


## Vector-Borne Diseases of Sheep and Goats

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### Definitions

- A disease that is transmitted to humans, plants, or animals by any agent, arthropod, or fomite is a *vector-borne disease*
- A vector carries and transfers an infectious agent



Rabies virus

### Examples


- Rabies – vectors are raccoons, skunks, foxes, bats
- Lyme disease – vector is deer tick
- Anaplasmosis – vector is tick
- Cache Valley virus – vectors are mosquitoes and biting midges
- Meningeal worm / Deer worm – vector is snail or slug

### Lyme disease

- deer ticks (*Ixodes*) carry the bacterium, *Borrelia burgdorferi*.
- tick needs to be attached for at least a day to spread the disease
- very serious in humans - rash, often in a bull's-eye pattern; flu-like symptoms; joint pain and weakness in the limbs
- treatment is doxycycline in people, dogs and horses

### Lyme disease in sheep and goats?

- described by veterinarians in Lyme CT
- in regions where Lyme disease affects other animals.
- many have antibodies, few show signs such as lameness, unable to culture from goats
- may be footrot or CAE instead
- prevent with permethrin every 2 weeks



### Anaplasmosis

- bacterium *Anaplasma phagocytophilum*
- anaplasmosis
- vectored by ticks (*Ixodes* deer tick)
- live in white blood cells ("granulocytic")
- dogs show lameness, joint pain, fever, lethargy, and lack of appetite
- high fevers in horses in the fall
- people get fever, headache, chills, and muscle aches after tick bite
- treat with doxycycline

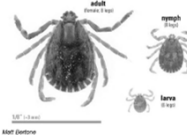
### Anaplasmosis in sheep and goats?

- > common in Europe
- > tick-borne fever
- > sheep may abort
- > susceptible to other infections such as Staph ("tick pyemia") because not enough white blood cells – septic arthritis
- > not seeing locally
- > maybe don't have right strains



### Asian long-horned ticks

- > first found in US in 2017 – widespread now
- > *Haemaphysalis longicornis*
- > may spread Rocky Mountain spotted fever, less apt to spread Lyme or anaplasmosis
- > females can reproduce without males
- > SR can bleed to death
- > very small



### Probably won't spread Lyme Disease

- Breuner NE, Ford SL, Hojgaard A, et al. Failure of the Asian longhorned tick, *Haemaphysalis longicornis*, to serve as an experimental vector of the Lyme disease spirochete, *Borrelia burgdorferi sensu stricto*. *Ticks Tick Borne Dis.* 2020 Jan;11(1):101311.

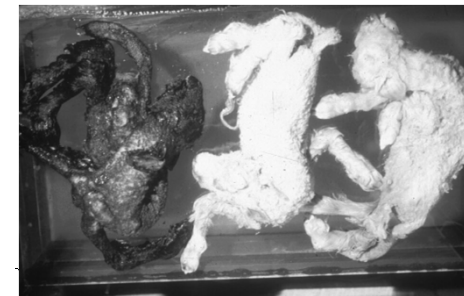
### Cache Valley virus

- > named for a valley in Utah and Idaho where trappers hid their trading goods – first isolated from mosquitoes there in 1956
- > identified as the cause of malformations in lambs in Texas in 1987-1989
- > later found to infect **deer**, cattle, horses – these animals can multiply and spread the virus, but don't see malformed fetuses
- > rare human infections, but no spread from people

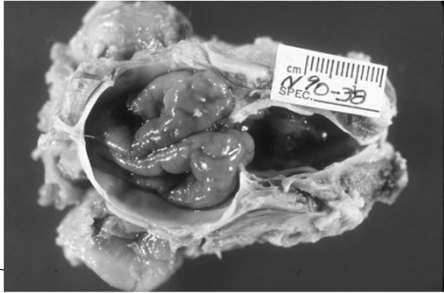
### Some big words to describe malformed lambs

- > arthrogryposis – joints don't bend properly, fused (muscle contractures)
- > hydrocephalus – fluid accumulates in brain
- > hydranencephaly – cerebral hemispheres replaced by sacs of cerebral spinal fluid
- > scoliosis – sideways curvature of the spine
- > kyphosis – upward curvature – hunched back

### Lambs with arthrogryposis frequently cause dystocia



This lamb has hydranencephaly and the brain has collapsed – skull has been opened



### Cache Valley virus in USA

- Bunyavirus
- Akabane, Schmallenberg virus elsewhere - cattle, sheep, goats affected
- mosquito vectors, some *Culicoides* midges
- virus crosses placenta at 30-40 days
- abortions, mummification
- arthrogryposis, hydrocephalus, hydranencephaly
- fetal and maternal serology to diagnose

### Cache Valley virus in NY sheep

- traditionally saw in January lambing in Cornell flock – would have been 30 days pregnant in early September
- next lambing was March – did not see (mosquitoes killed by frost by early Nov)
- global warming is changing this!



Lamb delivered February 1, 2021 in Newark Valley



Lamb delivered March 2, 2021 in Ithaca NY



Parrot mouth = Brachygnathism – short lower jaw Feb 2021

### Boer goat farm

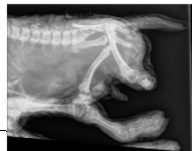
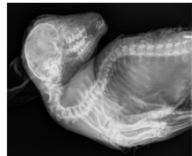
- upstate New York, USA
- established herd
- 31 Boer and Boer cross does, 1 purchased buck
- 3 unexplained abortions in November and December 2015
- negative lab tests (Q fever, toxoplasmosis, chlamydia, leptospirosis)



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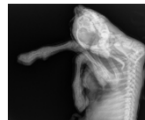
### Dystocias - #1

- Dec 24 – 4 feet presenting – neighbor pulled the kid straight out – 2.8 kg, male cryptorchid, ankylosis, short hind limbs, scoliosis, kyphosis, hydranencephaly



### Dystocias - #2a

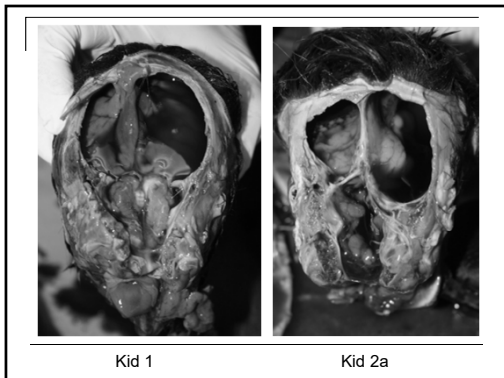
- December 25 twins
- 2.0 kg dead deformed female; scoliosis, cervical kyphosis, arthrogryposis, short lower jaw, hydranencephaly, cerebellar hypoplasia, short hind limbs



### Dystocias - #2b

- December 25 twins
- 3.9 kg male with head tilt and nystagmus, euthanized; mild torticollis, kyphosis, mild hydranencephaly





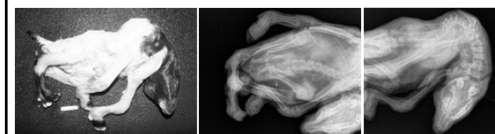
### Dystocias - #3a

- > December 28 twins
- > 2.6 kg cryptorchid male with arthrogryposis, "seal flippers", hydranencephaly, atrial septal defect



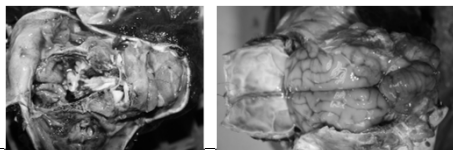
### Dystocias - #3b

- > December 28 twins
- > 2.6 kg female with severe scoliosis, arthrogryposis, hydranencephaly



### Dystocias - #4

- > January 5 single
- > 4.7 kg male very similar to #1, front limbs fixed along body
- > hydranencephaly, no cerebellum



### Bunyavirus suspected

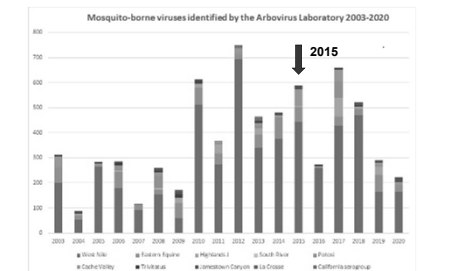
- > Cache Valley viruses detected previously in sheep in New York (January lambing)
- > kids thawed and examined
- > CVV serogroup antibodies detected in serum using dam blood and kid blood or thoracic fluid in this outbreak
- > two does that aborted had CVV antibodies
- > Schmallenberg, bluetongue, bovine virus diarrhea virus types 1 and 2 ruled out

### Why this outbreak?

- > arbovirus surveillance data in New York State NYSDOH, obtained in 2017
  - > 2014 - no Cache Valley virus detected
  - > 2015 - total of 67 positive samples
  - > 2016 - no Cache Valley virus
- > other viruses detected during these 3 years: 133 total of FLAV, HJC, JCV, POTV, TVTV

### Data from New York State mosquito pools

<https://www.wadsworth.org/programs/id/arbovirology/services>



Cache Valley virus is green, West Nile virus is dark blue

### How about CVV cases in 2022?

We identified a total of 12 positive mosquito pools this year, ... an average year in terms of prevalence. Importantly, there was also evidence of 2 human infections, which is quite unique. We have a manuscript coming out soon showing that the general increase in activity since 2010 may be driven by the emergence of lineage II CVV in NYS, which we experimentally demonstrated is more transmissible by mosquitoes. Whether or not this translates to increases in infection or disease in lambs is not clear but something to consider.

Alexander T. Ciota, Ph.D., Director, Arbovirus Lab.

### Cache Valley Virus Summary

- goats as well as sheep can be affected
- mosquito-borne
- teratogenic
- enzootic to much of North America
- white-tail deer may be host
- infected does expected to be immune for next pregnancy
- delay breeding until end of the vector season



### *Parelaphostrongylus tenuis*

deer worm  
meningeal worm

- nonpathogenic in the white-tailed deer, *Odocoileus virginianus*

### Life cycle in deer

- slug or snail ingested – this is the vector
- digested in abomasum
- larvae migrate through abomasal wall to peritoneal cavity
- migrate along nerves to spinal cord in 10 days
- develop in spinal cord

### Life cycle in deer

- return to surface of cord at 40 days
- mature and migrate to cranium
- eggs laid into blood vessels
- hatch into first-stage larvae in lungs
- enter bronchial tree, coughed up, swallowed



### Prevalence of *P. tenuis* in White-tailed Deer

- 41% of 172 adults - Ontario
- 58% of adults, 33% of juveniles - NY
- 59% of deer > 1 year - MN
- 0 to 100% in counties in S.E. USA (soil type?)

### First-stage larvae of *P. tenuis*

- pass larvae 90+ days after infected
- in mucous coat of deer fecal pellet
- killed by drying, solar radiation
- resist freezing

### Intermediate hosts

- land snails and slugs crawl over feces
- larvae penetrate gastropod's foot
- develop to third stage, encyst (3-4 wk)
- persist for life of snail or slug
- 0.04% infected on summer range, 0.16% in winter deer yards
- mean of 3 larvae each

### Reported Distribution - *P. tenuis*



### Aberrant hosts of *P. tenuis*

- moose
- caribou
- wapiti
- red deer
- black-tailed deer
- mule deer
- antelope
- llamas
- alpacas
- sheep
- goats
- fallow deer
- (cattle)
- (horses)

### Infection of Aberrant Hosts

- stay longer in spinal cord
- worms active, coil on themselves
- may reinvade cord or brain
- immune response
- usually not patent (don't shed larvae into the environment)

### Experimental Incubation Period

Very high doses used

- llamas: 45 - 53 d
- goat kids: 11 - 52 d
- lambs: 11 - 27 d
- fallow deer: 54 - 67 d
- signs common in fall, early winter

### Clinical signs of *P. tenuis*

- ataxia, hypermetria
- stiffness, lameness
- hindlimb weakness or paralysis
- progression to forelimbs
- circling, head tilt, twisted neck
- depression, blindness, nystagmus
- seizures, death







Your guard llama may also be affected

### Differential Diagnoses Sheep and Goats

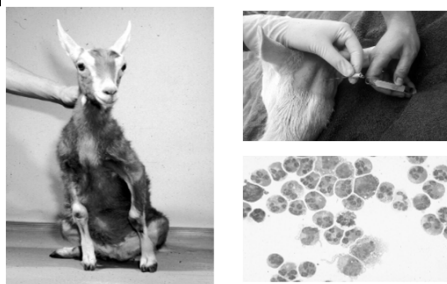
- CAE, OPP
- fracture, vertebral body abscess
- copper deficiency
- tail docking infection
- foot rot, white muscle disease

### Differential Diagnoses Sheep and Goats

- listeriosis
- polioencephalomalacia (thiamine deficiency)
- brain abscess
- rabies
- scrapie

### Cerebrospinal fluid with *P. tenuis*

- lumbosacral tap
- increased cells, usually eosinophils (not as common in sheep)
- increased protein
- llama normals: 30-70 mg/dl protein, 0-20 cells/ul
- goats: <40 mg/dl protein, 0-4 cells/ul



### Treatment of *P. tenuis* in White-tailed Deer

- ivermectin
  - kills larvae penetrating abomasum
  - ineffective after day 6 (in spinal nerves)
  - transient decrease in larval output
- albendazole 25 mg/kg for 2 weeks kills adult worms

### Treatment of *P. tenuis* in aberrant hosts

- often better to slaughter sheep
- no controlled studies published
- escalation of drug dosages
- ivermectin 0.2 to 1.0 mg/kg for 1-5 d
- fenbendazole 10 to 50 mg/kg for 1-5 d
- usually both simultaneously

### Treatment of *P. tenuis* in aberrant hosts

- anti-inflammatory drugs important
- corticosteroids if not pregnant:  
dexamethasone 0.1 mg/kg daily for 3-5 d
- flunixin 1 mg/kg daily or twice a day for 3 d
- [phenylbutazone 2-4 mg/kg q 2 d]

### Physical therapy

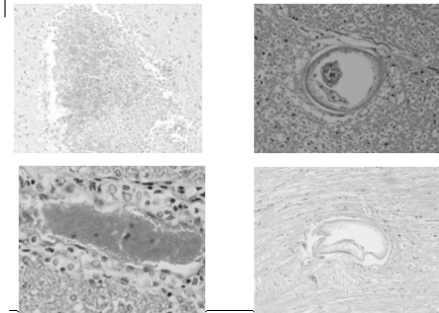
- deep straw bedding
- roll from side to side
- avoid urine scald, maggots
- flotation tank, cart
- sling? Don't hold up by tail!
- weight bearing, range of motion, muscle massage

### Prognosis

- depends on number of larvae ingested
- poor if recumbent (10 to 20% of down llamas recover)
- fair to good if can stand unaided (75 to 85% improve or recover)
- improvement over weeks to months
- some recover without therapy

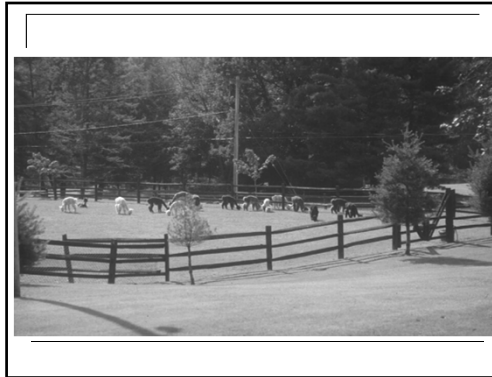
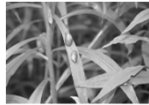
### Necropsy Findings

- exclude other diseases
- sections of parasite in cord or brain
- linear migration tracks; swollen axons, demyelination
- perivascular infiltrate - lymphocytes, plasma cells, eosinophils



### Prevention of exposure – control the host and vector

- exclude deer with double fencing
  - 6-strand electric slopes outward
  - inner netting, 8 ft high
- exclude mollusks
  - cordon sanitaire between fences
  - gravel, limestone, or plowed regularly
  - molluscicides (contaminate water)



### Prevention of exposure

- do not pasture at edge of woods
- avoid low-lying poorly drained fields
- fence off deer watering spots
- use fields deer prefer for hay, not grazing
- guardian dog may help
- take advantage of hunting season!

### Prophylaxis in abnormal host

- no controlled studies
- optimism prevalent
- injectable ivermectin q 4-6 wk to llamas
- pour-ons? (not sheep)
- resistant GI worms will kill S&G instead
- newer avermectins with longer duration?

