Elk Hoof Disease in Southwest Washington **Kristin Mansfield DVM MPVM**

Fish and Wildlife Commission Meeting August 8, 2014

Wild Ungulate Hoof Diseases

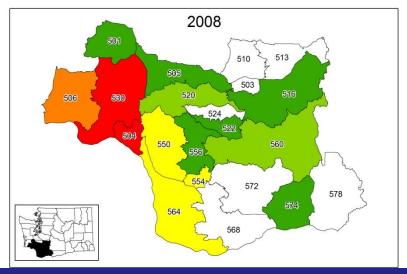
- Usually sporadic and many different causes
- Below are photos from an elk, a moose, and a mule deer, each with a different hoof disease, all collected during Fall 2012 in Eastern WA

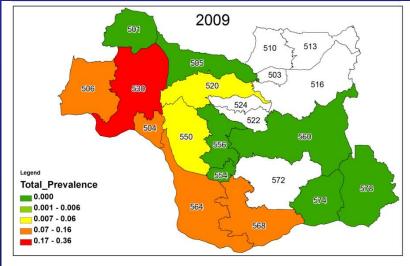


Examples of Deformed Hooves



Prevalence and Distribution 2008-2009

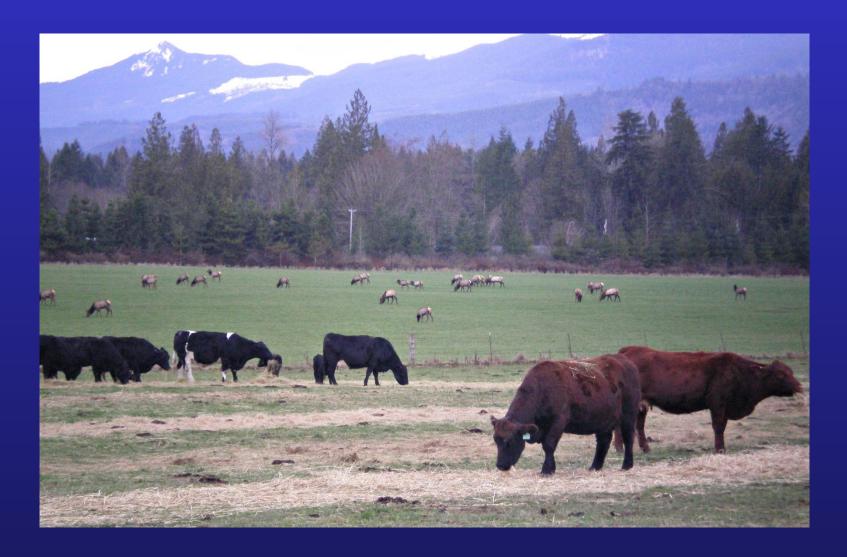




Novel Hoof Disease in Elk?



Spillover from Domestic Animals?



Common Hoof Diseases of Livestock

Foot Rot of Domestic Sheep

Digital Dermatitis of Cattle





Diagnostic Investigation Partners

Assistance of Veterinary Personnel From:

- WDFW
- Washington State University
- University of Washington
- ODFW
- Oregon State University
- University of Wisconsin
- Tufts University
- WSDA

Samples Sent to Veterinary Diagnostic or Research Labs At:

- Washington State University
- University of Idaho
- Colorado State University
- University of Wyoming
- University of Liverpool (U.K.)
- USDA National Veterinary Services Laboratory
- USDA National Animal Disease Center
- UC Davis

Collections

March 2009:

3 control

5 affected area

Feb/Mar 2013:

3 control

4 control

9 affected area

August 2013:

2 control

5 affected area

January 2014:

2 control

9 affected area

adult cows

- -- East of I-5
- -- Lewis/Cowlitz Co.

9-10 month old calves

- -- Pacific County
- -- Yakima / Kittitas Co.
- -- Lewis / Cowlitz Co.

3 month old calves

- -- Grays Harbor Co.
- -- Lewis Co.

8 month old calves

- -- Kittitas Co.
- --Cowlitz, Wahkiakum, Pacific, Grays Harbor Co.



Nostrils		**	
Oral Cavity	l V		Jury Wornstmum winter comma out
Tongue	1	H	+ token the prometors
Skin (earnotch, vent neck)	X	H	
Vulva/Penis			
Anus	T V		
Mammary gland			
INTERNAL EXAM			
Brain		H, VI, T - foil	also took moninges
Subcutaneous tissue			
Pre-scap LN (scap LN)	- X	H (cassette)	
Trachea (w/esoph & thy)	X	H	
Thyroid & parathyroid	×	Harman	The transfer of the second
Blood - RTT & LTT		S	manday flid
Bronchi/bronchioles	1		Jung Moxim
Lung	1	VI	12.13
DV x 2 sides		Н	
CV x 2 sides		H	
Mediastinal LNs (med LN)	X	H (cassette)	
Thymus		VI	tont about
Heart (long sec of walls)	X	H COMPLETE SECTION	10100100
Major vessels	X		
Diaphragm	X	Hallanda a la company	
Mesenteric fat	V	T- foil	VISITIFIE MISSMERY COL
Liver		H, VI, T x 3 - foil	TRY IN TRANSPORT
Spleen		H, VI	
Mesenteric LNs (mes LN)	4	H (cassette)	THE RESIDENCE OF THE PARTY OF T
Kidney	12	H (L&R), VI, Tx3 - foil	But and the second seco
Adrenal glands (L & R)	X	Himmon	THE PERSON NAMED IN COLUMN TWO IS NOT THE OWNER.
Ovaries/Testicles	X		
Uterus	X	*	mirature
Bladder	X.	H	
Urine		S (RT vial)	Mary padder
Skeletal muscle	1/	H, S (EtOH, cryo)	7.117.000
Popliteal LN (pop LN)	R	H (cassette)	The state of the s
Bone Physis		H	
Bone marrow (mid-femur)	7	S – bag	I raelatenak
Esophagus			1. OVERNO
Rumen	1 4	H	Look for ulcers!
Rumen contents	S S	S - bag	
Reticulum	X		
Omasum	X		

Diagnostic Investigation

- Gross necropsy
- Radiology
- Histology
- Parasitology
- Virus isolation
- Trace minerals
- Routine bacteriology
- Specialized bacteriology



Diagnostic Testing & Results

Radiology at CSU
No significant primary lesions

Histology at WSU

NSF above hooves, even in severely affected individuals

Parasitology at WSU

✓ Similar parasite loads in all groups

Diagnostic Testing & Results

Virus Isolation at UWyo

An adenovirus isolated from one eastside control, otherwise negative

Trace Minerals at UI

✓ Low selenium and copper, as expected

Serology at WSU and NVSL

No significant titers to BVD, EHD, BT, MCF, VSV

Diagnostic Conclusions

- Copper and selenium deficient
 - possible impacts on general health and immunity

Primary hoof disease with no other significant tissue involvement







Severe Hoof Deformities in Free-Ranging Elk in Western Washington State

Sushan Han DVM1, Kristin Mansfield DVM2, ¹Washington Animal Disease and Diagnostic Laboratory, Washington State University ²Washington Department of Fish and Wildlife

Abstract

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SEVERE HOOF DISEASE IN FREE-RANGING ROOSEVELT ELK (CERVUS ELAPHUS ROOSEVELTI) IN SOUTHWESTERN WASHINGTON, USA

Sushan Han^{1,3,4} and Kristin G. Mansfield²

- Washington Animal Disease and Diagnostic Laboratory, Washington State University, Pullman, Washington 99164-7034, USA
- ² Washington Department of Fish and Wildlife, 2315 N Discovery Pl., Spokane Valley, Washington 99216-1566, USA
- ³ Current address: Diagnostic Medicine Center, College of Veterinary Medicine and Biomedical Sciences, Colorado State University, 1644 Campus Delivery, Fort Collins, Colorado 80523-1644, USA
- 4 Corresponding author (email: Sushan.Han@Colostate.edu)

ABSTRACT: Reports of free-ranging Roosevelt elk (*Cercus elaphus roosevelti*) with abnormal hooves and lameness increased significantly in southwestern Washington, USA, during winter 2008. In March 2009 we examined five severely affected elk with clinical lameness from this region to characterize hoof lesions, examine the general health of affected elk, and potentially identify etiologies causing hoof disease. Three clinically normal elk from an adjacent but unaffected region were also collected as normal controls. Grossly, affected elk had deformed hooves that were asymmetrical, markedly elongated, and curved or broken, as well as hooves with sloughed horn. Most affected elk had severe sole ulcers with extensive laminar necrosis and pedal osteomyelitis. Histopathology of normal and abnormal hooves identified acute and chronic laminitis in all affected elk and one control elk. Hepatic copper and selenium levels in all affected and control elk were also deficient, and hoof keratin copper levels were low. No significant underlying systemic or musculos keletal disease was detected in the affected elk, and attempts to isolate bacterial and viral pathogens were unsuccessful. A primary cause of hoof deformity was not definitively identified in this chronically affected group. Studies to identify infectious hoof disease and to characterize acute and subacute lesions are underway.

Key words: Cervus elaphus roosevelti, copper deficiency, elk, hoof disease, lameness, laminitis, selenium deficiency, sole ulcer.

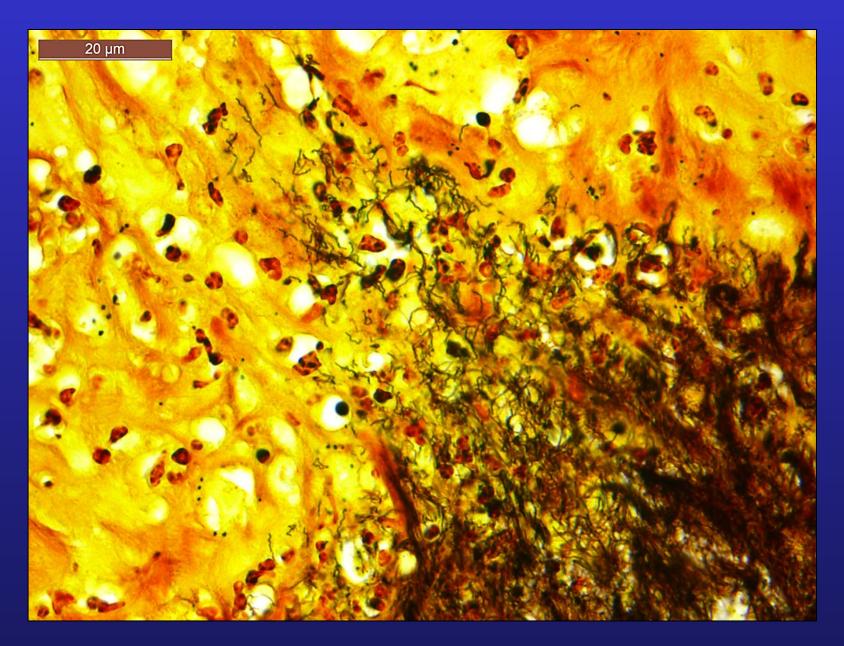
Winter 2013 Effort





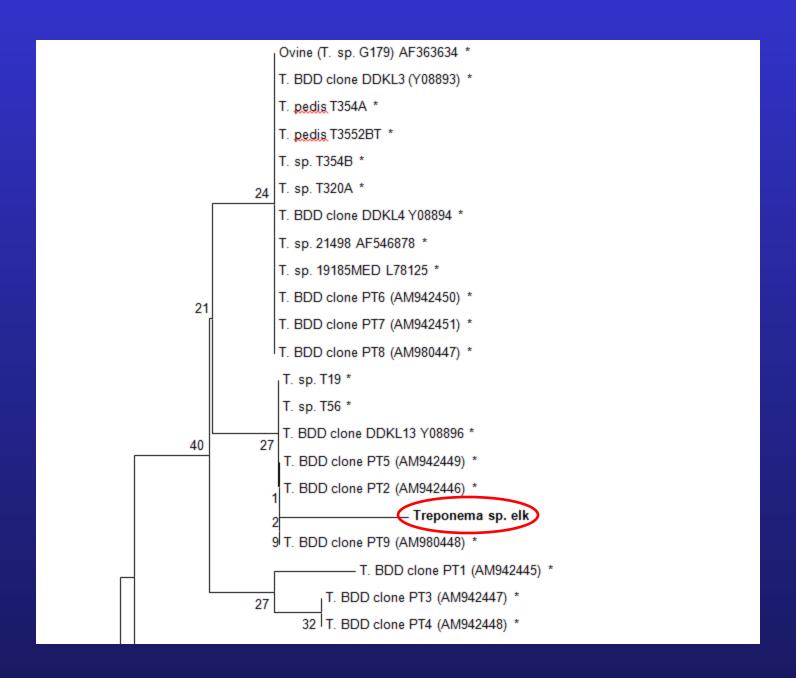


2013 – 9 month elk



Disease Status and Spirochete Detection Winter 2013

ELK ID	County	Population	Spirochetes	Treponema	Spirochetes
	County	Status	in Culture	sp. PCR	on Histology
001	Pacific	unaffected	ND	neg	neg
002	Pacific	unaffected	ND	neg	neg
003	Pacific	unaffected	ND	neg	neg
004	Kittitas	unaffected	ND	neg	neg
005	Kittitas	unaffected	ND	neg	neg
006	Yakima	unaffected	ND	neg	neg
007	Yakima	unaffected	ND	neg	neg
008	Lewis	affected	pos	pos	pos
009	Lewis	affected	neg	neg	neg
010	Lewis	affected	neg	pos	neg
011	Lewis	affected	neg	neg	pos
012	Lewis	affected	pos	pos	pos
013	Cowlitz	affected	neg	pos	pos
014	Cowlitz	affected	neg	neg	neg
015	Cowlitz	affected	pos	neg	neg
016	Cowlitz	affected	pos	neg	neg







Winter 2013 Diagnostic Results Summary

Findings very similar to 2009

- Chronic hoof changes even in 9 month old calves
- Pathogenic treponemes in diseased hooves
- Confirmed that disease limited to hooves
- Other tissues, including meat, are not affected



Summer 2013 Effort



August 2013



Disease Status and Spirochete Detection August 2013

ELK ID EL13-	County	Population Status	Sample	Spirochetes in Culture	Spirochetes on Histology	Sequencing UoL
017	Grays Harbor	unaffected	CB or IDS	neg	neg	
018	Grays Harbor	unaffected	CB or IDS	neg	neg	
021	Lewis	affected	IDS	neg	neg	
022	Lewis	affected			neg	
022	Lewis	affected	IDS	neg	neg	T. medium (2 isolates)
022	Lewis	affected	contra	neg	neg	
023			gross lesion	pos		
023						T. phagedenis subsp. vaccae (2 isolates)
023	Lewis	affected	contra	neg	neg	
024	Lewis	affected			neg	
024	Lewis	affected	СВ	neg	neg	T. medium T. phagedenis subsp. vaccae
024	Lewis	affected	contra	neg	neg	
025						T. medium
025	Lewis	affected	IDS	neg	neg	Trinedidiii

Summary Through October 2013

- Adult animals
 - Severe chronic hoof lesions; unable to determine primary lesion(s)
- 9-10 month old calves
 - Severe chronic lesions; unable to determine primary lesion(s)
 - Treponemes detected in diseased hooves
- 3 month old calves
 - Suggestion of early lesions grossly; unable to confirm histologically
 - Treponemes isolated from suspected gross lesions

January 2014 Effort



8 month old elk calf

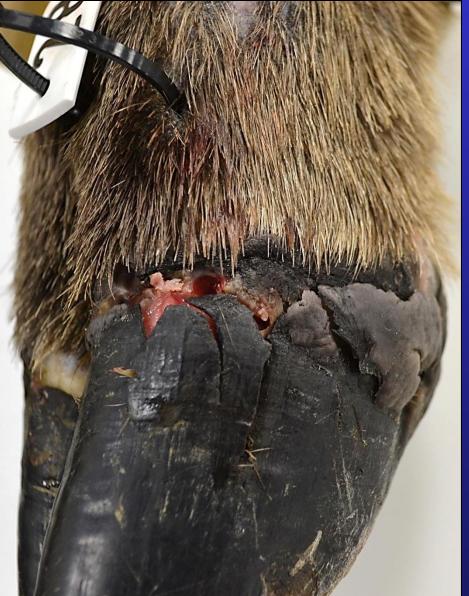




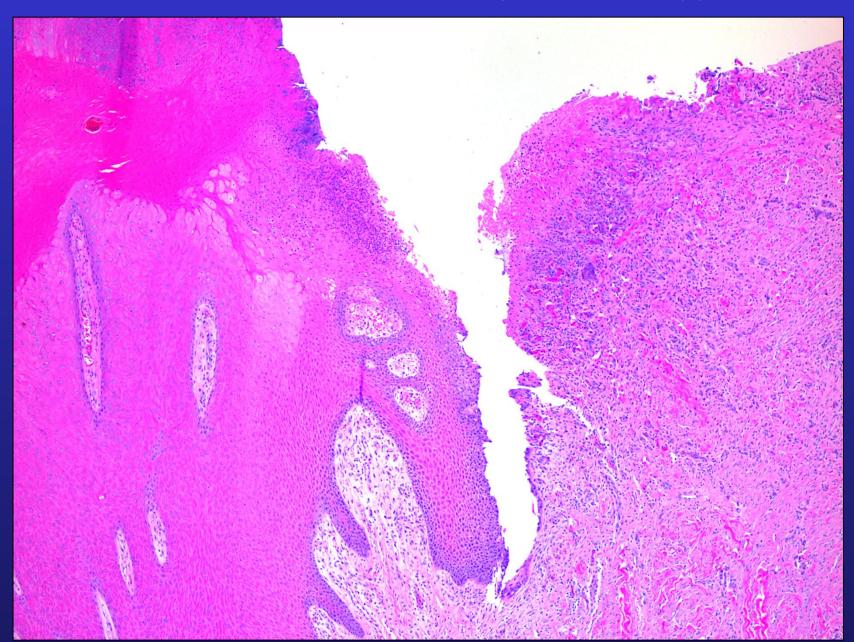
8 month old elk calf

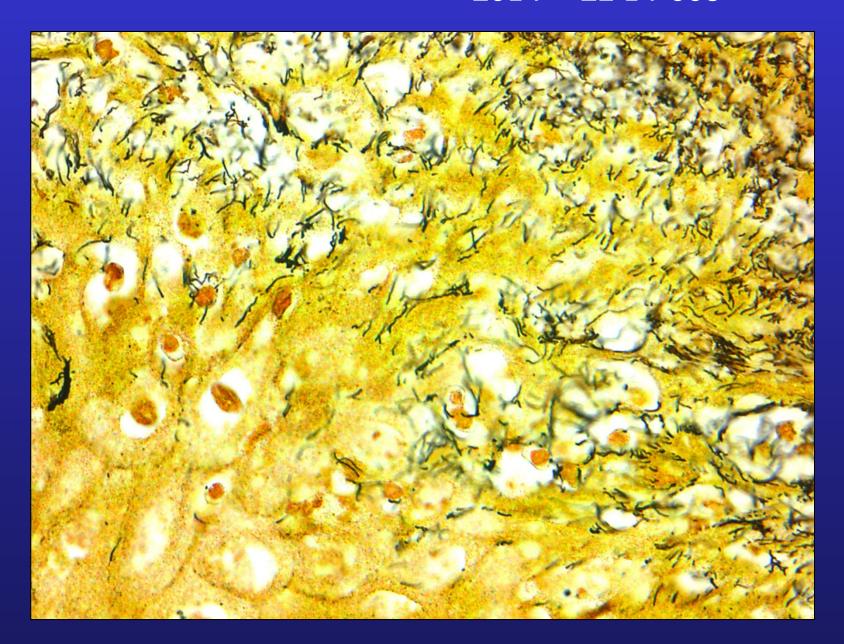


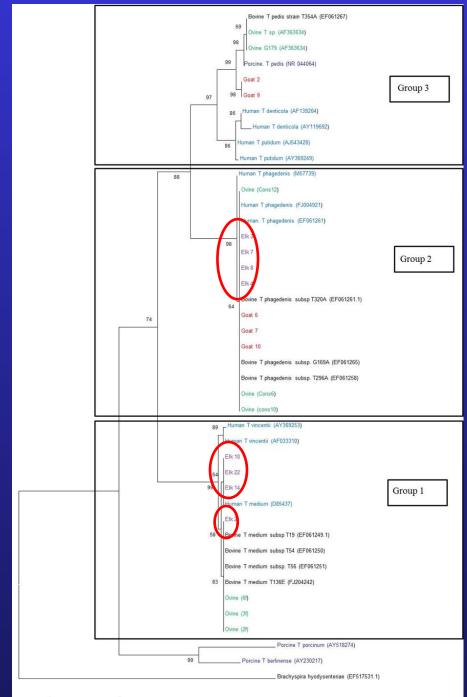












Clegg et al. (submitted to J. Clin. Micro 2014)

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Summary

3 Month August 8 Month
January

9 Month Feb-Mar 1 -7 Year

Adults

March

- Spirerbærterialesidiferat
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- Pobaeninitisitovergrowth

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What Do We Know About Digital Dermatitis?

• Emerged as a significant disease of dairy cattle in the US in the mid-1990s; other countries shortly thereafter

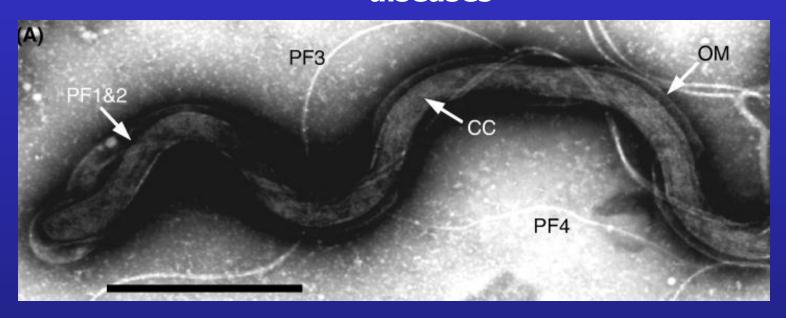


What Do We Know About Digital Dermatitis?

- 2007 NAHMS Survey
 - Present in 70% of dairies nationwide
 - Responsible for 50% of lameness cases within



From tooth to hoof: treponemes in tissue-destructive diseases

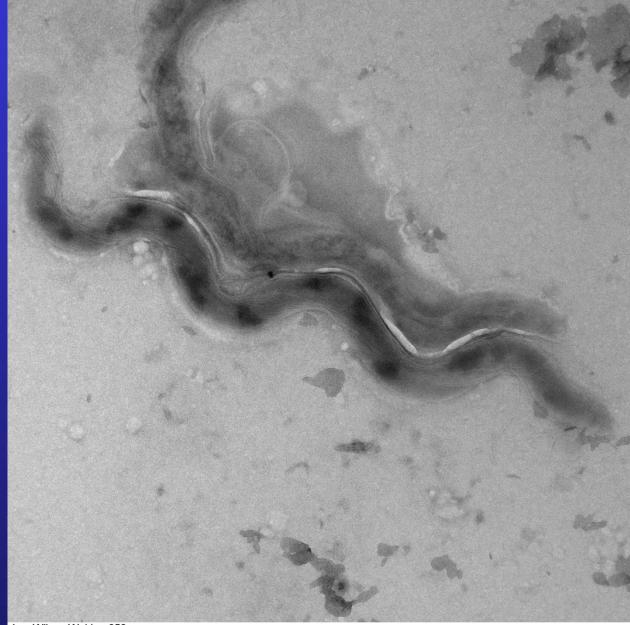


Treponemes: Spiral shaped bacteria, double membrane, flagella sandwiched between them.

Many innate immunity triggers hidden, thin corkscrew shape facilitates deep tissue penetration.

Most anaerobic (do not use oxygen), slow growth rate, very fastidious, amino acid users, produce volatile fatty acids

Journal of Applied Microbiology <u>Volume 94, Issue 5, pages 767-780, 10 APR 2003 DOI: 10.1046/j.1365-2672.2003.01901.x</u> <u>http://onlinelibrary.wiley.com/doi/10.1046/j.1365-2672.2003.01901.x/full#f1</u>



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600 nm HV=80.0kV Direct Mag: 23000x National Animal Disease Center

From tooth to hoof: treponemes in tissue-destructive diseases

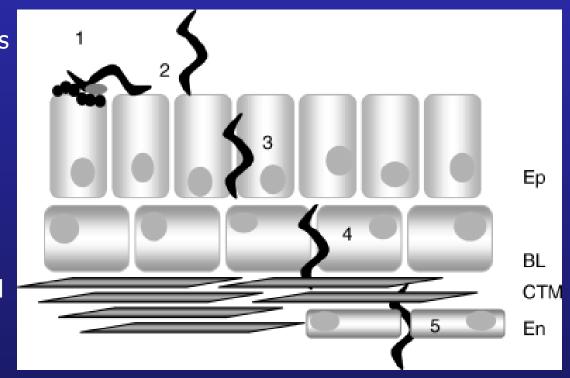
Similarity to human periodontal disease

Colonization in conjunction with other

bacteria: Fusobacterium, Porphyromonas and Streptococcus

Alterations in microenvironment allowing colonization with Treponemes

Treponemes have "virulence factors" that allow for deep penetration of epithelial and basal dermal layers



Journal of Applied Microbiology

<u>Volume 94, Issue 5, pages 767-780, 10 APR 2003 DOI: 10.1046/j.1365-2672.2003.01901.x</u> <u>http://onlinelibrary.wiley.com/doi/10.1046/j.1365-2672.2003.01901.x/full#f3</u>

Bovine Digital Dermatitis

- Leading cause of lameness in dairy cattle
 - Increasing incidences in beef cattle
- Severe economic losses due to decreased production, premature culling, footbaths/ treatment
 - A lame cow cost the producer \$346 per incident
 - 2007 Calif. Dairy Industry estimates \$1.5-5 million lost
 - 20% of culled cattle
- Animal welfare issue



Persistence of DD organisms in environment

<u>Vet Microbiol.</u> 2012 Apr 23;156(1-2):102-9. doi: 10.1016/j.vetmic.2011.09.029. Epub 2011 Oct 2.

Host and environmental reservoirs of infection for bovine digital dermatitis treponemes.

<u>Evans NJ¹, Timofte D, Isherwood DR, Brown JM, Williams JM, Sherlock K, Lehane MJ, Murray RD, Birtles RJ, Hart CA, Carter SD.</u>

-Treponemes found in oral cavity and rectal tissue of cattle from farms with DD

<u>Appl Environ Microbiol.</u> 2014 May 9. [Epub ahead of print] **Discovery of bovine digital dermatitis-associated Treponema in the dairy herd environment using a targeted deep-sequencing approach.**<u>Klitgaard K¹, Nielsen MW, Ingerslev HC, Boye M, Jensen TK.</u>

-Found DD Treponemes in manure slurry

Our Lab: viable when stored refrigerated for prolonged periods

DD Treatment and Control Options:

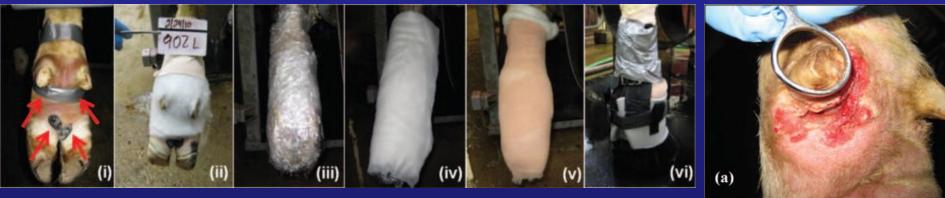
- NO VACCINE
 - Early attempts with Bacteroides and Treponema non-efficacious
- Footbaths: copper sulfate, zinc sulfate, formalin, antibiotics
 - daily use, 2-3x week
 - Not in winter in upper-midwest
 - Environmental and human toxicity issue
- Trimming and wrapping: topical antibiotics, copper sulfate
- Topical application of lincomycin (antibiotic) wraps alone required retreatment and were more likely to become active.
 - Berry et al., The Veterinary Journal, 193 (2012) 654-658





Trouble with DD:

- 20 years of study, no solid answers!!
- No infection model
 - Some success with macerated lesion material
 - 60% rate, LONG incubation, looks different



A. Gomez, N.B. Cook, N.D. Bernardoni, J. Rieman, A.F. Dusick, R. Hartshorn, M.T. Socha, D.H. Read, D. Döpfer, An experimental infection model to induce digital dermatitis infection in cattle, Journal of Dairy Science, Volume 95, Issue 4, April 2012, Pages 1821-1830, ISSN 0022-0302, 10.3168/jds.2011-4754.

(http://www.sciencedirect.com/science/article/pii/S0022030212001476)

DD lesions

- Papillomatous digital dermatitis, Hairy heel warts, strawberry warts, Mortellaro disease
- Circular to oval distinct region
- Foul smell
- Hairless, mature lesions can have keratin-like protrusions
- Moist, prone to bleeding when probed
- Extremely painful granular tissue





What Do We Know About Digital Dermatitis?

- Emerged as a significant disease of dairy cattle in the US in the mid-1990s; other countries shortly thereafter
- 2007 NAHMS Survey
 - Present in 70% of dairies nationwide
 - Responsible for 50% of lameness cases within dairies
- Sheep form (contagious ovine digital dermatitis-CODD) emerged in the UK shortly after cattle form



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J. Med. Microbiol. - Vol. 50 (2001), 1061-1068 © 2001 The Pathological Society of Great Britain and Ireland

BACTERIAL PATHOGENICITY

Identification of Spirochetes Associated with Contagious Ovine Digital Dermatitis^{*}

G. Sayers¹, P. X. Marques¹, N. J. Evans³, L. O'Grady¹, M. L. Doherty¹, S. D. Carter³ and J. E. Nally^{1,2,*}

+ Author Affiliations

ABSTRACT

Spirochetes of the convertence Vet J. 2005 Mar; 169(2):232-41.

dermatitis in Treponema n remaining cul medium/Treμ ⊕ Author information

Dhawi A1, Hart CA, Demirkan I, Davies IH, Carter SD.

denticola/Tre Abstract

Isolation and characterisation of a novel spirochaete from severe virulent ovine foot rot

I. DEMIRKAN, S. D. CARTER, C. WINSTANLEY*, K. D. BRUCE†, N. M. McNAIR‡, M. WOODSIDE§ and C. A. HART*

Departments of Veterinary Immunology and *Medical Microbiology and Genitourinary Medicine, University of Liverpool, Liverpool, †Division of Life Sciences, Franklin-Wilkins Building, Kings College, London, ‡Veterinary Research Laboratory, Belfast, Northern Ireland and &Clare Veterinary Group, Ballyclare, Northern Ireland

A novel spirochaete was isolated from a case of severe virulent ovine foot rot (SVOFR) by immunomagnetic separation with beads coated with polyclonal anti-treponemal antisera and prolonged anaerobic broth culture. The as yet unnamed treponeme differs considerably from the only other spirochaete isolated from ovine foot rot as regards morphology, enzymic profile and 16S rDNA sequence. On the basis of 16S rDNA, it was most closely related to another unnamed spirochaete isolated from cases of bovine digital dermatitis in the USA, raising the possibility of cross-species transmission. Further information is required to establish this povel avine enirochasts as the cause of

A potential pathological role for spirochaetes in bovine digital dermatitis (bovine DD) and severe virulent ovine foot rot (SVOFR) has been considered and a treponeme isolate obtained from each disease in the UK. In this work, we have investigated the hypothesis that the two diseases may have a shared (common) spirochaetal aetiology. Experiments were designed to identify serological similarities and differences between the two spirochaetes; an enzyme-linked immunosorbent assay (ELISA) was developed to detect anti-treponeme antibodies in the sera of cows and sheep against the twotreponeme isolates. Sera were further tested for antigen reactivity by Western blotting. Cattle and sheep with bovine DD and SVOFR, respectively, had increased seropositivity rates to both treponeme isolates, with different patterns of reactivity between farms. In some cattle herds, significant correlations were shown between antibodies to bovine DD treponemes and SVOFR treponemes (P<0.001). In other herds, there was no apparent cross reaction, suggesting the presence of more than one treponeme in bovine DD on some farms. There was no significant correlation between the two treponeme isolates when ELISA-tested against 58 sheep sera from SVOFR cases (P>0.05); sheep showed strong evidence of reactivity to one or the other treponeme antigens, but never to both. Western blotting against both treponeme antigens showed that they frequently displayed different antigen epitopes, although some minor bands were common to both organisms. The data suggest that there are a number of spirochaetes in UK farms, which could be involved in the pathogenesis of either bovine DD or SVOFR.

Bovine digital dermatitis and severe virulent ovine foot rot: a common spirochaetal pathogenesis.

Contagious Ovine Digital Dermatitis

Same bacterial community profile as bovine digital dermatitis: multiple **treponeme** species, multiple *Fusobacterium* species, *Peptostreptococcus*, *Streptococcus*, *Staphylococcus*, *Macrococcus* (Firmicutes) and *Dichelobacter*





Calvo-Bado L A et al. the ISME Journal (2011) 5, 1426-1437

Duncan J S et al. Veterinary Record 2011;169:606

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CODD







CODD vs. Elk Hoof Disease





J.S. Duncan, J.W. Angell, S.D. Carter, N.J. Evans, L.E. Sullivan, D.H. Grove-White, Contagious ovine digital dermatitis: An emerging disease, The Veterinary Journal (2014), doi: 10.1016/j.tvjl.2014.06.007

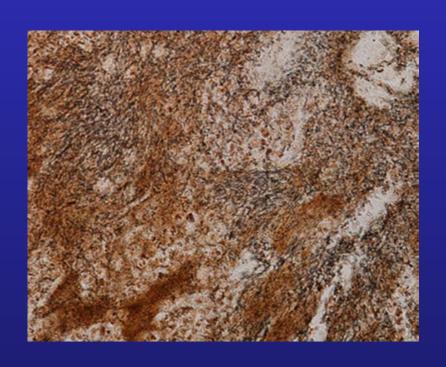
CODD vs. Elk Hoof Disease

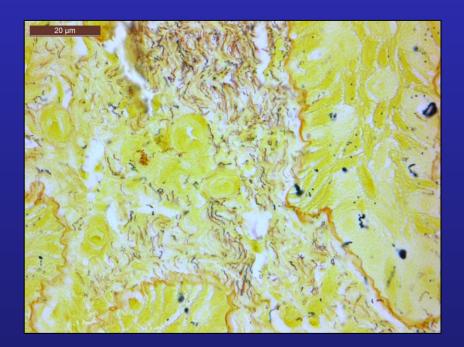




J.S. Duncan, J.W. Angell, S.D. Carter, N.J. Evans, L.E. Sullivan, D.H. Grove-White, Contagious ovine digital dermatitis: An emerging disease, The Veterinary Journal (2014), doi: 10.1016/j.tvjl.2014.06.007

CODD vs. Elk Hoof Disease





CODD of Domestic Sheep



Consensus

TAG June 3, 2014

- Available evidence is most consistent with an infectious bacterial hoof disease
- The disease shares many features and most resembles treponeme-associated contagious ovine digital dermatitis (CODD)
- Environmental factors, including wet conditions, are likely important in disease initiation and propagation

Information Needs

TAG June 3, 2014

- Being maintained in elk population?
- Elk movements/habitat use
- Develop immunity?
- Effects on survival & reproduction
- Progression of disease over time (individual & herd)
- How transmitted?
- Presence in environment (fecal & soil sampling)

FAQs/Concerns

Live Animal Testing

Herbicides

Leptospirosis

Safety of Meat

