COYOTES AS A RESERVOIR FOR THE EMERGING ZOONOTIC PARASITE, *ONCHOCERCA LUPI*, IN THE SOUTHWESTERN UNITED STATES
ONCHOCERCIASIS

- Filarial nematode
- Eye and skin disease
- *O. volvulus*: African River blindness
- Transmission: black fly bit, *Simulium tribulatum*
- 114 million treated in 2015
- Adult worms live ~15 years in host
- Female worms: 13-19 inches
- Male worms: 7-16 inches
- *Wolbachia* endosymbiont
Distribution and status of preventive chemotherapy for onchocerciasis, worldwide, 2015
Based on a figure from CDC
Based on a figure from CDC
Blackfly (genus Simulium) takes a blood meal and L3 Larvae enter bite wound. **Infective Stage**

1. Blackfly (genus Simulium) takes a blood meal and ingests microfilariae.

2. Microfilariae penetrate blackfly’s midgut and migrate to thoracic muscles.

3. Migrate to blackfly’s head and proboscis.

**BLACKFLY STAGE**

**HUMAN STAGE**

Adults produce unsheathed microfilariae that typically are found in skin and lymphatics of connective tissues, but also occasionally in peripheral blood, urine and sputum. **Diagnostic Stage**
Blackfly (genus *Simulium*) takes a blood meal and L3 Larvae enter bite wound. Infective Stage

3. Migrate to blackfly’s head and proboscis

2. Microfilariae penetrate blackfly’s midgut and migrate to thoracic muscles

1. Blackfly (genus *Simulium*) takes a blood meal and ingests microfilariae.

HUMAN STAGE

L3 Larvae

L1 Larvae

Human Subcutaneous tissue

Adults in subcutaneous nodules

Adults produce unsheathed microfilariae that typically are found in skin and lymphatics of connective tissues, but also occasionally in peripheral blood, urine and sputum. Diagnostic Stage

Based on a figure from CDC
1. Blackfly (genus *Simulium*) takes a blood meal and L3 larvae enter bite wound. **Infective Stage**

2. Microfilariae penetrate blackfly’s midgut and migrate to thoracic muscles.

3. Migrate to blackfly’s head and proboscis.

4. Blackfly (genus *Simulium*) takes a blood meal and ingests microfilariae.

5. Adults in subcutaneous nodules. Adults produce unsheathed microfilariae that typically are found in skin and lymphatics of connective tissues, but also occasionally in peripheral blood, urine and sputum. **Diagnostic Stage**

Based on a figure from CDC
# ILLUSTRATIVE NUMBERS ON ONCHOCERCIASIS

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Females per nodule</td>
<td>2 – 50 worms (^a)</td>
</tr>
<tr>
<td>Males per nodule (constantly exchanging)</td>
<td>1 – 10 worms (^b)</td>
</tr>
<tr>
<td>Microfilariae produced per day per adult female</td>
<td>1600</td>
</tr>
<tr>
<td>Total body daily microfilariae turnover (steady state)</td>
<td>10,000 – 300,000</td>
</tr>
<tr>
<td>Total body loads</td>
<td>As high as 150 million microfilariae</td>
</tr>
</tbody>
</table>

\(^a\) females remain incarcerated in nodules  
\(^b\) Males move in and out of nodules throughout lifespan
Heartworm

Filarial nematodes

Host range:
- Antilocapridae
- Bovidae
- Caprini
- Canidae
- Cervidae
- Cervinae
- Capreolinae
- Equidae
- Felidae
- Hominidae
- Ranidae
- Suidae
- Tropiduridae

Zoonotic cases

* Heartworm

Lefoulon et al 2017
Wyatt Earp
Rescue from Northern Arizona Reservation
Shotgun wounds
Venereal diseases
Eye infection in both eyes
Broken tail
ONCHOCERCA LUPI

- Found: Northern AZ reservation
- Adopted: January 17, 2009
- Traveled:
  - Yuma: December 2009
  - Lee’s Ferry: March 2010
- New eye infection symptoms:
  August 2010
- Found single worm, sent off for morphological identification
- *Onchocerca lupi*
TREATMENT

- Surgical excision of nodules
- Melarsomine: An organic arsenical compound injected into the dog’s lumbar muscles.
- Doxycycline: Antibiotic targets *Wolbachia* endosymbiont, sterilizes adult worms
- Ivermectin: Anti-parasite medication
- Prednisone: Anti-inflammatory steroid
- Lots of eye drops..
<table>
<thead>
<tr>
<th>Age</th>
<th>Case 1 (22 months)</th>
<th>Case 2 (10 ya)</th>
<th>Case 3 (50 ya)</th>
<th>Case 4 (13 ya)</th>
<th>Case 5 (5 ya)</th>
<th>Case 6 (10 ya)</th>
<th>Case 7 (11 ya)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residence</td>
<td>Arizona</td>
<td>New Mexico</td>
<td>Arizona</td>
<td>Arizona</td>
<td>New Mexico</td>
<td>Texas</td>
<td>Arizona</td>
</tr>
<tr>
<td>Location of nodule</td>
<td>Cervical spine</td>
<td>Scalp</td>
<td>Forearm</td>
<td>Cervical spine</td>
<td>Cervical spine</td>
<td>Superior rectus muscle</td>
<td>Ocular</td>
</tr>
<tr>
<td>Method confirming diagnosis</td>
<td>Histology</td>
<td>Histology, PCR</td>
<td>Histology, PCR</td>
<td>Histology</td>
<td>Histology</td>
<td>Histology</td>
<td>Histology, PCR</td>
</tr>
<tr>
<td>Histologic findings</td>
<td>Gravid adult</td>
<td>Nongravid adult</td>
<td>Nongravid adult</td>
<td>Nongravid adult</td>
<td>Gravid adult</td>
<td>Multiple nongravid adults</td>
<td>Unknown</td>
</tr>
<tr>
<td>Management</td>
<td>Biopsy, ivermectin</td>
<td>Nodule excision</td>
<td>Nodule excision, ivermectin, doxycycline</td>
<td>Partial excision, ivermectin, doxycycline</td>
<td>Nodule excision, ivermectin, doxycycline</td>
<td>Nodule excision, ivermectin, doxycycline</td>
<td>Unknown</td>
</tr>
</tbody>
</table>
ARIZONA CASE #1: 22 MONTH OLD FROM NORTHERN AZ

Eberhard et al, 2013
ARIZONA CASE #2

- 50 year old female, Southern Arizona
- Nickel-sized subcutaneous nodule on right forearm (November 2013)
- Rubbery, nontender, non-erythematous, and non-pruritic
- Travel to Monument Valley in Moab, Utah (2008)
- Subcutaneous granulomatous cyst removed (May 2014)
- Cyst contained *O. lupi*

Cross-section of adult female worm.
ARIZONA CASE #3

- 13 year old male, NE Arizona
- Week + worsening left-sided neck pain, sore throat, dysphagia, and headache
- Treatment with anti-inflammatories and antibiotics
- Worsening pain/headache 2 days later, with meningismus
- CSF evaluation revealed bacterial meningitis
- Treatment → Improvement
ARIZONA CASE #3 CONT’D

- Symptoms reoccurred 4 weeks later
- CT normal
- MRI showed intradural, extramedullary mass within upper cervical spinal canal
- *O. lupi* infection confirmed by CDC
- Ophthalmological examination normal
- Patient treated with 6-weeks of doxycycline
- Repeat MRI after showed decrease in size of mass
May 2012
22 months
Apache County

April 2014
13 years
Apache County

May 2014
50 years
Maricopa County

July 2017
11 years
Coconino County

2015-2017
Coyote Project Implementation
Canines as suspected host and sentinels.
STUDY OBJECTIVES

• Characterize the presence and geographic distribution patterns of *O. lupi* in Arizona coyote populations
• Identify the role of coyotes as potential hosts of *O. lupi* and as a potential reservoir for domestic dog or human infections
SAMPLE COLLECTION

• December 2015 - May 2017
• Sampling kits provided
• Skin tissue from base of ear
• Routine coyote removal operations

603 Coyotes

571 Arizona
26 New Mexico
6 Nevada
Majority of coyotes sampled were adults.
Majority of coyotes sampled were male.
METHODS

- Tissue processing
- DNA extraction
- Real-Time PCR screening
- Amplicon sequencing
- Bioinformatics
U.S. strains are closely related.

Fairly new introduction of *O. lupi* in the U.S.
NEXT STEPS

• Surveillance
  • Black flies
  • Humans
  • Animals
  • Expand study site
• Outreach
  • Clinicians
  • Veterinarians
• Diagnostic
  • Collect blood from positive and negative canine samples
• Draft genome
  • Sequence whole genome
    • Better population genomics
COLLABORATORS

- Hayley Yaglom
- Dr. David Engelthaler
- Dr. Jennifer Urbanz
- Veronica Harrison
- Ted Lyons
- Dr. Jolene Bowers
- Wyatt Earp
THANK YOU

Chandler Roe, MS
Chandler.Roe@nau.edu | 928-503-3280