosion of about 50%, for sole contusions of about 30%, for white line separation of about 10% and for double soles of about 7%. A longitudinal study of Distl and Schmid (1993) in German Simmental as well as German Black and White cows of the university farm at Munich revealed that heelhorn erosion was most frequent, followed by dermatitis interdigitalis and sole contusions. Enevoldsen et al. (1991a, 1991b) studied the incidence of claw diseases at claw trimming in Denmark. Sole ulcers in one foot or more than one foot occurred in 20 and 29.7% first lactating cows and in 23.5 and 24.7% second or higher lactation cows.

The economic importance of claw and leg problems needs consideration. Esslemont (1990) summarized economic evaluations for sole ulcers, digital diseases and interdigital diseases. According to stage of lactation and milk yield losses the costs of a case of solce ulcer in an individual cow ranged between 205 and 401 £, a case of digital disease from 127 to 254 £ and a case of interdigital disease from 23 to 104 £.
The amount and quality of information on the incidence of claw and leg problems has considerably increased in the last years. Claw and leg problems are now quantified in many epidemiological studies. The economic importance of claw and leg problems has reached such a serious level that breeding programs have to take these traits into consideration. Justification is given by their economic importance, their negative effects on longevity as well as selection intensity within a herd and their impact for the cow's welfare.

2 Defining claw and leg quality

Genetic improvement of claw and leg conformation should enable animals to resist influences of the environment without suffering from diseases or reducing their performance ability. Claw and leg traits for breeding objectives have to be carefully defined and the traits chosen need to be tested for their usefulness in practical breeding work and according to the environment the animals are exposed. Possible negative side effects on other characteristics of the musculoskeletal system should be avoided. Target traits to be used in breeding work may then be related to susceptibility for claw and leg diseases as well as management requirements as e.g. low need for footcare and functional aspects of locomotion. In addition animals with a high claw and leg quality should be able to increase their longevity and lifetime performance. These effects can be referred to minor disturbances of claw status which are on a subclinical level and difficult to diagnose and which impaire the animals in their efficiency. Important parameters for claw and leg quality can only be identified when traits used in breeding work are closely related to claw health, longevity, lifetime performance and functional efficiency of the animal. This definition implies that claw and leg quality cannot be recorded by just one trait. The traits necessary seem to be more complex and may be of different importance in dependence of the exposure to environmental effects. Particularly, claw shape is a result

of the interaction between individual factors and environment. Genetic components may differently respond to specific environments and in each specific environment other genetic components may play the predominant role.

3 Traits for claw and leg quality in cattle based on phenotypic records

Selection procedures in animal breeding assume an additive genetic model including an infinite number of alleles each with very small indistinguishable effects. The true genotypic value of an individual animal cannot be observed, however, estimation procedures are well developed in order to maximize genetic progress. The method of choice in this approach is to record the phenotypic trait value and to use a linear regression of genotypic values on phenotypic records for ranking of the animals. Trait-based selection for claw and leg quality using records of males and females should be more effective than using only those traits in females.

Phenotypic traits to be used in genetic improvement of claw and leg characteristics should contribute to the decrease of the lameness problem in future generations. As the most common cause of lameness is referred to the claws, more selection pressure should be put on claw traits. Genetic progress in claw and leg quality is determined by the correlated selection response of the traits chosen in the breeding programme. The approach to select on correlated traits garantuees that claw and leg quality are changed in such direction to be most efficient for a disease-free high production and long survival. Therefore genetic correlated effects on anatomical and physiological aspects of claw and leg function deteriorating production efficiency can't have any advantage in selection.

Candidate traits for claw and leg quality have to meet certain requirements to be suitable for breeding purposes:

- objectively measurable or subjective score with high repeatability
- feasible costs for recording: traits that have to be registered in large numbers of animals require lower average recording costs per animal, whereas traits that need to be recorded only in a small number can demand higher average recording costs per animal.
- sufficient additive genetic variation of the target traits and the traits used in practical breeding. The upper limit of genetic progress is given by the additive genetic variation of the target traits. The genetic and phenotypic correlations as well as the additive genetic variation of the traits recorded influence the genetic progress, too. Claw and leg traits with low genetic correlations to the target traits are not useful to achieve genetic improvement in claw and leg quality. If measuring errors inflate the residual variation, heritability estimates are usually low and the genetic gain is substantially reduced.
- target traits for claw and leg quality have to be defined carefully. They should include the incidence of all relevant claw and leg diseases and of correlated diseases as well as production traits which are related to claw and leg quality. Traits used for selection on claw and leg quality are often recorded in young animals, like young bulls at an age of about one year and first lactating cows, and therefore these traits should have predictive value for later life. In dual purpose breeds with emphasis on meat production, the development of the size and burden of the claw in relation to body weight should be regarded when target traits for claw and leg quality are discussed.

The most common claw traits were discussed by the EAAP Working Group "Claw Quality in Cattle" (Politiek et al., 1986; Distl et al., 1990). These traits were measures of claw shape, claw horn and inner structures of the claw. Several studies could show that these claw and leg traits exhibit a sufficient high additive genetic variation to achieve genetic improvement. Claw shape measures can be recorded at moderate costs with high accuracy. Heritability estimates based on paternal half sibs were almost in the range from $h^2 = 0.2$ to $h^2 = 0.4$. The additive genetic variation of claw diseases is the limiting factor for the genetic progress that could be achieved using claw and leg quality traits. Several studies have shown that additive genetic variance and heritabilities for claw and leg diseases are of moderate size and mostly range between $h^2 = 0.15$ and $h^2 = 0.30$ (Baumgartner et al., 1990; Junge, 1983; Nielsen and Smedegaard, 1984; Petersen et al., 1982; Reurink and Van Arendonk, 1987; Smit et al., 1986). These studies gave evidence for polygenic inheritance of claw and leg diseases, even if conclusions should be carefully drawn on genetic resistance against specific infectious agents. More detailed analyses are necessary to get more insight in the pathogenetics of infectious agents and their dynamics in housing systems. In sheep a possible involvement of

genetic polymorphism of the class II region of the major histocompatibility system could be shown for footrot infection and antibody titres after vaccination against footrot (Litchfield et al., 1993).

Heel erosion, sole ulcers, sole contusion and interdigital hyperplasia were found to be highly repeatable from one to another lactation (Distl and Schmid, 1993; Enevoldsen et al., 1991a, 1991b). In a Swedish study comprising 169 cows from the 1st to 5th lactation, the cow within breed and environmental group effect explained about 39% of the variation and was highest for all effects in the model (Ral et al., 1993).

Claw measurements were significantly correlated on the genetic and phenotypic basis with the prevalence of claw diseases, longevity and lifetime performance of dairy cows. The most useful parameters were found to be angle of dorsal wall, length of dorsal border, heel depth, heel length and diagonal length (Baumgartner and Distl, 1990; Nielsen and Smedegaard, 1984; Reurink and Van Arendonk, 1987; Rogers and McDaniel, 1989; Rogers et al., 1989). Baumgartner et al. (1990) developed a selection index for a progeny test based on claw shape measurements in first lactating cows. The traits to be genetically improved were all claw disorders in front and rear legs. They could show that the claw shape measurements length of the dorsal border, heel length and diagonal length gave a selection response of 63% relative to a direct selection against all claw diseases included in the index. Adding leg judgements to claw measures in the selection index increased expected genetic progress by about 20%.

A performance test of young bulls would provide the opportunity to record claw measurements in a standardized environment and seems to be economically more efficient than recording of about 40 - 50 daughters and their herdmates on farms. However, the genetic correlations between claw shape measures of young bulls and frequency of claw diseases of their daughters were lower than the corresponding genetic correlations in daughters.

Chemical composition and histological traits of claw horn characteristics exhibited medium to high additive genetic variance and heritabilities, but these traits were not genetically correlated with claw shape measurements and wear rate of claw horn in paternal half brothers (Distl et al., 1982). These results seem contradictory to the opinion that a large number of horn tubules per mm^2 indicates good claw horn quality. There can be additional factors which influence wear of claw horn, if both traits were compared at the same location of the horny capsule. Hardness and moisture content of

claw horn displayed additive heritable components when half sibs were kept in the same housing system (Distl et al., 1982). In conclusion, measurements of microarchitecture, chemical and physical characteristics are difficult to standardize, rather expensive to record and despite of their rather high additive genetic component, most of them are lacking a clear genetic relationship to traits that express the breeding objectives.

Distribution of pressure underneath claws might be a valuable parameter for claw quality (Distl and Mair, 1993). Studies in a small sample of dairy cows indicate that there exist differences between the breeds German Simmental and Black and White under the same housing system and management conditions. These breed differences in pressure distributions seem to be correlated with the incidence of heel erosion and sole contusions (Hubert, 1993; Hubert and Distl, 1994).

4 Selection programmes for claw and leg quality

Genetic investigations in claw traits showed that implementation of selection on claw and leg quality supports improvement of lifetime performance, longevity and claw soundness in dairy cows. Selection should be based on all available information of own performance, progeny, half and full sibs and futher relatives. Information should be combined in a BLUP-procedure with the relationship matrix of the animal. Which claw and leg traits may be used in tested animals and in the different types of breeding programmes depends on costs and net returns of the claw and leg quality programme. As traits included in a selection index are combined on a monetary scale, the relative importance of claw and leg traits is given by their economic weight put in the total merit index. Norway, Sweden and Denmark are the only countries having included the trait legs and feet in their total merit index, otherwise the average of all conformation traits has to exceed a fixed selection limit. The relative weights compared to milk yield are 5:19 (0.26) in Norway, 3:29 (0.10, SRB) and 3:26 (0.12, SLB) in Sweden, 6:24 (0.25, RDM) and 7:22 (0.32, SDM) in Denmark. These indices were introduced in the Nordic countries at the end of the seventies. The conclusions for this selection strategy were that the overall efficiency is superior to single trait selection for milk yield because functional and constitutional traits are stabilized or improved (Andersen et al., 1993).

Breeding programmes based on AI

• *Information on daughters in dairy farms*

Subjective scores for claws and legs are widely used in progeny testing programmes as well as for selection of young bulls and bull dams. These by visual inspection recorded traits are based on a linear system scoring system. Additive genetic variance and heritabilities almost range between $h^2 = 0.1$ and $h^2 = 0.3$ (Boldman et al., 1992; Distl, 1990; Erf et al., 1992; Klassen et al., 1992; Misztal et al., 1992; Smothers et al., 1993). Traits mainly regarded are side view of legs, foot angle, height of heel and spreading of claws. Data analysis from US-Holsteins showed that type traits are genetically correlated with productive life and the reliability of breeding values for productive life could be increased by incorporation of breeding values for fourteen type traits (Boldman et al., 1992; Short and Lawlor, 1992; Misztal et al., 1992; Weigel et al., 1994). The estimated correlations indicated that continued selection for milk yield could result in undesirable effects of some conformational traits, but leg and feet traits would not be those most affected. Rogers (1993) emphasized that inclusion of nonyield traits as somatic cell score, udder depth, teat placement and foot angle with index weights 3 to 4 times less as much as milk yield would help to reduce negative correlations with selection for increased milk yield. Type classification records in Canadian Holsteins were phenotypically correlated with lifetime production around 0.07 for rear heel, bone and rear set, negative genetic correlations could be observed only for rear heel (-0.16 to -0.27) (Klassen et al., 1992). Also phenotypic and genetic associations could be established between herdlife and feet and leg traits of the type classification system (Boldman et al., 1992; Burke and Funk, 1993; Foster et al., 1989; Short and Lawlor, 1992). As type classification takes place at the beginning of the first lactation, there should be no big combined effects of management and production records in later life what could lead to biased results. Genetic analyses between production records and type traits of legs and feet have to be done very carefully if selection for increased milk yield causes poorer claw and leg quality. In this case good claw and leg quality can't be associated with higher production.

Progeny testing of a sample of daughters in field for measurable claw traits was recommended by the EAAP Working Group. Claw shape measures should be taken on claws of one front and one rear leg and traits selected were diagonal length, angle of dorsal wall, length of dorsal border and length of heel. Judgements of leg position proved

valuable and should also incorporated into the progeny test. Even if costs at recording seem feasible, no breeding organisation has decided to use claw measurements for progeny testing. Another interesting way could be to improve linear type classification systems. The Royal Dutch Cattle Syndicate (NRS) decided to introduce the diagonal as a claw trait in the Dutch conformation evaluation programme. The diagonal was easy to judge visually if the staff was constantly trained. In general, claw and limb measures might be used in training programmes for type trait classifiers.

• *Information on young bulls and male progeny*

Claw shape measures as well as judgements of leg and feet can be easily obtained from sons which are progeny tested at stations for growth and carcass traits. As these programmes are widely used in dual purpose and beef cattle breeds recording of claw and leg traits should be possible in many countries. Heritability estimates of claw traits from male paternal half sibs seem to be higher as compared to those from field test of female progeny groups (Distl et al., 1982). It may be supposed that the error variance may be smaller under the more uniform environment of a test station. Genetic relationships between claw measures of sons and their paternal half sisters may be expected at least in the size as those estimated for performance tested bulls.

Nucleus breeding programmes based on MOET

These breeding programmes were designed to make intensive use of own performance, full and half sib information. The number of breeding animals is rather small (usually smaller than 100 to 400) and all animals are kept in a central test station. Nucleus breeding programmes provide good opportunities to include claw measurements and cinematographic gait analyses. Also the application of an electronic measurement system for recording pressure distributions underneath claws should be possible. These breeding programmes allow to develop and test new parameters for claw and leg quality traits. Parameters under test can be recorded at a test station with fairly similar conditions for all breeding animals and there are also available many daughters and sons from progeny tests. More effort in research should be put in these breeding programmes to estimate the necessary population parameters and to use the good conditions for further developments in claw and leg quality traits.

Marker assisted selection (MAS)

The recent developments in mapping the bovine genome made it possible to search for

quantitative trait loci (QTL) (Bishop et al., 1994; Womack, 1993). Quantitative traits marked by DNA-polymorphisms are QTL's and the variance explained by these DNA-markers can be handled in selection like single genes. QTL's are identified by exploiting the linkage between quantitative traits and the genetic markers. Heterozygous grandsires and their sons are genotyped and the quantitative traits are recorded in the daughters of these sons. There are ongoing several projects in order to detect QTL's for milk production, type and health traits (Da et al., 1994; Georges, 1994). It might be expected that also QTL's may be found for claw and leg quality traits if reliable and objective records will be available from many daughter groups. This might be a very important area of further research in order to achieve genetic improvement of claw and leg quality by MAS. Another interesting aspect would be to detect candidate gene loci influencing claw and leg diseases directly. The concept of laminitis suggests that the epidermal growth factor and its receptor could be tested as candidate genes. However, due to the multifactorial aetiology of many claw and leg diseases the most relevant gene loci contributing to disease expression have to be identified. Otherwise the moleculargenetic control of a disease would be rather difficult.

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Breed differences in pressure distributions underneath claws of dairy cattle

by O. DISTL and C. HUBERT

Pressure distributions underneath claws as well as hardness and electrical resistance of claw horn of 10 German Black and White (DSB) cows as well as 10 German Simmental (DFV) cows were analysed using computerized measuring systems. The cows were kept all year round in a loose housing system. The measurements were taken at the right front leg and were first done in claws not trimmed since six months. The second measurements were performed six weeks after trimming of the claws. The intended use of the measuring system is for standing animals. The pressure distribution recording system consists of a measuring platform equipped with 2048 pressure sensors working independently of each other, a central control unit and additional peripheral devices. Twenty pressure distributions are registered during the measuring cycle of one second. The pressure distributions are transformed into a uniform coordinate system, averaged and analysed by means of specially developped software. Symmetry and homogeneity of pressure distributions as well as loading of partial areas of ground surface are evaluated by key indices and eight claw quality factors. The two measuring platforms to be used for measuring hardness and water content of claw horn are integrated in one system and controlled by a personal computer. The hardness of the claws is determined by means of a 200 mm x 300 mm platform with 4 x 4 sensors placed every 4 cm like in a matrix. The test procedure is in accordance with Shore D, DIN 53 505. Electrical resistance of claw horn is recorded by 16 spring sensors arranged like the elements of a 4 x 4 matrix in a distance of 3 cm. The dimensions of the platform are 200 mm x 200 mm. Water content of the claw horn is calculated by means of a calibrate graph for the electrical resistance. The results of the pressure distribution analysis showed that the medial claws of either the DSB and the DFV were overloaded. The central zones, especially the medial claws, were loaded by significantly higher average and maximum pressures in DFV as compared to DSB. In both breeds investigated, trimming of the claws significantly reduced the average and maximum pressure on the medial and lateral claws, and also equalised the varying pressures among the medial and the lateral claws. In untrimmed claws local pressure peaks up to 110 N/cm² were registered, whereas on recently trimmed claws pressure records did not exceed 98 N/cm². The analysis of the interaction between breed and claw trimming indicated that claw trimming in DSB cows lowered local pressure peaks and improved pressure distribution more as contrasted to DFV. Claw horn of the ground surface of DFV was not as hard as that of DSB. As far as the electrical resistance and humidity of claw horn of ground surface was concerned, there were no significant differences between both breeds.

DIGITAL DERMATITIS

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INTRODUCTION - The first report on Digital Dermatitis (D.D.) by Cheli and Mortellaro in 1974 was followed by several publications on the subject. D.D., after being for many years circumscribed to Northern Italy, in the early Eighties was reported in other Europeans countries such as Holland, Czechoslovakia, the UK, France and Ireland. Even more recently also in Germany, the US, Japan, Iran, Austria, Israel and others.

On the basis of personal communications, the incidence of D.D. is higher than official reports show; yet the growing incidence may be due to the fact that in the past the disease was not recognised as such.

AETIOPATHOGENESIS - In spite of many studies and specific research, the exact aetiology of D.D. is still unknown. We still believe it is a multifactorial disease, even though in some cases high morbidity and apparent contagiousness suggest that microbial, micotic or viral agents are primarily involved.

In particular the presence of Spirochaetes, already evidenced by some Dutch authors in the Eighties, has been recently emphasised by some researches; in the past two years our studies have also evidenced the presence of Spirochaetes in histological sections, but we cannot state that they play a prominent role in the D.D. aetiology.

CLINICAL PRESENTATION - The lameness is not a consistent finding in cows affected with D.D. In many cases they exhibit some discomfort (the foot affected is rhythmically lifted

discomfort (the foot affected is rhythmically lifted from the ground), or more often an abnormal stance may be noticed. A severe lameness is seldom observed, and usually may indicate the extension of the disease to the horny structures or pododerma rather than the chronicity of the lesion itself.

Close inspection of the digital region may reveal the typical presence of more or less circumscribed erosion / ulceration of the skin bordering the plantar commissure of the interdigital space. Less frequently D.D. involves the dorsal commissure.

Lesions with the same morphology are sometimes asymmetrically localised at the skin - horn junction, proximally to the heel. Less common localisation of D.D. include the skin around the accessory digits, the skin close to the abassial aspect of the coronet and sometimes the interdigital space. In this last case, a contemporary phlogosis of the skin surrounding the interdigital space is frequently diagnosed. In addition, lesions suggesting D.D. may complicate a pre-existing interdigital hyperplasia.

Finally, most frequent are lesions characterised by reactive or proliferative features (respectively "strawberry-like" and "papillomatous-like"), which closely resemble "verrucose dermatitis" and "interdigital papillomatosis".

However, several D.D. lesions have borderline characteristics; therefore, because of simultaneous occurrence of several morphological features, the distinction between "erosive", "strawberry-like" and "proliferative" forms has actually lost its original significance.

The most frequent complications of D.D. are represented by perioplic and heel horn changes leading to erosions, fissures,

under-running, septic pododermatitis and, exceptionally, sole ulcer.

DIAGNOSIS - Diagnosis of D.D. is easily accomplished when the disease has the typical ulcerative or granulating aspect and is localised in the midplantar/mid-dorsal area of the digital region. Conversely the lesions localised predominantly in the interdigital cleft (without "digital skin" involvement) or on the surface of interdigital skin hyperplasia as well as around the accessory digits, may represent a diagnostic dilemma and are sometimes difficult to interpret.

The proliferative forms, characterised by papillomatous keratinised finger-like projections, often representing the evolution of ulcerative or "strawberry-like" lesions, are frequently misdiagnosed as "interdigital papillomatosis". Our findings don't substantiate this diagnosis and the coexistence in the same herd, in the same cow or in the same digit of both ulcerative and proliferative aspects, should suggest more caution in using this misleading term.

Differential diagnosis commonly includes interdigital phlegmon, interdigital dermatitis, verrucose dermatitis and pododermatitis of the 2nd and 5th digit, the last condition firstly reported by us at the Vienna symposium in 1980. Interdigital phlegmon has well defined characteristics, which makes the diagnosis fairly simple.

Interdigital dermatitis instead is not so easily recognisable as it was in the past. Actually, careful attention should be paid at not defining as interdigital dermatitis those lesions which, though localised in the interdigital space, more often fit in the clinical picture of D.D., due to their morphological aspect.

Pododermatitis of the 2nd and 5th digit, in sprite of our 1980 report, may also be considered - on the basis of recent clinical observations - as an atypical localisation of D.D.: a lesion which seems to have in the polymorphism its main characteristic. In this view, differential diagnosis is not motivated; even verrucous dermatitis, though often referred to as a different condition, might be included among the various forms of D.D. .

THERAPY - For many years the therapy of D.D. has been involving the excision of the entire area affected in conjunction with an accurate foot trimming, in order to remove all horny alterations (overgrowth, fissures, deep cracks etc.) caused by the primary lesion.

Since early Eighties, the most effective form of therapy, firstly experimented by Dutch colleagues, consists in topical application of oxytetracycline hydrochloride added with gentian violet. The latter component of the medication was recently demonstrated not influencing the final outcome.

However the conservative local therapy, with or without gentian violet, give the best results when properly used. For this purpose, the drug must be sprayed uniformly and for some seconds on the affected area, previously and carefully cleaned. A second application highly increases the efficacy of the treatment; the curettage of horny lesions and a proper trimming are strongly recommended.

However, in most complicated or neglected cases of D.D. and when dealing with proliferative forms (by some authors erroneously called "interdigital

papillomatosis" !!), the surgical removal of all involved tissues is required.

Although the individual treatment of D.D. is easily feasible and the results are on the whole positive (recurrence may however occurs), herd outbreaks are often frustrating to manage. Footbaths containing formalin (5%), copper sulphate (2,5%), tetracycline, zinc sulphate (20%) etc., are inconstantly reported to be successful.

Therefore, the efficacy of foot-bathing remains controversial when this measure is used as sole treatment modality in farms largely "contaminated" by D.D. . In such an evenience, individual treatment is preferred and recommended, followed by regular footbaths that represent nevertheless the most effective method of prevention.

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INTERDIGITAL CAUSES OF LAMENESS

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INTRODUCTION

Interdigital disease remains a major cause of lameness. Russell et al (1982) described interdigital necrobacillosis ("foot rot") as the most common cause of lameness in the UK, although there was considerable geographical variation. Collick et al (1989) demonstrated that the incidence of interdigital disease ("foot rot", interdigital skin hyperplasia and interdigital dermatitis) varied with stage of lactation, but was generally lower than the incidence of digital disease and solar ulceration. In a survey of 427 cases of lameness, 133 were caused by sole ulceration, 204 by digital disease and 90 (21%) by interdigital disease. More recently, in a survey of over 13,000 cases of lameness, Ward and others (personal communication) found incidences of 5.2%, 5.1% and 0.8% for foot-rot, interdigital skin hyperplasia and interdigital dermatitis respectively, namely 11.3% interdigital disease.

Based on the work of Collick et al (1989) and using data from the DAISY herd health and fertility programme, Esslemont (1992) has estimated the cost of a single case of interdigital lameness to be £99.88 (US$ 150.00). This is based on estimates of the time spent by the herdsman and the veterinarian in treatment, drug costs and yield reduction, with the major cost being the subsequent effects of lameness on fertility.

Interdigital lesions are often inter-related. For example, chronic irritation caused by interdigital dermatitis (IDD) appears to stimulate interdigital skin hyperplasia (IDSH) lesions and conversely, IDD may be seen as a cause of low-grade inflammation on the surface of an established area of IDSH.

This paper examines the various interdigital lesions and discusses their differentiation and control.

INTERDIGITAL DERMATITIS

This condition is described by Greenough et al (1982) as "an acute or chronic inflammation of the interdigital skin, without extension to the subcutaneous tissues". In this respect it differs from "foot rot" (interdigital necrobacillosis) which is an infection of the dermis caused by Fusobacterium necrophorum. Many authors implicate F. necrophorum and/or Dichelobacter (Bacteroides) nodosus as causative agents of interdigital dermatitis (Thorley et al 1977: Laing & Egerton 1978; Greenough et al 1982; Espinasse et al 1984; Toussaint Raven 1985; Peterse 1986).

Clinically, it is sometimes difficult to be sure if the interdigital lesion is an early case of foot rot (interdigital necrobacillosis), or a severe case of interdigital dermatitis (IDD). IDD lesions have three characteristics which make them more similar to DD than to foot rot. These are:

1. Many cases of IDD have the pronounced foetid smell characteristically associated with DD. Toussaint Raven (1985) also makes specific reference to the characteristic smell associated with IDD.

2. There is no fissure in the epithelium and none of the dermal involvement one would expect to see with foot rot.

3. Most lesions respond well to topical antibiotic aerosols. This would be

   expected with DD, whereas the treatment of foot rot requires parenteral therapy.

The marked similarity between DD and IDD prompted investigations to see if the two conditions had a similar aetiology. The work is proceeding, but to date some 35 biopsies have been examined both histologically and by electron microscopy (Blowey, Done & Cooley 1994 - in press). Digital dermatitis produces a characteristic histological picture, showing the primary change to be invasion of the epidermis by a spirochaete which

produces liquefaction of the keratin. (Detailed changes are reported in the Proc. 8th Int. Lameness Symposium).

It is probable that it is the liquefaction of the keratin which produces the characteristic foetid smell associated with the disease. The epithelium responds to invasion by hypertrophy and hyperplasia, trying to "grow" the invading spirochaete away from its surface. This is probably the reaction which produces the "hairy warts" originally reported by Rebhun et al (1980) and now commonly seen in California (Read et al 1992). Verrucose dermatitis (Greenough 1962; Greenough et al 1982; Espinasse et al 1984) could well be a further manifestation of the DD/IDD complex. However, this is relatively rarely seen clinically in the UK.

The surprising degree of pain associated with DD and IDD is thought to be due to exposure of the nerve endings. The epidermis is richly supplied with sensory nerve endings and often erosion to the lower layers of the epidermis produces a more painful area than a deeper lesion exposing the dermis itself.

Having established a characteristic histological picture for DD, biopsies were then taken from a series of sites where it was considered the same organism might be invading. These sites included:

- typical IDD lesions
- IDD lesions on the surface of interdigital skin hyperplasia
- those occasional sole ulcers which are slow to heal and where protruding granulation tissue has a rough, granular appearance.
- anterior digital dermatitis, namely erosive epithelial lesions, situated on the skin on the anterior aspect of the foot and often eroding the coronet. (In protracted cases these lesions may lead to a vertical fissure of the axial hoof wall, with protrusion of granulation tissue).

- heel necrosis, that is erosion at the heel/horn junction.

Histological changes similar to DD, including the presence of spirochaetes, have now been identified at all sites. The actual identity of the spirochaete remains to be clarified, although recently a high proportion of clinical cases of digital dermatitis were found to be seropositive for Borrelia burgdorferi.

THE ROLE OF DICHELOBACTER (BACTEROIDES) NODOSUS.

As stated previously, many authors (Thorley et al 1977; Laing & Egerton 1978; Espinasse et al 1984) have implicated D.nodosus, the sheep foot-rot organism, as a cause of IDD. This has been reviewed by Kasari and Scanlan (1988), who consider that Fusobacter necrophorum may also be involved. In a description of the clinical signs of IDD however, these authors describe a lesion on the skin between the heels, which has a "... thin, grey-coloured odoriferous exudate ..." and which shows " ... slight tenderness..." when palpated. These changes are also seen with digital dermatitis. Although D. nodosus is considered to be "aetiologically specific for IDD", the authors admit that because of the fastidious growth requirements of the organism, culture is rarely used to confirm the diagnosis and gram-stained examination of the surface exudate is carried out. The spirochaete which appears to be implicated in DD and IDD is found deeper in the epidermis and not on the surface. In our own findings we have been consistently unable to identify D. nodosus on culture. Samples from six typically active DD lesions were placed immediately into horn transport medium and cultured by the Moredun Institute, which has extensive experience in culturing D. nodosus from sheep foot-rot. In all cases cultures were negative (Blowey & Sharp 1986, unpublished data). This was repeated by Done (1993 -unpublished data), again with negative results. More recently, eight samples from typical IDD lesions were similarly examined. Again, all gave negative results, even though the majority of these eight lesions showed characteristic histological changes of IDD.

On the basis of these findings it is proposed that D. nodosus is not a consistent cause of IDD and that the aetiology of IDD is very similar, if not identical, to DD. Further investigations are required in this field.

TREATMENT AND CONTROL OF IDD

Many consider IDD and DD to be part of the same condition and hence use identical methods of treatment and control. This consists of topical antibiotic aerosol for treatment of individual animals and the use of a foot-bath containing antibiotic for herd treatments. The most common footbaths currently in use are:

- 150g LincoSpectin per 200 litres water for treatment
  125g LincoSpectin per 200 litres for control

- 6-8g/litre oxytetracycline

Lincomycin and Erythromycin (4-6x70g sachets per 150-200 litre footbath) have also been used with effective results. In a badly affected herd the effects can be dramatic, with a marked improvement in gait and a decrease in restlessness in the parlour seen within 24-48 hours. One passage through the footbath is usually sufficient. Response to treatment is improved if the heels are first cleaned by spraying with water, or by walking the cows through an initial footbath which only contains water.

PREVENTION OF IDD

IDD and DD appear to be most prevalent in confined cattle. In the UK it is primarily a winter condition and is particularly associated with cubicle (free stall) housing. Factors which produce a high incidence appear to be:

1. Inadequate scraping of cubicle passages. Outbreaks have been seen following a change from three times daily to twice daily milking (and therefore from

three times to twice daily scraping of the cubicle passages).

2. Pitted concrete and other areas where stale slurry can accumulate. Lesions appear to develop at anaerobic sites, namely sites where slurry becomes caked onto the backs of heels and between the digits.

3. Automatic scrapers. Increased incidence of disease is often seen in farms with automatic scrapers which pass along the slurry channel. This could be due to:

   - cows stepping into a deep wave of slurry as the scraper passes

   - damage to the interdigital skin caused by standing astride the chain.

   - an indirect effect, in that housing systems using scrapers often have a high stocking density.

4. Lack of bedding. When out at grass, in straw yards or in cubicles where bedding is generously available, the bedding seems to "brush" the feet clean. The use of rubber mats, or very restricted bedding has the reverse effect and may produce an increase in both IDD and DD.

5. Continually wet conditions. The use of hydrated lime, applied to cubicle beds once a week to help in the control of mastitis, seems to help to control interdigital lesions. Read (personal communication) has suggested that the automatic teat sprayers used in the large Californian dairies are a contributory factor, in that water running down the leg may act as an irritant to the fetlock. The author has also seen cases of DD and IDD in Argentina, when grossly excessive quantities of water used for manual udder washing ran down the cows' legs.

6. Large herds with a high culling rate. A degree of immunity appears to develop to IDD and DD. When disease is first seen in a herd, a high proportion of the animals become affected. In subsequent years it is mainly heifers, recently purchased cows and a proportion of fresh calvers which become affected. This would suggest that some immunity develops. However, Read (personal communication) has been able to reinfect cows experimentally and hence immunity is by no means certain.

INTERDIGITAL NECROBACILLOSIS (FOOT ROT)

Foot rot is a bacterial infection, leading to necrosis of the interdigital skin. Typically the epidermis is split (and as such foot rot differs from IDD) to involve the underlying dermis and there is commonly an ascending cellulitis, leading to swelling from the coronet to the fetlock. The organisms isolated from natural lesions are Fusobacterium necrophorum and Bacteroides melaninogenicus (Berg & Loan 1975) and these authors found that both organisms were necessary to reproduce the disease experimentally. The experimental challenge followed scarification of the interdigital skin. However, Clark et al (1985) were able to reproduce foot rot by experimental cultures of F. necrophorum alone, although their experimental technique involved injecting through the interdigital skin and into the dermis. These results suggest that B. melaninogenicus penetrates the epidermis following which F. necrophorum produces the cellulitis leading to lameness. F. necrophorum and B. melaninogenicus appear to act synergistically when in culture. Under natural conditions, interdigital skin would be exposed to B. melaninogenicus from faeces and hence simultaneous exposure to F. necrophorum could produce foot rot. However, it is interesting to note that in some of the cattle experimentally infected, only a mild superficial dermatitis was produced, without necrosis (Berg & Loan 1975). Today we would classify this as IDD. These mild lesions were only produced when an experimental culture of B. melaninogenicus and Actinomyces pyogenes was applied to scarified interdigital skin. Inclusion of F. necrophorum in the culture invariably appeared to lead

to a necrotic lesion. The variation in the lesions induced following experimental inoculation can therefore be associated with:

1. The size of the inoculum
2. The depth into the skin the inoculum is administered
3. The concurrent presence of B. melaninogenicus
4. The strain of F. necrophorum. Strains vary considerably in their pathogenicity.

"SUPER FOUL". Over the past 1-2 years an apparently new type of foot rot has become of increasing importance in the UK (David 1993). It is seen initially as a rapid onset of acute lameness with a swelling extending from the coronet to the pastern, forcing the claws apart but with no fissure in the interdigital skin. However, within 12 hours there is extensive interdigital damage, initially seen as skin rupture and haemorrhage and, later, necrosis. The standard single dose of antibiotic (penicillin, oxytetracycline or sulphonamide) commonly used by UK dairy farmers to treat foot rot is certainly not adequate for "Super Foul". Very prompt and aggressive therapy for 4-5 days is required, often at higher dose rates, plus local treatment of some feet. Even then, the outcome is not always successful, with some cows developing an uncontrollable, ascending cellulitis and others an interdigital prolapse of what appears to the be the navicular bursa, with continuous discharge of serous fluid. The savage onset of the lameness and the extent of the interdigital damage is striking. Limited cultural examinations which have been carried out have shown that some of the strains of F. necrophorum isolated from such cases are resistant to penicillin.

The term "super foul" is not particularly descriptive. "Blind foul" has also been used, although this normally refers to early cases where the integrity of the interdigit apparently remains intact. As the organisms isolated appear to be identical to those causing normal interdigital necrobacillosis, probably the term

"peracute foul" would be ideal.

CONTROL OF FOOTROT

In the UK, the standard control measures for foot rot include:

1. Maintain clean passageways and fill holes in the concrete, thereby reducing exposure of the feet to faeces (and B. melaninogenicus).

2. Maintaining as dry an environment as possible. The use of lime on cubicle beds will help to achieve this. Wet conditions soften interdigital skin.

3. Remove stones and other debris from gateways. Attention to rough floor surfaces which could otherwise traumatise the interdigital skin, allowing the entry of F. necrophorum. Solid mud caused by frosty conditions can also cause skin damage and predipose to disease.

4. Use of a footbath (e.g. 5% formalin solutions) once a week, to clean the interdigital skin.

5. Both F. necrophorum and B. melaninogenicus are gut organisms and hence faecal contamination is clearly of importance. When faced with an outbreak of foot-rot, some authors have suggested whole herd treatment with oral inorganic iodides (Greenough et al 1982), thereby decreasing the excretion rate of these organisms. Antibiotics such as chlortetracycline have also been suggested.

6. Prompt treatment of affected animals. Even in normal cases of foot-rot the "label" dose of penicillin is quite low and it has been suggested that this should be increased to three or four times the recommended level (Greenough, personal communication). Part of the problem seems to be that many manufacturers (in the UK at least) still refer to cows as weighing 400kg! Because of its zero milk withholding, Ceftiofur is being used increasingly in the UK as a treatment and seems to

give a good response, provided that cases are treated early. In herds where there is a high incidence of digital dermatitis, herdsman treatment of "foot rot" might be delayed, as the condition may not be suspected. This may also lead to a disappointing response to treatment.

These measures do not appear to control "Super Foul". A few herds have recently used LincoSpectin footbaths, with some apparent success. However, it is difficult to assess their value accurately, because:

- the incidence of "Super Foul" is very variable, with only 1-2 cases occurring in some herds

- no controlled studies have been carried out.

LincoSpectin would also control DD and IDD. Could it be that IDD can act as the agent allowing penetration of F. necrophorum through the epidermis? It would appear that "Super Foul" occurs primarily in herds infected with IDD and DD, but no surveys have been carried out to confirm this.

INTERDIGITAL SKIN HYPERPLASIA ("CORNS")

Interdigital skin hyperplasia (IDSH) develops from the small fold of skin adjacent to the axial hoof wall. The skin adjacent to the lateral digit is more commonly affected than the medial, although in a proportion of animals it appears to be the centre of the interdigital cleft which is affected. Peterse (1986) suggests that central lesions are secondary to footrot, whereas lateral lesions are secondary to IDD. Lameness is caused by the pinching effect of the claws when walking, or by secondary infection with conditions such as IDD and foot rot.

The incidence of IDSH is thought to be influenced by factors such as:

1. Hereditary. The condition seems to be more common in the heavier breeds of animal, e.g. Friesians,

Herefords and in some families of Holsteins. This is discussed in detail by Greenough et al (1982).

2. Solar overgrowth, reducing the space between the digits. The interdigital cleft is then more likely to become compacted by dirt and debris, leading to chronic irritation. Removing excess horn from the axial walls is often sufficient to induce spontaneous resolution of IDSH.

3. Chronic irritation in the interdigital cleft, for example that caused by IDD. Small areas of epidermal erosion characteristic of IDD are frequently seen on the surface of IDSH, but it is not possible to be sure if this is primary or secondary.

4. Excessive splaying of the claws, leading to stretching of the interdigital skin, may be a factor (Greenough et al 1982).

TREATMENT

Small lesions may resolve spontaneously if excess horn from the axial wall is removed, thereby reducing the pinching action on the IDSH. Treatment of secondary infection such as IDD (using topical antibiotic aerosol) is also important, and removal of chronic irritation in this way can also lead to spontaneous resolution. Larger lesions require surgical removal. In the writer's experience, where surgical removal of IDSH leads to exposure of the fat in the dermis, then application of a dressing, plus parenteral antibiotic therapy, is required. However, if only fibrous tissue is exposed, topical antibiotic aerosol, with or without parenteral therapy, is all that is required.

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RISK FACTORS IN THE DEVELOPMENT OF DIGITAL DERMATITIS IN DAIRIES IN TEHRAN AREA, IRAN

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Abstract:

To determine the risk indicators associated with the definitive onset of digital dermatitis, 19 dairies with different sizes and management systems in the vicinity of Tehran the capital of Iran were selected and a 18 months observational study in the form of cross - sectional was made. Intrinsic and extrinsic (internal and external to the host) determinants were recorded and the 2×2 contingency table was constructed for calculating the odd-ratio an approximate to the relative risk.

A total of 3780 cows were involved in this study and 414 cases of digital dermatitis were diagnosed. Results of this study which were graphically illustrated as a figurative venn diagram indicated that the disease could be recognized as a multifactorial epizode which the three major risk indicators e.g.nutrition, housing and host characteristics play a significant role in the aetiology of disease when they interact rather than independent action.

PAPILLOMATOUS DIGITAL DERMATITIS AND ASSOCIATED LESIONS OF DAIRY CATTLE IN CALIFORNIA: PATHOLOGIC FINDINGS

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Abstract

Inflammatory skin lesions of the feet of 74 Holstein cows in 8 dairy herds in southern California were classified by gross and histopathologic criteria. The following classes of lesions were identified:

1. Papillomatous digital dermatitis (PDD;n=129 lesions in 67 cows).
2. Non-papillomatous interdigital dermatitis (NPID; n=27 lesions in 18 cows).
3. Focal ulcerative dermatitis of the plantar pastern (FUDP; n=6 lesions in 6 cows).

Seventeen of the 74 cows had more than one class of lesion: 16 had PDD and NPID and 1 had PDD and FUDP.

Lesions of PDD (n=129) were categorized by anatomic location: 82% were situated proximal and adjacent to the interdigital space; 9% were proximal and adjacent to the base of the bulb of the heel; 8% involved the plantar pastern; and, 2% exclusively involved the interdigital space. A great majority of lesions proximal and adjacent to the interdigital space (IS) extended locally to involve several millimeters of the IS. Eight percent of cows had lesions involving multiple sites; no consistent pattern of involvement was observed. Posterior (plantar/palmar) aspects of the feet were involved in 82% of cows; anterior (dorsal) and both anterior and posterior aspects were involved in 13% and 3% of cows, respectively. Medial and lateral aspects of individual feet were exclusively involved in 39% of cows; lateral, extensive (axial, medial and/or lateral), axial and medial aspects were exclusively involved in 24%, 12% and 6% of cows, respectively.

The gross pathology of PDD (n=134 lesions in 73 cows) was characterized by shape, contour, color and surface characteristics for 3 sizes of lesions: small (~1cm), medium (~2cm) and large (~3-6cm), measured across their greatest dimensions. The majority of lesions

were medium to large (88%); circular to oval (78%); raised (59%); and, variable in color (yellow, grey, brown and/or black with multifocal red areas) and in degree of papillary proliferation (82%). A considerable proportion of medium to large lesions were flat (29%) and extensively red and granular (25%). A small (9%) proportion of large lesions were "U-shaped." This was because they involved the entire edge of the proximal skin of the posterior aspect of the IS. Small lesions were relatively uncommon (12%); they possessed similar characteristics to those of the medium to large lesions except that most had extensively red granular surfaces.

Other highly characteristic gross features of PDD included: discrete margins of demarkation/ circumscription; expansive growth involving coronet/periople of the bulb without necrosis of the corium; partial to complete alopecia; moist and prone-to-bleed surfaces; and, hypertrophy of hairs adjacent to lesion margins.

Histopathologic evaluations were made on 70 biopsies of untreated inflammatory skin lesions of the feet of 51 cows in 8 herds. According to the gross pathologic criteria, 59 lesions were PDD, 5 were NPID and 6 were FUDP. Of the 59 PDD lesions biopsied, 51 were situated proximal and adjacent to the IS; and, 4, 3 and 1 involved the plantar pastern, heel bulb area and IS, respectively; 16 were flat/raised, red and granular with patchy papillary areas, 24 were flat/raised, red and granular, 14 were raised and extensively papillary, 3 were concave, red and granular and 2 were "U-shaped" raised red/yellow and granular.

Histopathologic criteria for PDD were established in 58 of 59 lesions that were grossly characterized as PDD. Essential criteria were: parakeratotic hyperkeratosis with profuse colonization by spirochetes; absence of stratum granulosum; confluent acanthosis with invasion of outer stratum spinosum by spirochetes; absence of deep ulceration; emigration of neutrophils into outer dermal papillae and stratum spinosum; perivascular infiltration of reticular dermis by mononuclear leucocytes; and absence of dermal fibromatous change. In addition, highly characteristic (but not absolute) features were: focal-segmental orthokeratotic hyperkeratosis; ortho and parakeratotic papillae formation; sparse colonization of parakeratotic epidermis by mixed

bacilli; vacuolar degeneration of parakeratotic epidermis with foci of suppuration and hemorrhage; congestion, thrombosis, necrosis, suppuration and profuse spirochetal invasion of ulcerated tips of dermal papillae; perivascular infiltration of reticular dermis by lymphocytes and plasma cells; eosinophil infiltration of reticular dermis and nearby stratum basale; excess disorderly keratin synthesis without dyskeratosis or cellular atypia in stratum spinosum; increased mitotic figures in stratum basale; atresia of central and hypertrophy of peripheral hair follicles; and hypertrophy of dermal arterioles.

Characteristic lesions of NPID were strikingly similar to those of PDD. However, there was an absence of papillary proliferation and a relative prominence of epidermal spongiosis, dermal plasmacytosis and large bacilli interspersed in the spirochetal mat.

Lesions of FUDP were characterized by scab formation consisting of pus and serum, absence of colonizing or invasive spirochetes, deep ulceration and peripheral acanthosis and furunculosis.

PAPILLOMATOUS DIGITAL DERMATITIS OF DAIRY CATTLE IN CALIFORNIA: CLINICAL CHARACTERISTICS

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Introduction

Over the past 15 years an apparently new, contagious, painful wart-like disease of the feet of dairy cattle emerged in many parts of North America. Veterinarians recall seeing sporadic cases of similar lesions on the feet of cows[1] and bulls[10] 20 or more years ago, but the apparent contagious nature of the present disease was not evident until it broke out in two dairy herds in New York in the late 1970's.[13] Morbidity in these herds reached 40% over a 30-month-period and 73% over a 3-month-period, respectively. The authors named the disease "interdigital papillomatosis" (IP) because histopathologically the lesions were squamous papillomas and commonly involved skin adjacent to the interdigital space.

In Europe, a similar but less papillomatous disease was reported in dairy cows in Italy in 1974.[5] The authors named the condition "digital dermatitis" (DD). Since that time, DD has spread to several countries, including The Netherlands, France, England, Czechoslovakia, Germany and Ireland.[4,6]

In California, we reported papillomatous digital lesions in dairy cows similar to IP and DD in 1992.[12] Since that time, the disease has spread geographically throughout southern and south central California. Similar disease is also observed in 25 U.S. states and in 4 Canadian provinces. Morbidity rates similar to those reported for IP are now frequently cited throughout North America (Read, Unpublished data, 1994).

In a recent European review of DD, French and New York workers proposed that DD and IP are the same disease.[6] They contended that the reported differences in the degree of papillomatous change merely reflected differences in the stages of the lesion most commonly seen. Recent reports from the U.K. and Italy support this view on clinical and histopathologic grounds, respectively.[4,7]

We now prefer to name the North American disease "papillomatous digital dermatitis," rather than "interdigital or digital papillomatosis." This will acknowledge that the primary disease process is inflammation, not neoplasia; yet it will recognize the fact that the mature lesion is often histopathologically indistinguishable from a squamous papilloma.

The purpose of this report is to briefly characterize PDD in southern California in terms of epidemiology, clinical signs, anatomic distribution, macroscopic appearance and response to treatment.

Observations

At the present time, the prevalence of dairy herds in southern California affected by PDD ("Footwarts," "Hairy footwarts," "Heelwarts") is approximately 90%. Between-herd morbidity varies from 0.5 to 12% per month. Within-herd morbidity is generally greater during spring and summer months. For instance, the disease reached epidemic proportions in the Chino dairy preserve in July of 1993. Estimates of the cost of PDD to the dairy industry in California vary from $1.25 to $5 million per year.

Lesions of PDD are most commonly seen in first calf heifers and young cows a few months after they enter the milking herd. Lesions are confined to the feet. In 82% of affected cows, only the hindlimbs are involved. Forelimbs are exclusively involved in 13% of cows and both fore and hindlimbs are involved in 5% of cows. Plantar skin, proximal and adjacent to the interdigital space and heel bulb, is typically involved. Not uncommonly 2 lesions may involve a limb, usually one on either side of the plantar aspect of the interdigital cleft. Occasionally, as many as 7 lesions may involve an individual limb.

Clinical characteristics include intense lameness, decrease in body weight, milk production and fertility, clubbed hooves, minimal to no digital swelling, dramatic therapeutic response to topical or parenteral antibiotics and a high (60%) recurrence and new lesion development rate.

Typical lesions are distinctly demarcated/ circumscribed, spherical to oval, 0.5 to 6cm across, partially or completely alopecic, moist, painful-to-touch, prone-to-bleed plaques of flat or raised

proliferative tissue. Lesion surfaces vary in appearance from being extensively red and granular (31%), often with patches of yellow or grey filiform papillae (41%), to extensively grey, brown or black and papillary (28%).

Discussion

The epidemiologic, clinical and macroscopic features of PDD serve to distinguish it from other diseases of the digital skin of cattle.[2,8,14] The features are also strikingly similar to those of ID[13] and DD[3-5] and of verrucose dermatitis and digital papillomatosis in Japan.[19] The probability that these entities belong to a single disease complex should be addressed by comparative international studies, especially histopathological evaluations.

Some minor differences possibly exist between PDD and DD. Cows with PDD[12] responded to parenteral procaine penicillin, whereas cows with DD did not.[3] However, since the dose rate used for DD was not reported, this difference might be explained by the very high dose rate we used for PDD (18,000 units/kg BID). PDD often becomes more prevalent during spring and summer months in California, whereas the morbidity of DD increases during winter.[4,11] This difference may not be assessable because, during winter months, cattle are housed indoors in Europe and outdoors in California. Some workers report that DD lesions have a characteristic pungent odor.[3,6] We did not note an odor from PDD lesions, but, by the same token, we did not purposely smell them.

Many questions about PDD remain unanswered. Although a bacterial pathogenesis is evidently important in PDD, the precise etiology of the disease has yet to be determined. The possible role of invasive spirochetes is receiving considerable attention. All attempts to demonstrate papillomaviruses have been negative.

The reason why some farms have a high prevalence and others nearby have "never seen a case" is a mystery. The environmental or biological factors that induce an outbreak on a dairy are not known, as are the factors which allow its spread geographically.

PDD is mostly seen in drylot or freestall dairies; it is rarely reported in cattle confined to pasture. These observations suggest that an organically rich, wet, oxygen-lacking environment underfoot might be

necessary for the disease to proliferate. Against this are numerous field reports of outbreaks in drylot dairies in mid-summer when the corrals are dry and a report of 90% prevalence in a herd housed in concrete-floored freestalls that are flushed three times a day.

The fact that PDD occurs mostly in heifers and young cows raises the possibility that infected cows become immune as they age. However, we observed recurrent and new lesions in 60% of 26 cows that were re-examined 7 to 12 weeks after prior successful treatment. This observation raises the question that treatment may offer only a temporary cure and that immunity may be poor at best. Answers to these questions will significantly impact treatment and control strategies.

PDD is a disease that warrants multidisciplinary investigation in order to avert possible epidemics. It is with this in mind that the School of Veterinary Medicine (UC Davis), recently established a task force to study various facets of the disease. Additional funding is now underway for continued studies on the etiology of the disease, as well as for new studies on epidemiology, treatment and control.

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CURRENT INVESTIGATIONS INTO THE CAUSE OF DERMATITIS DIGITALIS IN CATTLE

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The practitioners first found lesions of dermatitis digitalis in March 1992 in four Holstein Friesian dairy herds in Slovenia. One month later we discovered the disease on one farm near Ormoz with about 350 dairy cows and heifers. Symptoms were indistinguishable from those described in Atlas en coleur des affections du pied des bovins et des ovins (Espinasse et al. 1984). Clinical signs corresponded to those described in the Atlas. Samples were taken on several occasions for bacteriological examination. In 1994 samples were also taken in order to examine for papova viruses using the PCR method (polymerase chain reaction). Examination was made for spirochetes in biopsy material after tissue samples were fixed in 10% balanced formaldehyde, processed in Paraplast and cut into six micron thin sections, which were stained in silver (Levaditi). Bacteriological examination and cultures were also made from smears of material taken from superficial skin lesions of the heels. In 1992 cows were treated by topical tetracycline spray BID for two to three days. Later in 1993 and especially in 1994 when many cases of chronic dermatitis digitalis were found, cows were treated by surgical removal of diseased masses and protective bandaging applied for several days.

Results

In 1992 in dry cows in the straw yard changes characteristic for digital dermatitis were found in the plantar skin of both hind legs. All cows with such lesions were very lame. The lesions, raspberry red with white epithelial edge were 1-2 cm in diameter, in rare cases more extensive. Changes at the horn-interdigital space were U-shaped or oval, but never extended into the cleft. Later in 1993 and especially in 1994 we found more and more lesions in form of filiform papillomata.

These papilloform changes were not found only in winter when animals were in straw yards, but they

extended throughout the year. Interestingly, these papilloform-like changes did not respond to topical therapy with tetracyclines. Furthermore, these changes were no longer painful.

With bacteriological analysis of smears no specific microorganisms were found. On tissue samples using a special transport agar for spirochetes together with bacteriological analysis for *Treponema* spp. spirochetae-like organisms were identified. They were also identified in histopathological samples coloured with Levaditi, and on EM examination. With histopathological examination was seen papillomatous type of hyperplasia with long keratinized papilomata extending to the surface and separated in some areas only by few layers of parakeratotic cells. The hyperplastic papillae were vascular, oedematous and contained numerous inflammatory cells predominantly neutrophil leukocytes.

Epithelial cells of the stratum germinativum contained single or multiple mitotic forms. Epithelial cells of the stratum basale and stratum spinosum were seen to contain pigmentary granules of melanin. An intensive inflammatory reaction in the dermis included a marked perivascular infiltration of the inflammatory cells (polymorphonuclear neutrophils, eosinophils, basophils, plasma cells and macrophages).

Endothelial cells of blood vessels were swollen. In some cases normal skin epithelium with a thin keratinized layer was adjacent to areas of marked epithelial hyperplasia and papillomatous and acanthotic changes. The typical stratum germinativum was absent, and the stratum spinosum cells lay adjacent to parakeratotic cells. Vacuolated epithelial cells with variously sized keratohyline granules were evident only in acanthotic epithelial masses on the border between keratotic cells and cells of the stratum spinosum.

Because changes were similar to those in some cases of bovine papillomatosis, we tried to prove the presence of papova viruses in destroyed cells. With EM examination we found some inclusions in cell nuclei, which were similar to those in some forms of bovine papillomatosis, caused by papova viruses types BPV1-BPV6. Papova viruses are very small, very difficult to cultivate, therefore we tried to identify the presence of virus with the PCR method, which is

very usual in the identification of the human types of papova viruses. Till now we have any success.

In 1992 all animals were treated by topical spray (tetracycline or in some cases lincomycine), and were no longer lame two or three days after treatment started. Later when chronic lesions were present all animals had to be treated surgically (excision of diseased area) and bandaged for 5 to 7 days. The result was complete healing after two dressing changes. Neither animal showed any lameness after two days of treatment.

Discussion

We found in Slovenian outbreaks of dermatitis digitalis pronounced papillomatous type hyperplasia of epithelium and parakeratotic hyperkeratosis, which was always situated clearly above the acanthotic epithelial masses.

The secondary haemorrhagic and inflammatory changes result from erosion of the superficial parakeratotic layers and by subsequent infection characterized by an intense neutrophil leukocyte migration. The primary changes closely resemble those described in bovine papillomas and verrucae, which are caused by different types of papova viruses, BPV1-BPV6. The lesion surface was extremely vulnerable to damage due to parakeratosis, so that papillomatous changes were rapidly followed by infection and an inflammatory reaction. Because of continuing observation of the same animals over a long period, in which we could identify chronic cases, we found clinical changes in the form of filiform papilomata. Therefore, we can conclude that in our cases a more suitable term for this disease would be dermatitis digitalis papillomatosa. In our cases dermatitis was not primary but a secondary change.

All of Slovenian outbreaks of dermatitis digitalis have occurred in buildings housing cattle, with a high standard of claw care, a normal biochemical profile, and with a good quality diet. Because we could not reproduce the disease with transmission of material or with isolates of *Treponema* spp., we suggest that we are dealing with a multifactorial disease. We come to this conclusion because of the changed histopathological picture, differing clinical signs and variable responses to treatment. Also on basis of the histopathological

picture we believe that the possible involvement of an autoimmunal response to the organism should be considered (i.e. high number of eosinophils leukocytes in tissue samples).

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STUDIES ON THE PATHOGENESIS AND CONTROL OF DIGITAL DERMATITIS

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Digital dermatitis is an epidermitis most commonly affecting the skin at the plantar aspect of the foot, midway between the heel bulbs (Blowey & Sharp 1988). First reported in Italy (Cheli & Mortellaro 1974), the condition has been seen in Holland (Peterse 1986) and in the United Kingdom (Blowey & Sharp 1988). A similar condition was reported in North America (Rebhun et al 1980) and more recently in the large dairies of California (Read et al 1992). Initial studies (Rebhun et al 1980; Cheli & Mortellaro 1986: Peterse 1986) were unable to identify any viral cause and results of bacteriology were inconsistent. Peterse (1986) was occasionally able to culture Dichelobacter (Bacteroides) nodosus, the sheep foot-rot organism, from typical lesions. Thorley et al (1977) in the UK and Laing & Egerton (1978) in Australia, also reported the isolation of D. nodosus from cases of interdigital dermatitis, the gross description of which bears a close resemblance to the interdigital lesions described in this report. However, sampling directly into horn transport medium, Blowey & Sharp (unpublished data) were unable to culture the organism from ten typical cases of digital dermatitis, nor from ten cases of interdigital dermatitis (Blowey, Done & Cooley, Vet. Rec. in press). Using Warthin & Starry stain, Read et al (1992) reported the presence of spirochaetes in the epithelium and in a retrospective examination of their original biopsy material, Blowey et al (1992) identified similar organisms.

From a series of biopsies, a characteristic pathology of digital dermatitis was established (Done et al 1993). This included:

1. Epithelial hyperplasia and hypertrophy, to 4-6 times the normal thickness.

2. Erosion of the superficial layers of the epidermis, the exposed surface of which then becomes covered

with large numbers of a variety of bacteria.

3. Deeper in the epidermis, two spirochaetes can be demonstrated, using Warthin & Starry stains. A long, spiral, filamentous organism 12 um long and 0.3 um wide and a shorter, thicker spirochaete 5-6 um long and 0.1 um wide.

4. The organism appears to have a predilection for keratin. Very early lesions are seen as a liquefactive necrosis of keratin, producing pockets in the epithelium. Large numbers of spirochaetes can be demonstrated in these pockets. Electron micrograph studies demonstrate that it is the longer spirochaete which penetrates the keratinising epithelial cell.

5. Involvement of the dermis is limited to secondary invasion by inflammatory cells. In most cases the epidermis remains intact, i.e. there is no ulceration.

Because of the similarity in appearance and odour of digital dermatitis and the variety of interdigital lesions, biopsies were then taken from other sites where it was considered that the same organism(s) might be involved. These sites included:

1. Interdigital dermatitis lesions

2. Areas of epidermitis on the surface of interdigital skin hyperplasia

3. The heel/horn junction, in association with heel/horn erosion
4. Anterior dermatitis lesions, which often involve the coronet and which may lead to an under-run axial wall.

5. Occasional sole ulcers which have a "granular" superficial appearance.

Histological changes characteristic of digital dermatitis include the presence of spirochaetes

(demonstrated by Warthin & Starry silver stain) have now been identified at all sites. By no means all biopsies have shown identical lesions, although the majority have shown the presence of spirochaetes. This variation in histological appearance could be due to a variety of factors, for example:

1. The difficulty of obtaining a good biopsy from interdigital lesions

2. A proportion of interdigital lesions also showed early histological changes of "foot rot", i.e. there would appear to be a phase where these two conditions are not easily distinguishable on clinical signs alone. This concurs with the observations of Greenough (1962).

3. More than one disease is present. It may be that the spirochaete producing the initial damage to the epidermis is a primary factor for several different conditions.

Rebhun et al (1980) described a papillomatous condition with hyperkeratinisation. However, in the current study, total loss of keratin was seen as an early and consistent change and hence it is unlikely that the two lesions are identical. Read et al (1992) described their lesions as histologically similar to those of Rebhun et al (1980), although no details were given. However, Read et al were able to demonstrate large numbers of spirochaetes in the lower layers of the dermis. These authors suggested a similarity to Yaws, a papillomatous condition of the lower legs in man, caused by Treponema pallidum var. pertenue. The lesions described by Read et al (1992) are very similar to verrucose dermatitis (Greenough et al 1982; Espinasse et al 1985) and hence it would appear that verrucose dermatitis could be part of the complex of diseases.

Kasari and Scanlan (1988) reviewed interdigital dermatitis and the possible association with Bacteroides nodosus. Many of the lesions they described were strikingly similar to digital dermatitis, particularly the moist, odoriferous exudate.

The aetiology of the causative spirochaete has yet to be determined. Using fluorescent antibody tests, Read et al (personal communication) have obtained negative results with group antisera for Treponema, Leptospira, Serpulina and Borrelia species. However, Blowey & Carter (unpublished data) in a serological survey of 38 clinical cases of digital dermatitis found a surprisingly high proportion of cows (71%) positive to Borrelia burgdorferi, strain B31 (IgG2). In 41 unaffected heifers, only 7.3% were seropositive. Investigations are continuing to determine if the seroconversion is related to age or exposure to digital dermatitis, or both. Borrelia burgdorferi is highly sensitive to oxytetracycline (Luft et al 1988; Malton & Melckebeke 1990) and has been shown to be the cause of a dermatitis in man (Steere 1989). It is also a long, thin spirochaete (Steere 1989), with dimensions similar to the causative organism of digital dermatitis.

In the field, digital dermatitis can be successfully controlled by a single passage through a footbath containing 5-6g/litre oxytetracycline (e.g. Terramycin, Pfizer Ltd.) or 150g LincoSpectin 100 (Upjohn Ltd.) in 200 litres of water. For optimum effect, the heels of the cows should be washed thoroughly prior to entering the footbath. Repeat treatments may be needed after 4-6 weeks, depending on the extent of the environmental challenge. As neither product is licensed for use in a footbath, antibiotic contamination of milk might occur from residues being splashed onto teats, particularly in herds where teats are not washed and wiped before milking. In seven herds with digital dermatitis, cows were walked through a footbath as they made their exit from the parlour. The bath contained either oxytetracycline (two herds) or LincoSpectin (five herds) at the concentration stated above. A pretreatment bulk milk sample was taken from each herd at the milking immediately prior to the foot-bath and a second, post-treatment sample at the milking following its use. Milk samples were tested for antibiotic (Delvotest, Gist Brocades) and in all samples, both pre- and post-treatment, no evidence of antibiotic was detectable at 0.01 iu/ml. From this limited survey it would therefore

appear that there is no significant risk of antibiotic contamination of milk following use of a footbath at these concentrations. It is possible that cows might drink small amounts of the antibiotic solution, which could result in antibiotic failure in milk and/or significant ruminal microflora disturbances.

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DIGITAL DERMATITIS: FURTHER CONTRIBUTIONS ON CLINICAL AND PATHOLOGICAL ASPECTS IN SOME HERDS IN NORTHERN ITALY

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Introduction

The typical lesion of Bovine Digital Dermatitis is an inflammation of digital skin associated with erosion and ulceration. Lesion with granulating ("strawberry-like") and proliferative features (often "papillomatous like") have also been described. The etiopathogenesis of the disease is still unknown, but many authors suggest that bacteria, particularly Spirochetae, may play an important role.

The aim of this study is to focus the clinical aspects of Digital Dermatitis and to verify the present reliability of the previous classification. The presence and the role of Spirochete and Papillomavirus in the etiology of the disease is also evaluated.

Materials and Methods

Eighty-eight cases of D.D. have been studied since 1991-1993. Location and gross morphological features have been recorded for each case. The lesions were then classified according to the current criteria in three groups. Thirty-seven cases were studied histologically. The sections were stained with haematoxilin and eosine for routine investigation, with Warthin-Starry silver method for detection of Spirochetae and were tested with the Immunohistochemical Avidin-Biotin Complex to detect Papillomavirus structural antigens.

Results

Concerning both the location and the morphology of the lesions some basic features were identified. Six digital skin areas were identified as possible locations of the lesions. The basic morphologic features of the lesions were: epidermal erosion and ulceration (45 cases), sclerodermia (17); granular epidermal surface (30), cutaneous proliferation (51). On the basis of the overall morphology, 28 lesions were classified as "erosive", 18 as "strawberry", 42 as "proliferative".

Histologically some basic morphologic features were seen in most of the samples: microabscesses mainly involving dermal papillae, dermal round cell infiltration, acute cell swelling and ballooning degeneration of the keratocytes of the stratum spinosum, acanthosis, hyperkeratosis, hyperparakeratosis and erosion of the stratum corneum and stratum lucidum. The difference among the lesions of the three classes was related to the prevalence of one or more of such basic lesions. Spirochetae were observed in part of the samples stained with Warthin-Starry silver method, however, bacillary and cocco-bacillary bacteria were also frequently seen. They were usually localized in the superficial epidermal layers, but occasionally were seen in small vessels of the dermis. Spirochaete were most frequently observed in the areas of the stratum lucidum and stratum corneum affected by ballooning degeneration and swelling. Immunohistochemical examination for papillomavirus structural antigens was always negative.

Discussion

The results of this study point out the presence of numerous border-line lesions (43) which are extremely difficult to classify. Therefore, actually the reliability of this standard of classification seems to be inadequate. On the contrary the capacity of Digital Dermatitis to show simultaneously several features seems to represent, paradoxically, the most common and significant character. The inconstant presence, in the histological sections, of bacteria, particularly Spirochetae, represents an interesting finding. But further investigations are required to focus their pathogenetic role. As a result of the histological investigation, we can exclude the