Haemonchus contortus

Haemonchus contortus

Take Homes

- Blood feeding nematode (GIN) of the abomasum of sheep, goats, & camelids.
- Most important helminth parasite of sheep& goats
- Haemonchosis manifests as hyperacute, acute, and chronic hemorrhagic diseases. Anemia!
- Pasture-borne nematode. Ingest L3s on pasture
- Transmission / Pasture Concerns: Periparturient rise, Spring Rise, Larval Storms.
- Clinical Signs: Pale Mucous Membranes, Bottle Jaw, Tarry Feces, Lethargy
- Diagnostics include FAMACHA, McMAsters (FEC & FECRT).
- Deworm at first sign of Haemonchosis, don't wait – FAMACHA. Supportive care if needed.
- Control & Refugia, based on FAMACHA (1^{st}) & FEC (2^{nd})
- Control: Good Deworming Practices & Good Pasture Management.
- Resistance is a huge issue: Resistant to all classes of dewormers. May need combination deworming.

Haemonchus contortus

General & Life Cycle

General

- Barber-pole Worm
  - White ovary wraps around red (blood-filled) intestine
- Most common & important parasite of Sheep & Goats (also Camelids)
- Sheep & Goats do not develop age-related immunity (v/s bovine)
  - Lambs & Kids **AND** Adult Sheep & Goats can show severe pathology.

Life Cycle

- Typical Pasture-borne Nematode Life Cycle
  - Ingestion of L3 on-pasture while grazing
- PPP – 3 weeks
- High fecundity (ability to produce a large number of offspring)
  - >1,000 eggs/worm/day
    - Affect on Diagnostics?
      - FEC > 1000 considered high => deworm to decrease pasture contamination.
      - May or may not be showing clinical signs
      - v/s *Ostertagia* FEC > 100 epg considered high

Haemonchus contortus

Pathology

- Voracious Blood feeders
  - Blood Loss → Anemia
    - Clinical Signs & Diagnostics?
      - Pallor (mucous membranes) → use FAMACHA
      - Black Tarry Feces
        - (no diarrhea, unless a mixed infection)
  - Mucosal Damage → Plasma Protein Leakage in to Gut Lumen → Hypoproteinemia → Edema
    - Clinical Signs?
      - Bottle-Jaw
      - Other edema – lips, sternum.

- Offending worm stages
  - Immature L5s
    - Affect on diagnosis?
      - Pathology w/o FEC
    - Affect on Treatment?
      - If Path severe → Don't wait, treat now, assume *Haemonchus*
  - Mature Adults – Egg Producing
    - Affect on diagnosis?
      - FEC will be positive
    - Affect on Treatment?
      - Check FAMACHA & FEC to determine <u>if treatment is warranted</u>
        - Don't forget to preserve refugia against resistance.

https://www.nadis.org.uk/disease-a-z/sheep/gastrointestinal-nematode-infestations-in-sheep/

Haemonchus contortus

Forms of Haemonchosis

Hyperacute (Peracute) haemonchosis

- Death in 1 week after heavy exposure
  - Usually Lambs & Kids
  - Sudden Hemorrhagic Anemia
    - Severe Blood Loss ➔ Death
  - High FAMACHA score
  - No FEC (Explain?)
  - Good Body Score (Explain ?)
  - No Bottle Jaw
  - High Mortality

Acute haemonchosis

- Pathology after heavy exposure
  - Older animals
  - Building Hemorrhagic Anemia
    - If Blood Loss > Hematopoietic capacity ➔ Death
  - Increasing FAMACHA score
  - Increasing FEC
  - Good Body Score
  - Bottle Jaw
  - Morbidity & Mortality about even

- Chronic haemonchosis
  - Compensated Hemorrhagic Anemia
    - Blood Loss </= Hematopoietic capacity
    - Older animals
    - Moderate FAMACHA score
    - Moderate FEC
    - Poor Body Score
      - Poor Doers, Progressive Weight Loss
      - Consider culling
    - +/- Bottle Jaw
    - High Morbidity, Low Mortality

Haemonchus contortus

Clinical Signs, Triggers

- Hemorrhagic Anemia
  - Pale Mucous Membranes
    - High FAMACHA scores
  - Low Hematocrit
  - Black Tarry Feces
    - (not diarrhea, unless mixed infection)
  - End-stage hemorrhage
    - Rapid, shallow breathing
    - High Heart Rate
    - Extreme Weakness & Prostrate
- Mucosal Damage with Protein Loss & Hemorrhage into Gut Lumen
  - Hypoproteinemia & Hypoalbuminemia
    - Bottle Jaw
    - Edema of lips
    - General Edema
- What may Trigger a Haemonchosis event?
  - Ultimately Heavily Contaminated Pastures
    - Over-crowding
    - Dewormer resistance
  - Periparturient Rise
    - Arrested L4 reactivate & become mature adults
      - Targets Ewe or Doe
        - Added blood-suckers during time of stress
          - Pregnancy & lactation
      - Targets Lambs & Kids
        - Added pasture contamination from adult worms in ewes & does
    - More Important Rise
  - Spring Rise
    - Same as Periparturient Rise
    - Affects both male & female hosts
    - Less Important Rise
  - Larval Storms

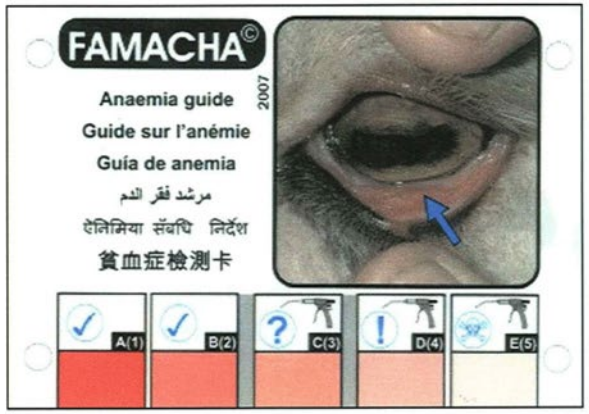
Haemonchus contortus

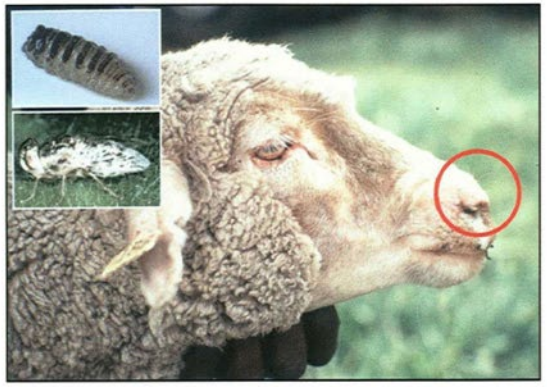
The 5-Point Check

Five-Point Check (small ruminants)

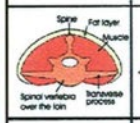
- 1. Eye – FAMACHA – (*Haemonchus*)
- 2. Back – Body Condition Score
  - May reveal weight loss / wasting
- 3. Tail – Dag Score – Most appropriate for diarrhea-causing GIN's, (ex. *Trichostrongylus*)
- 4. Nose – nasal discharge – (*Oestrus*)
- 5. Jaw – bottle Jaw – (*Haemonchus*)

Score cards for 5✓





Condition Scoring in Sheep

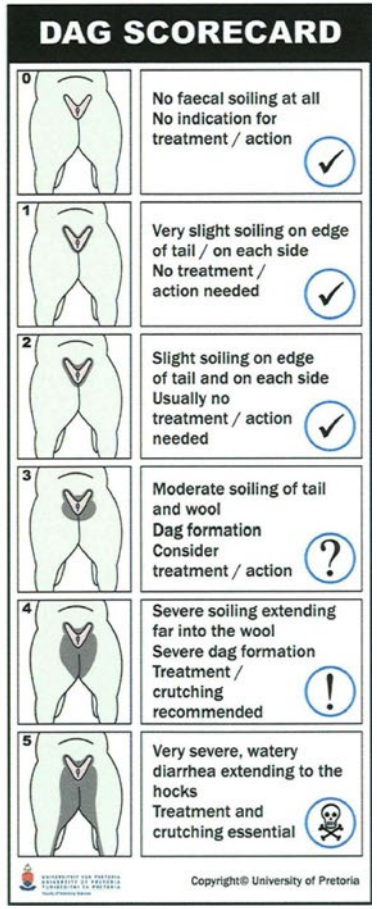
Spines	Individually clearly felt, sharp, obvious	Form a smooth line with deep undulations	Only slightly detectable undulations	Only detectable with firm pressure	Not detectable
Transverse processes	Fingers easily pass underneath	Smooth round edges	Well covered. Have to push firmly to get fingers underneath	Cannot be felt at all	
Muscle	Very little. Concave	Concave	Not concave. Not convex	Maximally developed. Convex	
Fat layer	No	Very thin	Moderate	Thick	Very thick to form a dip along top midline
					
Condition score	1	2	3	4	5

Description:

- The condition scoring is performed over the lower back area.
- Cases which do not fit these categories properly ie. fall between whole numbers, can be assigned half scores eg. 1.5, 2.5 etc.
- This scheme may be used in goats, but half a score is added to the score, since goats preferentially store fat intro-abdominally and not over the lower back.

ARC • LNR

University of Pretoria

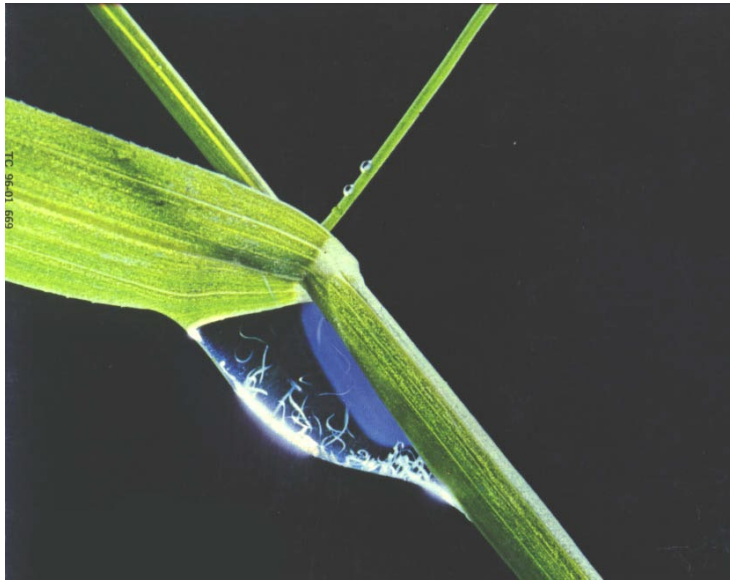


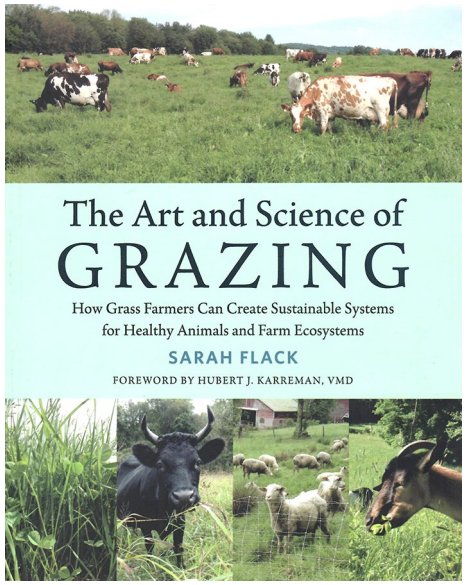
Haemonchus contortus

Pasture Management & Parasite Avoidance

Maintain Healthy Pastures

- Avoid Overgrazing and/or Overstocking
  - Continuous Grazing
    - Not so Good
  - Rotational Grazing
  - Planned Intensive Grazing





See article from
"The Art of Grazing" on the website

Parasite Avoidance

- Genetically Resistant / Resilient Host Breeds
- Avoid Overgrazing and/or Overstocking
  - Deters Excessive Pasture Contamination
- Include Plant Browse with anthelmintic properties
- Avoid infective L3s
  - Rotational Grazing
    - Run-away from L3s
      - prior to ova το L3 development
  - Planned Intensive Grazing
    - Avoid vertically migrating L3s
      - Graze forage to 4 inches then move
  - Compost Feces
  - Take Hay off contaminated pastures
  - Rest pastures until L3s die-off
  - Co-grazing (vacuum cleaners)
    - Interspecific (Host specificity)
    - Intraspecific (Age-related immunity)
  - Avoid Larval Storms

Haemonchus contortus

Control: Deworming Strategies

Salvage deworming

- @ clinical signs
  - Severe Anemia
    - FAMACHA

Strategic Deworming

- PPP interval deworming – BAD!
- Event Deworming
  - Spring Rise
  - Periparturient Rise
  - End of Grazing Season

Selective Deworming

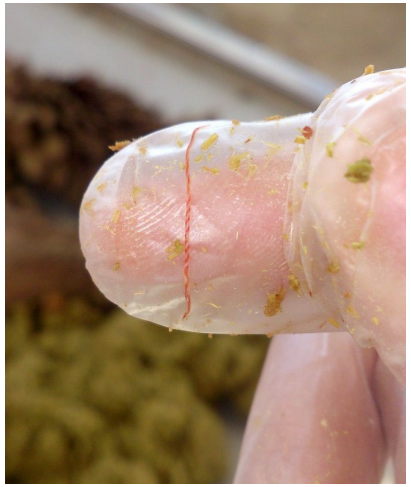
- FAMACHA
  - v/s *Haemonchus* in Small Ruminants
  - Slows Resistance development
- Test & Treat
  - FEC
    - epg "threshold"
      - Treat above threshold
        - to decrease Pasture Contamination & Avoid Pathology
      - Don't treat below threshold
        - Allows for refugia
    - Cull persistently high shedders

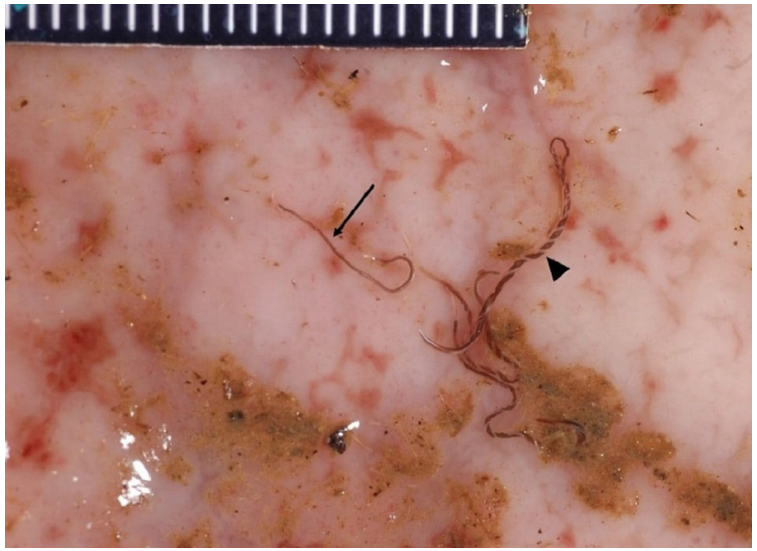
Resistance and FECRT

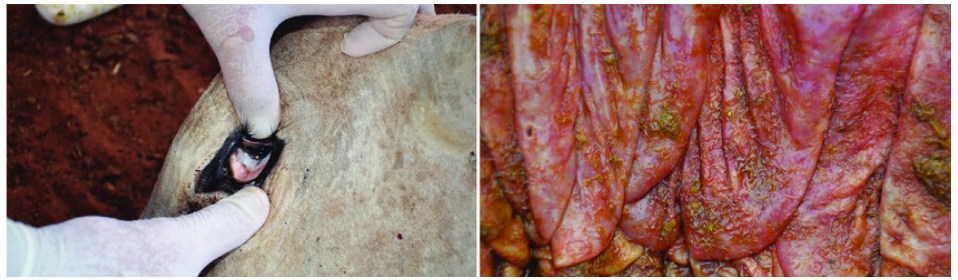
- **Haemonchus Resistance is a very serious problem**
  - **Resistance to all classes of anthelmintics**
- FECRT
  - Measures worm population's resistance to specific dewormer
  - Change Dewormer class
  - Combination Deworming may be needed
    - Treat with more than one-class of anthelmintic at one treatment

Haemonchus placei

- Barber-pole Worm <u>of Cattle</u>
  - Less important than *Ostertagia ostertagi*
- Anemia – pale mucous membranes
- Hypoproteinemia – Bottle Jaw, Sternal Edema
- Haemonchosis in cattle is usually a chronic issue
  - Calves: Anemic, unthrifty, weak







Haemonchus & other GINs

Parasite (Host)	Transmission	Pathology	Clinical Signs	Diagnostics	Treatment & Control	Notes
Haemonchus contortus (Sheep & Goats) Abomasum	Ingest L3s on pasture	Anemia	Pale Mucous Membranes, Bottle Jaw, Tarry Feces, Lethargy	FAMACHA, FEC, FECRT	Deworm @ 1st sign Based on FAMACHA & FEC ---------- Good Deworming practices, Good Pasture Management	Hyperacute, Acute, Chronic Most Important for S. Ruminants Resistance a huge issue
Ostertagia ostertagi (Cattle) Abomasum	Ingest L3s on pasture	Gastric gland damage, Increase pH, Digestion Stops, Protein catabolism	Watery Diarrhea, Bottle Jaw, Poor Body Condition, Anorexia	FEC, Blood Pepsinogens, Abomassal-centesis (increase pH)	Deworm & Supportive care ---------- Good Deworming practices, Good Pasture Management	Ostertagiasis Type I & Type II Moroccan Leather Most Important for Cattle
Small Strongyles (Horse) Cecum & colon	Ingest L3s on pasture	Granulomatous colitis, Larval Cyathostomiasis	Diarrhea, Colic, Ventral edema, Poor Body Condition	FEC, FECRT	Deworm & Supportive care ---------- Good Deworming practices, Good Pasture Management	Most Important for Horses
Trichostrongylus colubriformis (Sheep & goats) Small Intestine	Ingest L3s on pasture	Enteritis	Dark green watery Diarrhea, Dags, Dingle-berries, Poor Body Condition	FEC, FECRT	Deworm & Supportive care ---------- Good Deworming practices, Good Pasture Management	Fly Strike

Hookworms

Ancylostoma & Uncinaria

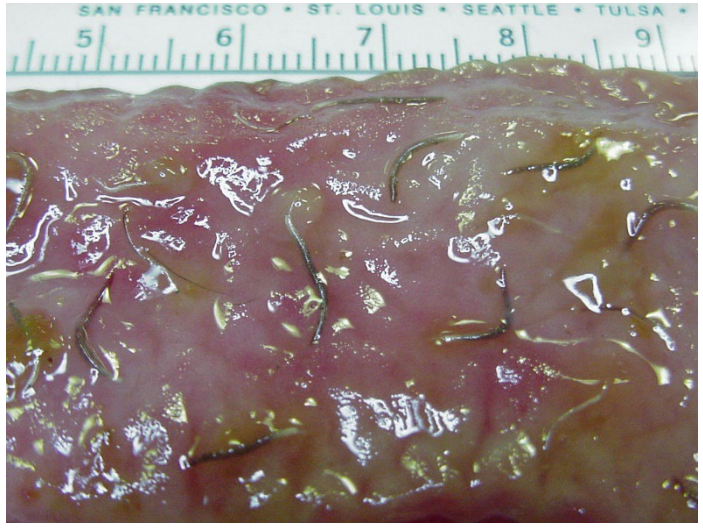
Hookworms

Species

- ***Ancylostoma caninum*** **-- dogs**
  - ***(primary concern)***
- ***Ancylostoma tubaeforme*** **-- cats**
  - ***(less pathogenic than A. caninum)***
- ***Uncinaria stenocephala*** **-- dogs and cats**
  - **More northern & less pathogenic**
- *Ancylostoma braziliense* -- dogs and cats
  - More tropical, Caribbean & aggressively zoonotic
- *Ancylostoma duodenale* -- humans
  - Europe, Africa, Asia
- *Necator americanus* -- humans
  - Predominant USA hookworm of humans

Ancylostoma spp.

Uncinaria spp.



Ancylostoma caninum

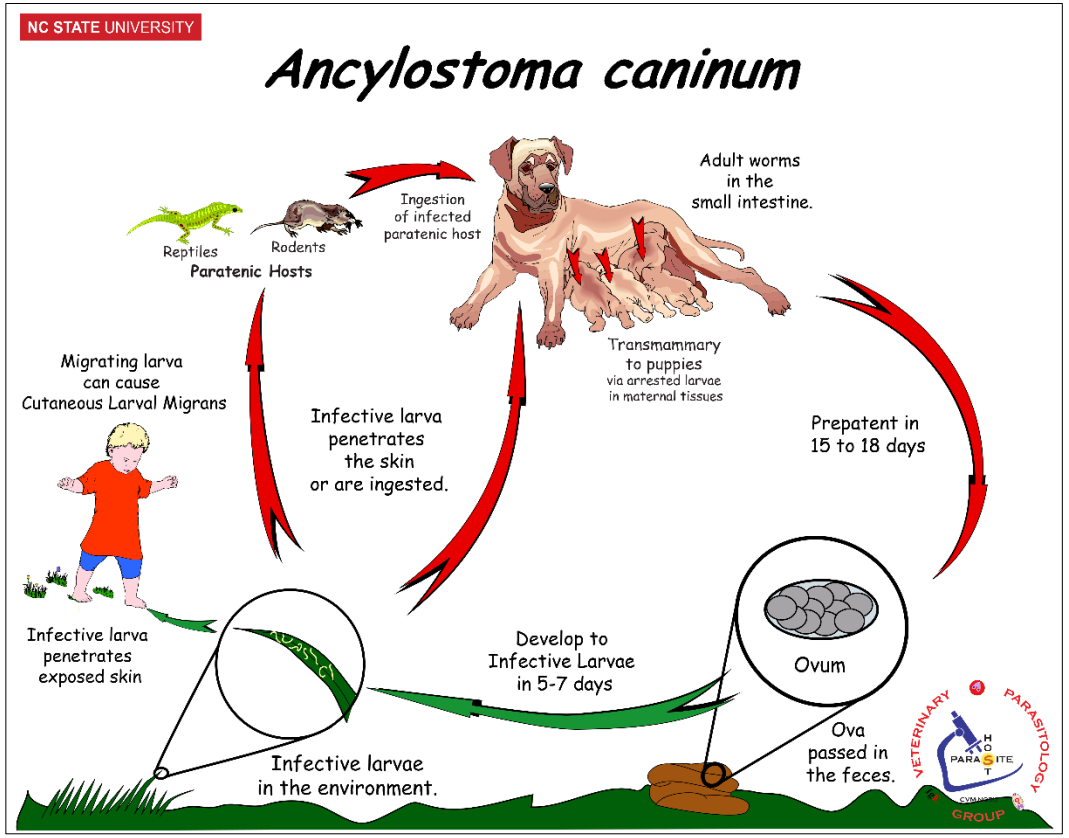
Take Homes

- Blood feeding nematode of the small intestine of dogs
- Hookworm disease manifests as peracute, acute, and chronic hemorrhagic diseases.
- The most important transmission is transmammary to puppies.
- Other routes of transmission include ingestion, skin penetration, and ingestion of paratenic hosts.
- Arrested larvae in the muscles are important for the transmammary route of transmission and the re-population of the gut in stressed adult dogs.
- Diagnostics include fecal float centrifugation, fecal antigen tests, and PCR tests.
- Puppies should be dewormed at 2 weeks of age & every 2 weeks until HW prophylaxis is begun.
- Females can be dewormed close to whelping to minimize transmammary transmission to the puppies.
- Multidrug Resistance (MDR) has developed in populations of *A. caninum* and a serious problem for vets.
- Sanitation with monthly prophylaxis is best control.
- Test puppies and adult dogs regularly for GI helminths, which includes A. caninum
- *Ancylostoma caninum* has zoonotic potential – Cutaneous Larval Migrans

Ancylostoma caninum

Life Cycle

- Adult worms in the Small Intestine of Dogs
- Eggs passed in feces; develop, hatch
- L1 & L2 in the environment develop to the infective L3 stage.
- Transmission:
  - Skin Penetration of L3s
  - Ingestion of L3s
  - Ingestion of infected Paratenic host
  - Transmammary transmission: female to puppies.



Ancylostoma caninum

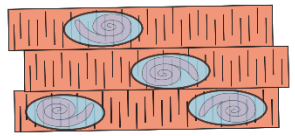
Puppies

Transmammary Infection of Pups → Larvae Migrate directly to Intestine and Develop in to Adults Worms. → Ova Contaminate Environment (PPP = 2-3 weeks)

Larvae Contaminated Environment → Skin penetration or Ingest of Infective Larvae → Tracheal Migration → Return to Gut and Develop to Adult Worms → Ova Contaminate Environment (PPP = 3 weeks)

Paratenic Host

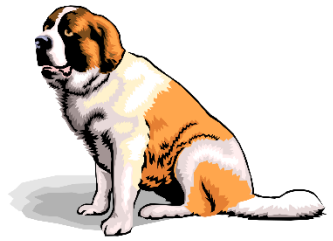
Larvae Contaminated Environment → Skin penetration or Ingest of Infective Larvae → Somatic Migration → Arrrested Larvae in Tissues



Adult Dog

Larvae Contaminated Environment → Skin penetration or Ingest of Infective Larvae → Somatic Migration → Arrrested Larvae in Tissues → (Pregnancy) → Reactivation of Arrested Larvae → Transmammary Infection of Pups

Ingest Paratenic Host with Arrested Larvae → Larvae Develop directly to Adults Worms in Intestine (no migration) → Ova Contaminate Environment (PPP = 2-3 weeks)



Larvae Contaminated Environment → Skin penetration or Ingest of Infective Larvae → Somatic Migration → Arrrested Larvae in Tissues → (Immunosuppression, Old age) → Reactivation of Arrested Larvae → Return to Gut and Develop to Adult Worms → Ova Contaminate Environment (PPP = 3 weeks)

Ancylostoma caninum

Larval Migrations in Adult Dogs

When do arrested larvae reactivate?

PREGNANCY

↓

REACTIVATION of tissue-arrested Larvae

↓

TRANSMAMMARY TRANSMISSION
Larvae in milk to pups
(but not kittens)

DEWORMING

STRESS

↓

REACTIVATION of tissue-arrested Larvae
(larval leak)

↓

REPOPULATION OF GUT
Larvae to adult stage in small intestine

Ancylostoma caninum

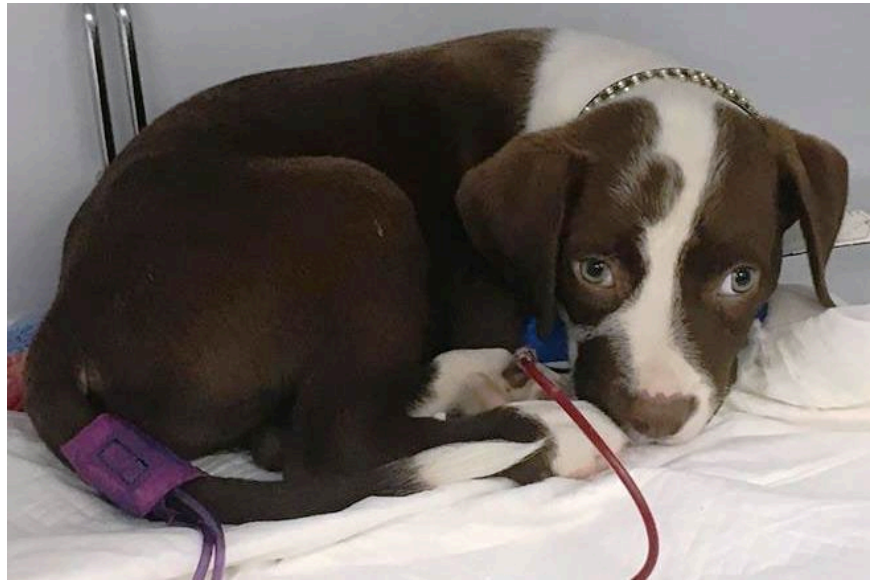
Peracute Hookworm Disease

Peracute hookworm disease (aka Puppy hookworm syndrome).

- First week puppy is fine, second week puppy crashes
  - Contributes to "Fading Puppy Syndrome"
- Severe acute anemia in nursing puppies with large worm burdens.
  - (50 adult worms can remove as much as 3 ml of blood per day).
- Caused by the larvae acquired via transmammary transmission.
  - In the female dog, previously acquired arrested larvae are reactivated and migrate to the mammary glands to infect the puppies. Reactivation is triggered by pregnancy & lactation.
    - Afterwards, puppies contaminate the whelping environment; thus "restocking" the stores of arrested larvae in the dam for the next litter of pups.
- No eggs in stool

When should one treat Puppy Hookworm Syndrome?

- Treat at the first sign of anemia with an anthelmintic
  - …..don't wait for ova in feces.
- Include supportive therapy: Iron supplementation and blood transfusions may be required in very small animals suffering extreme blood loss.
- Treatment should be repeated weekly due to continuing exposure to infection via transmammary and possible skin penetration.



Ancylostoma caninum

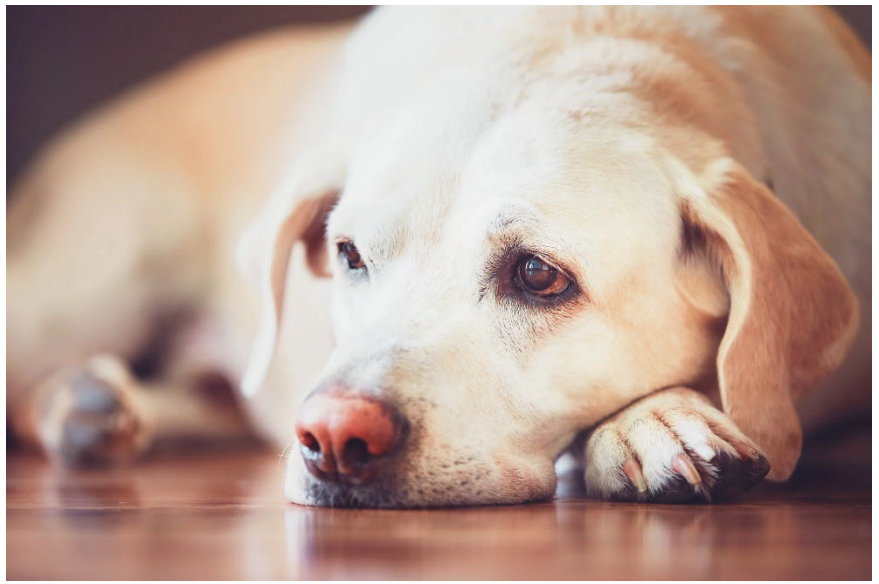
Acute & Chronic Hookworm Disease

Acute Hookworm Disease

- Acute anemia in older puppies.
- Due to Heavily contaminated environment.
- L3 larvae acquired via skin penetration, ingestion of L3.
  - Skin penetration may also cause a dermatitis with erythema, pruritus, and papules on the animal's feet, particularly in the interdigital spaces. (pododermatitis)
  - Large numbers of larvae migrating through the lungs may also cause respiratory issues.
- +/- Eggs in the feces

Chronic Hookworm Disease

- Chronic blood-loss & unthriftiness in older dogs.
- Due to "Larval Leak"
  - reactivation of arrested larvae in the host's tissues
    - Reactivation may be due to stress, immunosuppression, anthelminthic treatment, etc.
      - With anthelminthic treatment there is a loss of premunition.
- Eggs seen in the feces



Ancylostoma caninum

Diagnostics & Treatment

Diagnostics

- Clinical Signs include:
  - pale mucus membranes and anemia, ill thrift, failure to gain weight, poor hair coat, dehydration, and dark, tarry feces (melena). +/- diarrhea.
- Diagnostics include
  - Fecal Float centrifugation
  - Fecal antigen tests
    - detect PPP infections
  - PCR tests
    - Detect PPP infections
    - Detect MDR strains
- Regular testing to check program effectiveness and client compliance
  - Adult dogs at least 2X per year
  - Puppies at least 4X in 1st year of life.

Treatment

- In general, puppies should be treated at 2-3 weeks of age with a drug that controls hookworms and ascarids, and treatment should be repeated every 2 weeks till 2 months of age when the animal is put on a heartworm prevention program.
- Dams can be dewormed close to whelping to minimize transmammary transmission to the puppies.
  - Fenbendazole can be given daily at 50 mg/kg starting at the 40th day of gestation and continuing until two weeks after whelping.
  - Selamectin can be given during periparturient period and at whelping.
- Multidrug resistance has become a common issue with canine hookworm infections

Ancylostoma caninum

Multidrug Resistance

- Multidrug resistance
  - v/s Moxidectin, Ivermectin, Pyrantel and Fenbendazole
- Various Suggested Treatment Regimes
  - 2019 Hess et al. (Am Anim Hosp Assoc (2019) 55 (3): 160–166.)
  - 2020 Castro et al. (IJP: Drugs and Drug Resistance 13: 22–27)
  - 2020 Castro & Kaplan. (cliniciansbrief.com: August 2020: 61-68)
  - 2022 Peregrine, Andrew S. "Hookworms in Small Animals." Merck Veterinary Manual. www.merckvetmanual.com/digestive-system/gastrointestinal-parasites-of-small-animals/hookworms-in-small-animals.
  - 2023 Castro. (JAVMA 261 (3): 342-347)
- Note from a practicing veterinarian:
  - "We performed the advantage multi and drontal plus (within 24 hours of each other) once monthly starting September 3, 2020 and she finally tested negative for hookworms on both antigen and ova on February 22, 2021!"

- Drug Resistance v/s Larval Leak
  - Deworm & Pre-treatment fecal check
  - 14* days later do post-treatment fecal check (FERT)
    - A positive fecal at 14 days indicates the standing adult pop. is resistant.
    - A negative fecal at 14 days indicates the standing adult pop. was killed, and one is likely dealing with larval leak.
      - *After a natural post-treatment reduction in egg production (3-10 days post-treatment)
      - *But prior to re-population of gut from Larval Leak (21 days post treatment)

Ancylostoma caninum

Control & Zoonosis

Control

- Utilize a monthly HW prophylactic that is also effective against GI nematodes.
- Sanitation
  - Prompt removal of feces will minimize contamination of environment.
  - Keeping habitat dry allows for rapid desiccation of larvae.
- Prevent predation to avoid infection via paratenic hosts.

Zoonosis

- Cutaneous Larval Migrans
  - intensely pruritic, serpentine lesions of the skin
  - Caused by skin penetration by infective L3 in contaminated habitats (parks, beaches, etc.)
- Eosinophilic gastroenteritis (very rare)

Cutaneous Larval Migrans

Ancylostoma tubaeforme

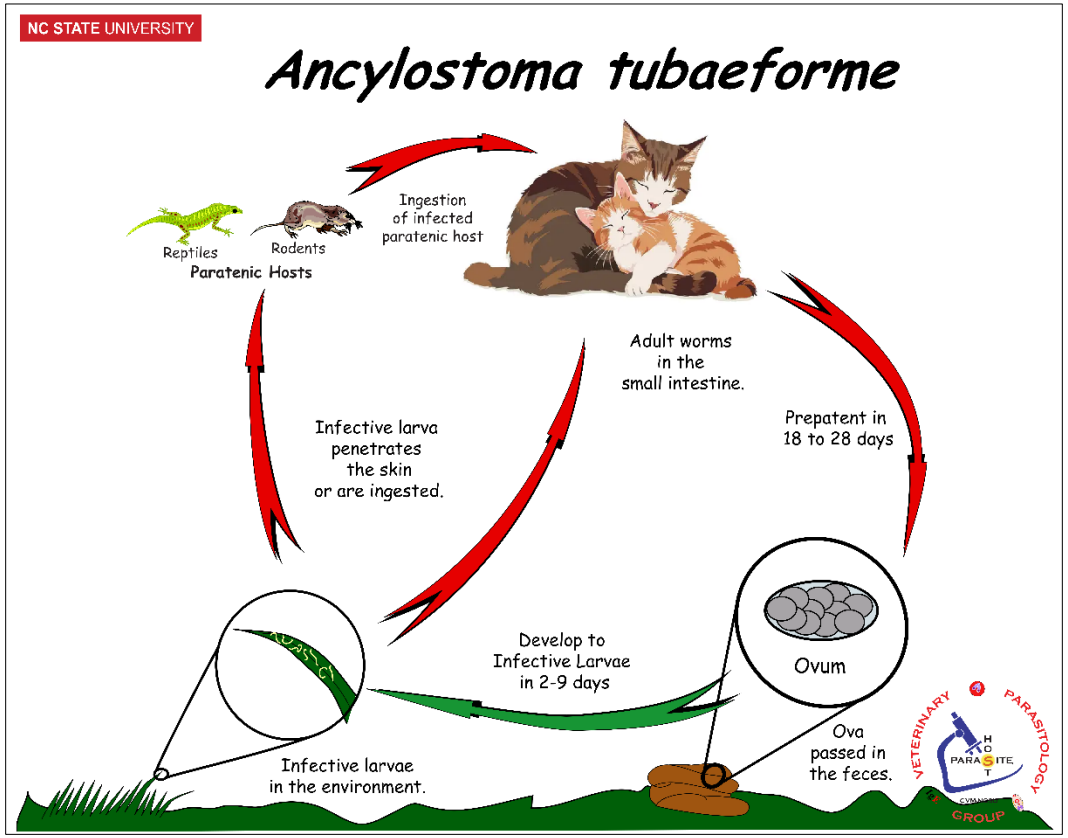
Take Homes

- Blood feeding nematode of the small intestine of cats
- Hookworm disease manifests acute or chronic hemorrhagic diseases.
- Acute disease occurs in kittens and contributes to "fading kitten syndrome"
- While chronic disease is less serious, in adult cats and maintains adult cats as sources of environmental contamination.
- Routes of transmission include ingestion, skin penetration, and ingestion of paratenic hosts. (There is no consensus about transmammary transmission in cats.)
- Diagnostics include fecal float centrifugation, fecal antigen tests, and PCR tests.
- Kittens should be dewormed at 2 weeks of age & every 2 weeks until HW prophylaxis is begun.
- Sanitation with monthly prophylaxis is best control.
- *Ancylostoma tubaeforme* has zoonotic potential – Cutaneous Larval Migrans

Ancylostoma tubaeforme

Life Cycle

- Adult worms in the Small Intestine of Cats
- Eggs passed in feces; develop, hatch
- L1 & L2 in the environment develop to the infective L3 stage.
- Transmission:
  - Skin Penetration of L3s
  - Ingestion of L3s
  - Ingestion of infected Paratenic host
  - (NO Transmammary transmission)



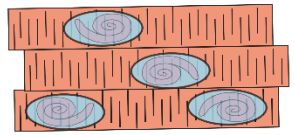
Ancylostoma tubaeforme

Kittens

Larvae Contaminated Environment → Skin penetration or Ingest of Infective Larvae → Tracheal Migration → Return to Gut and Develop to Adult Worms → Ova Contaminate Environment (PPP = 3 weeks)

Paratenic Host

Larvae Contaminated Environment → Skin penetration or Ingest of Infective Larvae → Somatic Migration → Arrrested Larvae in Tissues



Adult Cat

Larvae Contaminated Environment → Skin penetration or Ingest of Infective Larvae → Tracheal Migration → Return to Gut and Develop to Adult Worms → Ova Contaminate Environment (PPP = 3 weeks)

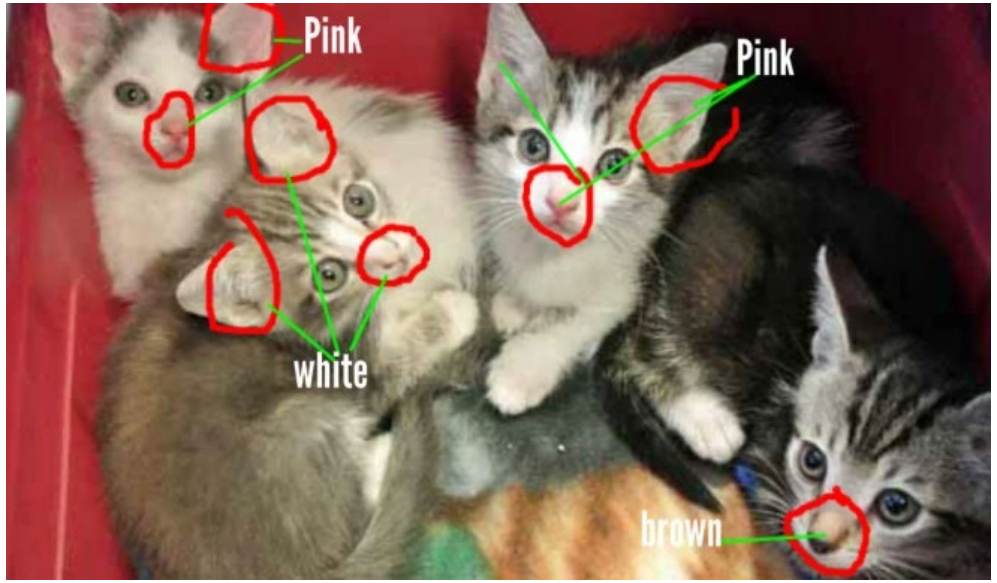
Ingest Paratenic Host with Arrested Larvae → Larvae Develop directly to Adults Worms in Intestine (no migration) → Ova Contaminate Environment (PPP = 2-3 weeks)

Ancylostoma tubaeforme

Hookworm Disease in cats

Kitten Hookworm Disease

- Anemia in kittens.
- L3 larvae acquired via skin penetration, ingestion of L3.
  - Due to contamination of the environment by kittens and adult cat.
- Eggs are usually seen in the feces



Cat Hookworm Disease

- Mild blood-loss in older cats.
- Larvae acquired from skin penetration, ingestion or **Paratenic host**
  - Adult worms develop in the small intestine
  - Adult cat becomes a source of environmental contamination
- Eggs seen in the feces

Ancylostoma tubaeforme

Diagnostics & Treatment

Diagnostics

- Clinical Signs include:
  - pale mucus membranes and anemia, ill thrift
- Diagnostics include
  - fecal float centrifugation
  - Fecal antigen tests
  - PCR tests
- Regular testing to check program effectiveness and client compliance
  - Adult cats at least 2X per year
  - Kittens at least 4X in 1st year of life.

Treatment

- In general, kittens should be treated at 2-3 weeks of age with a drug that controls hookworms and ascarids, and treatment should be repeated every 2 weeks till kitten can be put on a heartworm prevention program.

Control

- Utilize a monthly HW prophylactic that is also effective against GI nematodes.
- Sanitation
  - Prompt removal of feces will minimize contamination of environment.
  - Keeping habitat dry allows for rapid desiccation of larvae.
- Prevent predation to avoid infection via paratenic hosts.

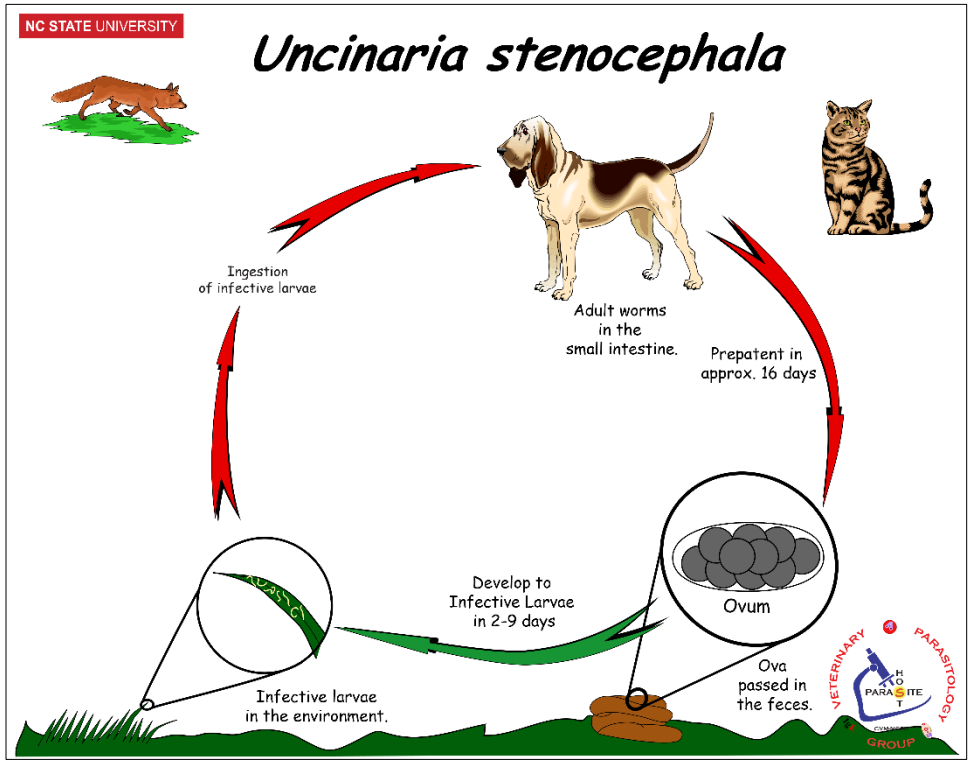
Zoonosis

- Cutaneous Larval Migrans

Uncinaria stenocephala

General

- Cutting plates (not fangs)
- Less Common hookworm of dogs, cats and fox
- Found in northern, cooler regions
- Relatively non-pathogenic
- Transmission only by ingestion of L3



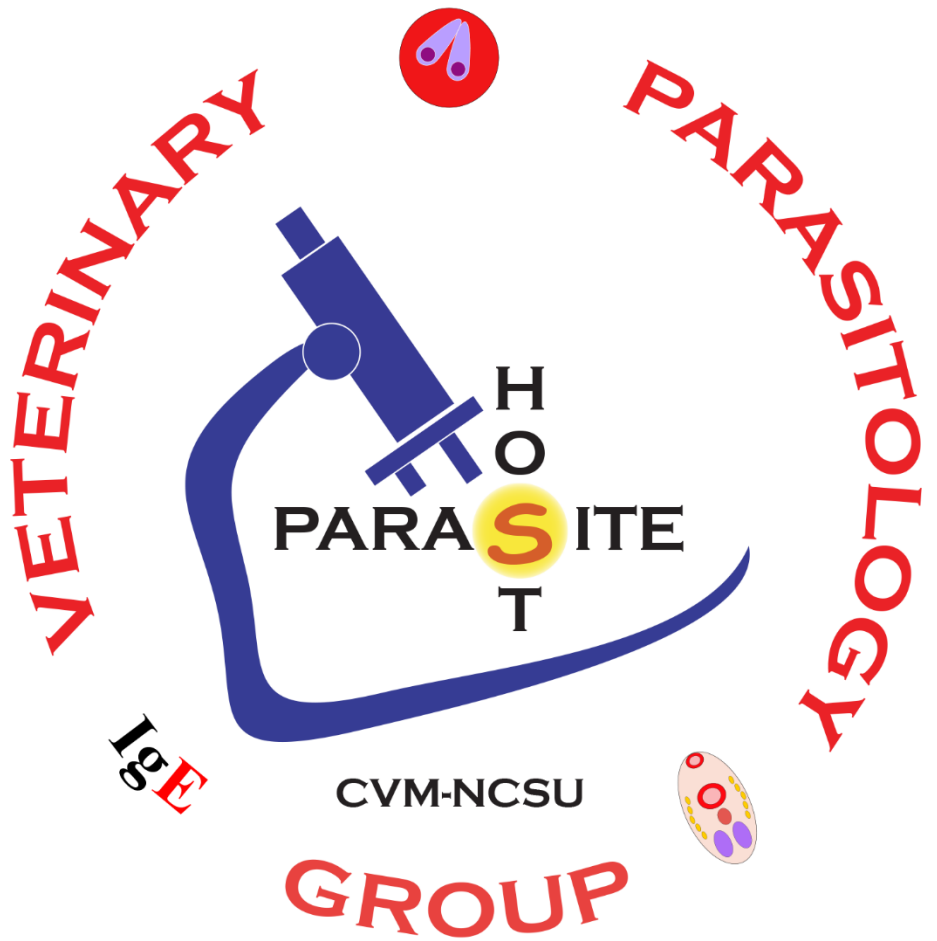
Cutting plates

Uncinaria →

← ***Ancylostoma***

Hookworms

Parasite (Host)	Transmission	Pathology	Clinical Signs	Diagnostics	Treatment & Control	Notes
Ancylostoma caninum (Dogs) Small Intestine	**Transmammary**, Ingestion, Skin Penetration, Paratenic Host	Anemia	Pale Mucous Membranes, Tarry Feces, Lethargy	Fecal Float Centrifugation, Fecal Antigen, PCR	Deworm @ 1st sign 2week old + every 2 weeks Supportive Care ---------- Sanitation	Peracute, Acute, Chronic Fading Puppy Syndrome MDR a significant / common issue
Ancylostoma tubaeforme (Cats) Small Intestine	**Ingestion, Skin Penetration**, Paratenic Host	Anemia	Pale Mucous Membranes, Tarry Feces, Lethargy	Fecal Float Centrifugation, Fecal Antigen, PCR	Deworm @ 1st sign 2week old + every 2 weeks Supportive Care ---------- Sanitation	Fading Kitten Syndrome Hookworm DZ not as pathogenic as seen in puppies
Uncinaria stenocephala (Dogs & Cats) Small Intestine	**Ingestion**	Non-Pathogenic	(Eggs found on fecal)	Fecal Float Centrifugation, Fecal Antigen, PCR	Deworm based on Fecal ---------- Sanitation	Northern, Cooler regions


VETERINARY
PARASITOLOGY
HOST
PARASITE
IgE
CVM-NCSU
GROUP