

# Introduction to Nematodes

*Dracunculus medinensis*

# Nematoda

- Among most abundant animals-1074 organisms (36 species)/6-7 ml mud.
- Ancient diseases described by Aristotle, Hippocrates, ancient Chinese texts.

## Classification of Selected Species

**Class:** Rhabditea

**Order:** Spirurida

*Dracunculus*

*Brugia*

*Loa loa*

**Order:** Ascaridida

*Ascaris*

**Order:** Strongylida

*Strongyloides*

*Necator*

**Order:** Oxyurida

*Enterobius*

**Class:** Enoplea

**Order:** Trichurida

*Trichinella*

*Trichura*

# Nematode Life Cycle

**Adult worm in definitive host**

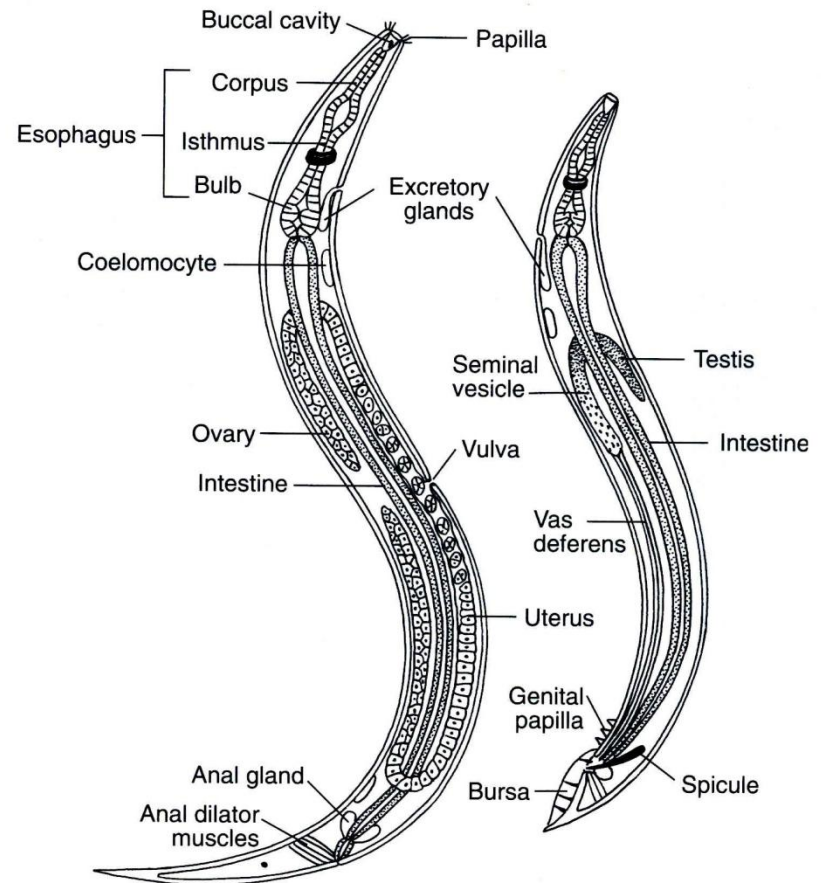
**L3 larvae infect by:**  
-Skin penetration  
-Insect bite  
-Ingestion

**Female releases  
Egg (embryo) or  
Larvae (L1)**

**Larval (L1-3)  
Development in:  
Soil, vector, intermediate host**

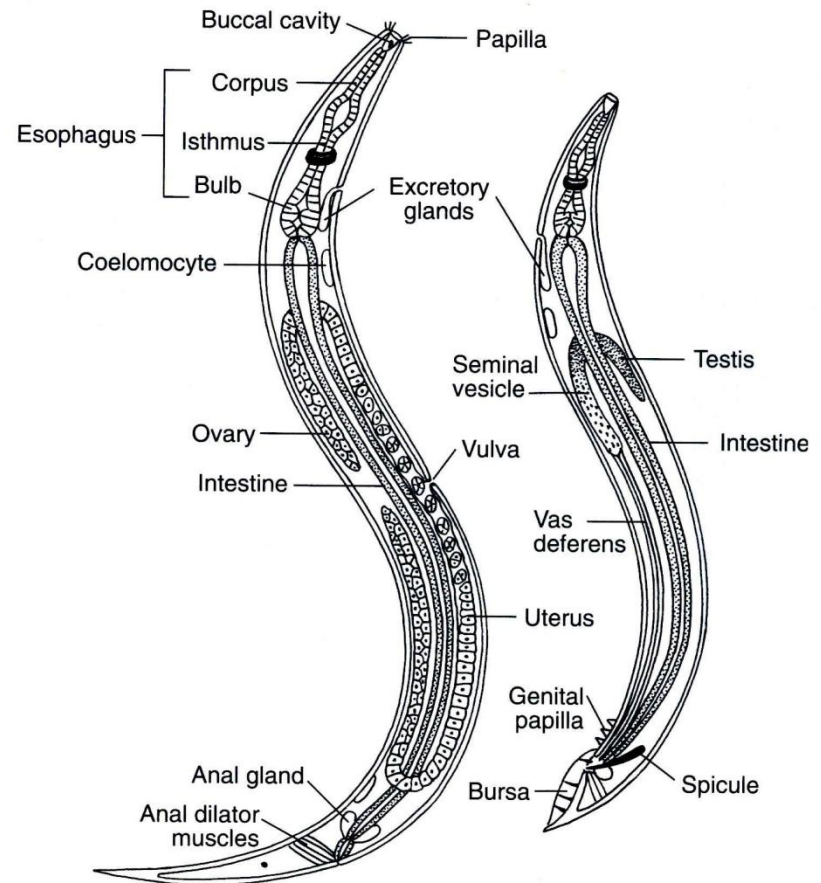
# Adult nematode: Morphology and Organization

- Complete digestive tract (mouth, intestine, anus).
- Separate dimorphic sexes.
- Body covered with acellular cuticle.
- Muscles one layer thick—all longitudinal.
- Variation in size among species (<1 mm to > 1 meter).



# Adult nematode: Morphology and Organization

- Fluid-filled cavity enclosed by muscles and body wall.
- Muscle contraction raises pressure on fluid.
- Movement occurs from muscle action and resulting transmission of fluid pressure.
- Fluid known as **hemolymph**.
- Transports electrolytes, proteins, fats, CHO from one tissue to another.



# Adult Nematode: Nutrient Acquisition

## ■ Mouth

- Circular opening surrounded by lips (2-6) and sometimes hardened plates.
- Take in blood, fluids, tissue, intestinal contents.

## ■ Esophagus

- Buccal cavity lies between mouth and esophagus.
- Muscles provide pumping to suck food into esophagus and intestine.
- Glands opening into lumen produce digestive enzymes.

## ■ Intestine

- Non-muscular tube with single layer of cells.
- Hydrostatic pressure causes defecation when anus is opened.

# Adult Nematode: Reproduction

## ■ Testes

- Single or paired, coiled around intestine.
- Ejaculatory duct opens into cloaca.
- Spicules hold vulva open while sperm is injected.
- Sperm are amoeboid with no flagella.
- Cement glands secrete hard material that plugs vulva after copulation.

## ■ Ovaries

- 1-6 elongated ovaries opening thru gonopore.
- Proximal end of oviduct has sperm storage area—eggs fertilized as they traverse area
- Distal end of uterus is muscular for ejection of ova.

## ■ Mating

- Variety of pheromones attract sexes.

# Adult Nematode: Drug Effects

- **Piperazine**-hyperpolarizes muscle and paralyzes worm.
- **Levamisole** and **pyrantel**-mimic acetylcholine, depolarizes muscles and paralyzes the worm.
- **Ivermectin**-inhibits esophageal pumping.
- **Benzimidazoles (mebendazole)**-inhibit mitochondrial electron transport; also binds to tubulin and paralyzes the worm.

Dracunculiasis-

“affliction with little dragons”

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*'My skin grows black and peels; my body burns with fever.'*

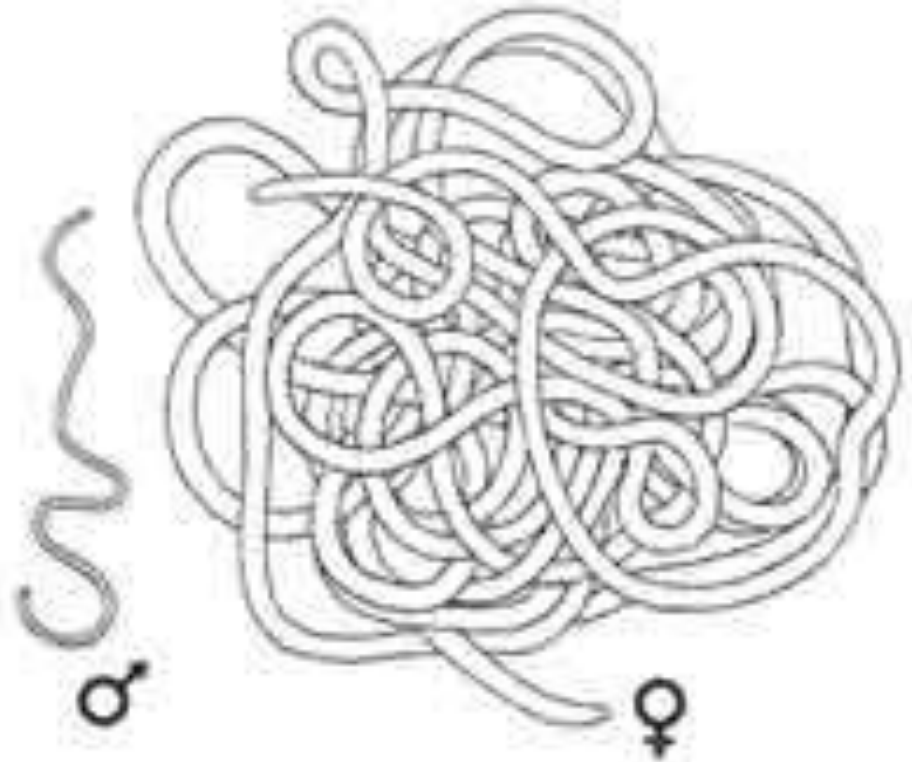
*--Job 30:30*

# Dracunculiasis

- It is believed that the 'fiery serpent' which afflicted the Israelites during their exodus was *D. medinensis*.
- The disease probably existed in Egypt and the Eastern Mediterranean as indicated in several texts from Pharaonic Egypt and Assyrian Mesopotamia.
- The disease was mentioned by Greek, Roman and Arab-Persian philosophers and physicians.

# Dracunculus: Guinea Worm

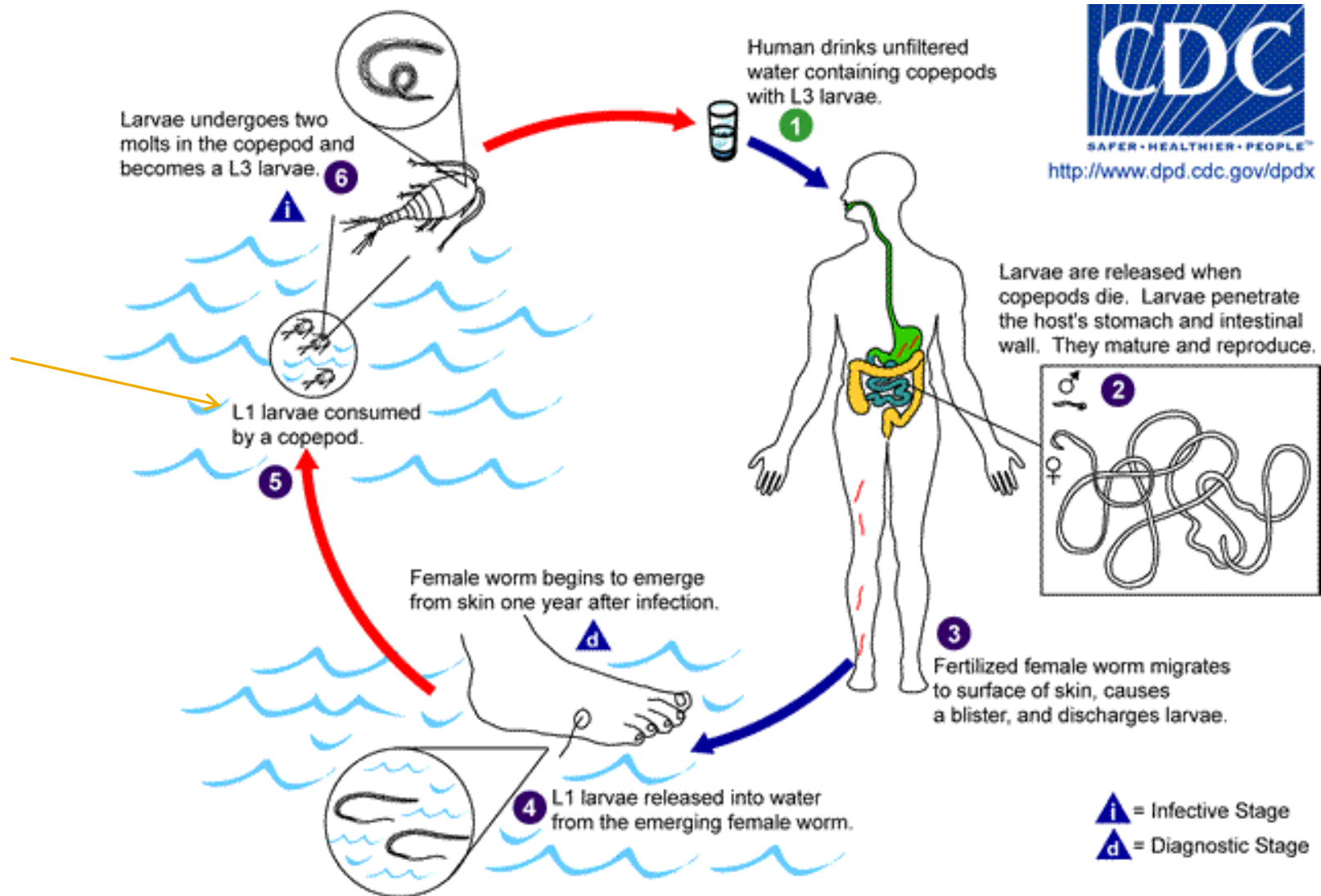
- **Adult worms**
  - **Female:** 60-120 cm in length; 1.5-2 mm diameter.
    - Longest nematode to infect humans
  - **Male:** 1-4 cm in length; 0.4 mm diameter.
  - **Larvae:** microscopic (450-14 μm).
- Documented infections in ancient texts; referred to a “fiery serpent” or “little dragon.”



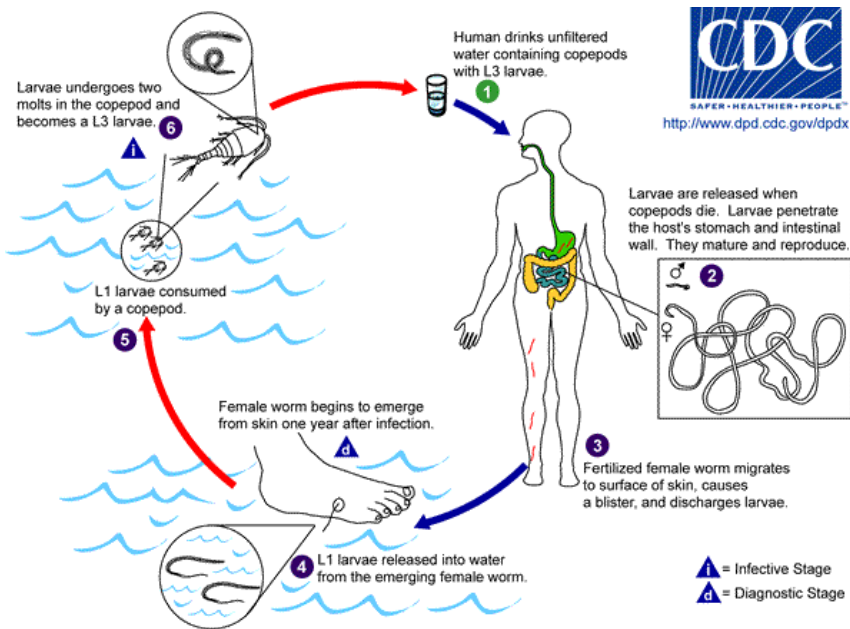
# Dracunculiasis: Medical Outcome

- Emergence from skin is:
  - Painful
  - Disabling
  - Incapacitates for 2-3 months
  - Humans only reservoir
  - No curative treatment
  - No vaccine

# *D. medinensis* Life Cycle

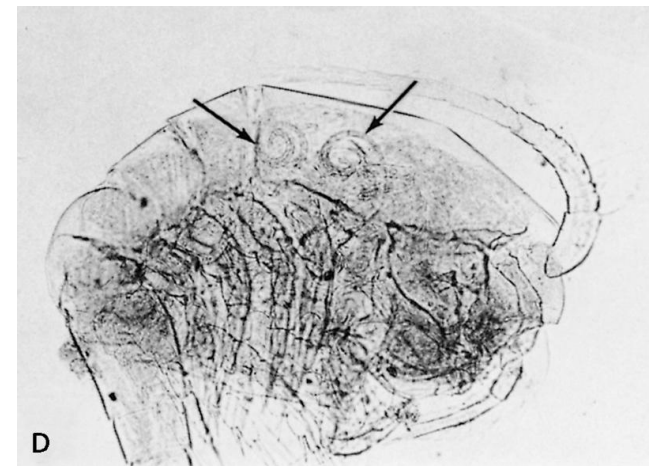
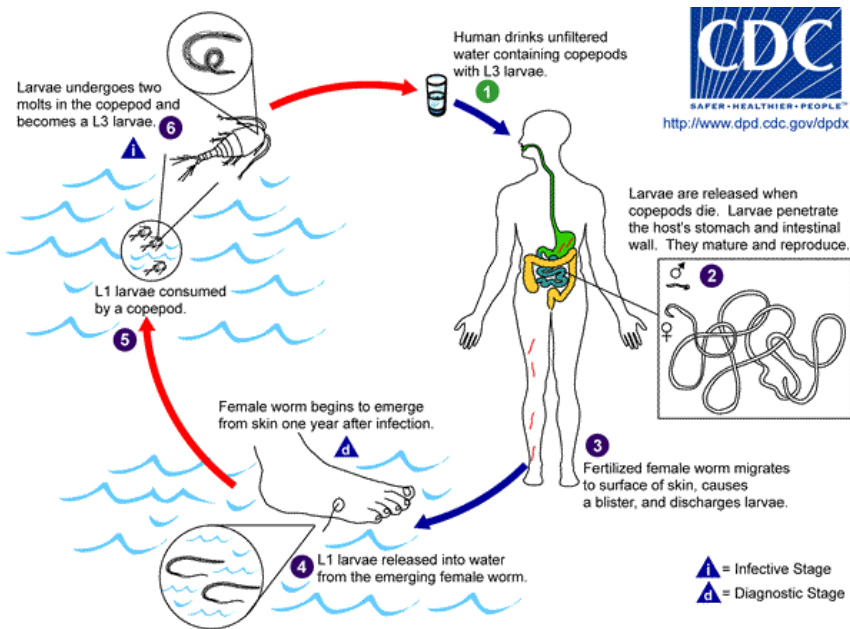


# *D. medinensis* Life Cycle



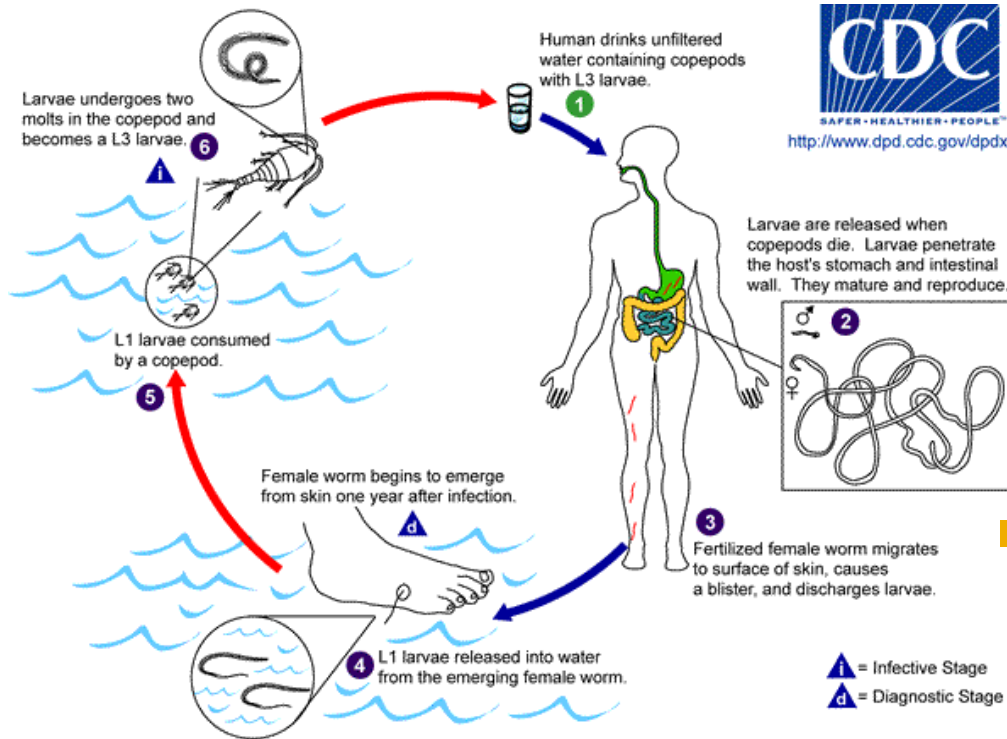
**L1 larvae**

# *D. medinensis* Life Cycle



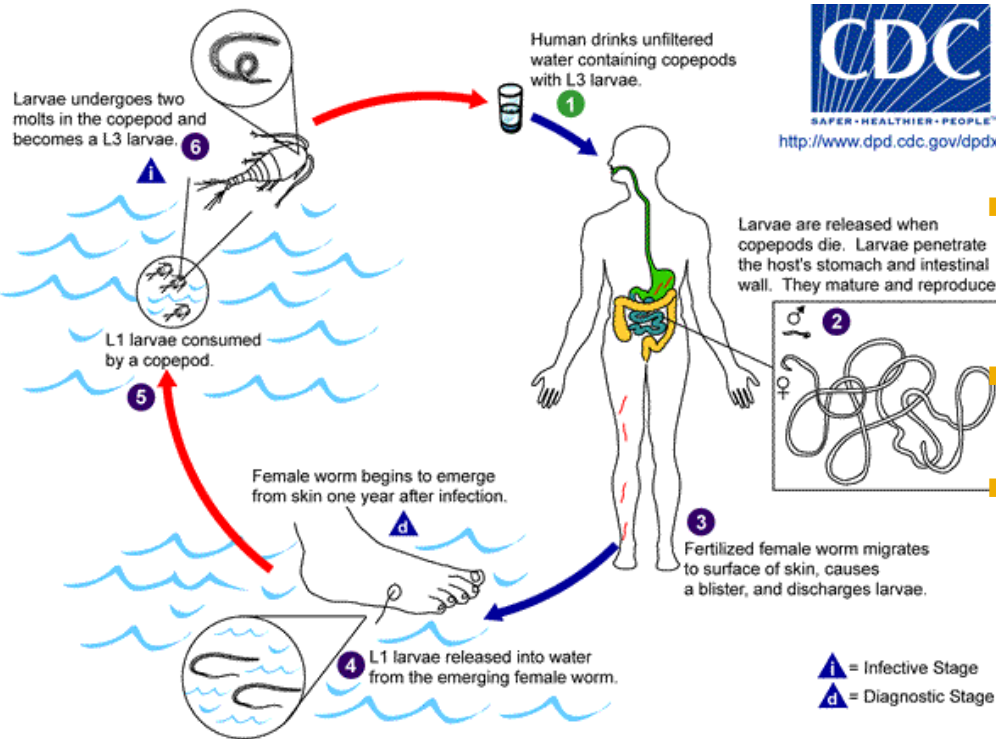
*Cyclops, Mesocyclops and Thermocyclops*

# *D. medinensis* Life Cycle



- L1 larvae quickly penetrate into the hemocele of the copepod.
- L1 larvae can live several days in water.
- Undergo 2 molts to become infective L3 larvae (1-2 wks).

# *D. medinensis* Life Cycle



- Once copepod ingested (digested), larvae are freed and migrate from the intestine to the peritoneal cavity.
- Reach connective tissue of the torso and limbs within several weeks.
- Molt 2 times before reaching adulthood.
- Male worms thought to die after mating have been shown to live up to 1 yr.
- May mate more than once.

# ***D. medinensis* Life Cycle**

- Life cycle takes about 1 year to complete.
- As female worms reach patency, they migrate to more superficial connective tissues below the skin, typically moving down the limbs toward the hands and feet.

# *D. medinensis* Life Cycle

- Painful blister (burning sensation).
- Systemically: blister formation accompanied by fever, nausea and vomiting.
- Rupture alleviates symptoms.



# *D. medinensis* Life Cycle

- Infected individuals try to relieve the burning feeling by immersing the blister into water.
- At some point after submersion, the worm releases thousands of L<sub>1</sub> larvae.
- Although the worm may release larvae several times during the next 7-10 days, most are released in the first wave.



# *D. medinensis*-Extraction

- Extraction of the female worm accomplished over the course of several weeks by gentle traction and winding of the worm on a stick.



# *D. medinensis*-Extraction

- Sometimes the lesion becomes infected, which slows or arrests healing and causes a larger ulcer.
- Commonly, joints become inflamed, and sometimes there is sepsis and even death.
- 80-90% emerge from the legs.



# Origin of Medical Symbol

STAFF OF AECLEPIUS (GREEK)



CADUCEUS (ROMAN)



# ***D. medinensis*-Migration to Other Sites**

- Most infections involve one worm.
- An unknown number of worms die, disintegrate, are resorbed or become calcified.
- Fewer than half the female worms emerge.
- Ectopic sites include the head, spinal cord, eyelid.



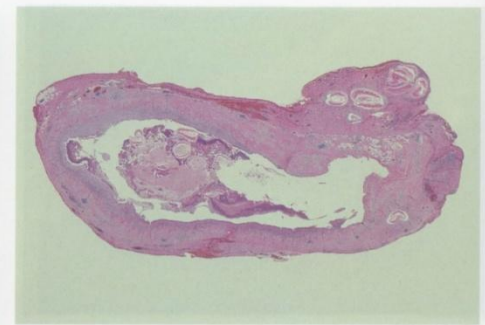
**Radiodensity of the abdominal wall of Pakistani patient.**

# *D. medinensis*-Migration to Other Sites-Eye

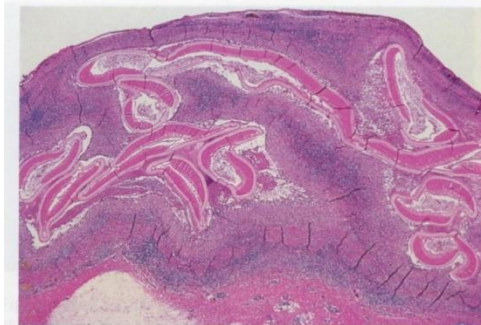
- Lesion removed from the upper eyelid of a 3-year-old in Kano, Nigeria.
- The cross sections reveal one adult, gravid coiled female.



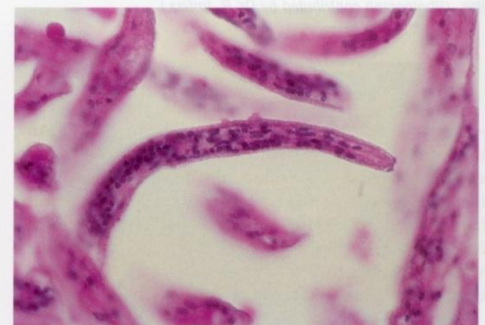
A



B



C



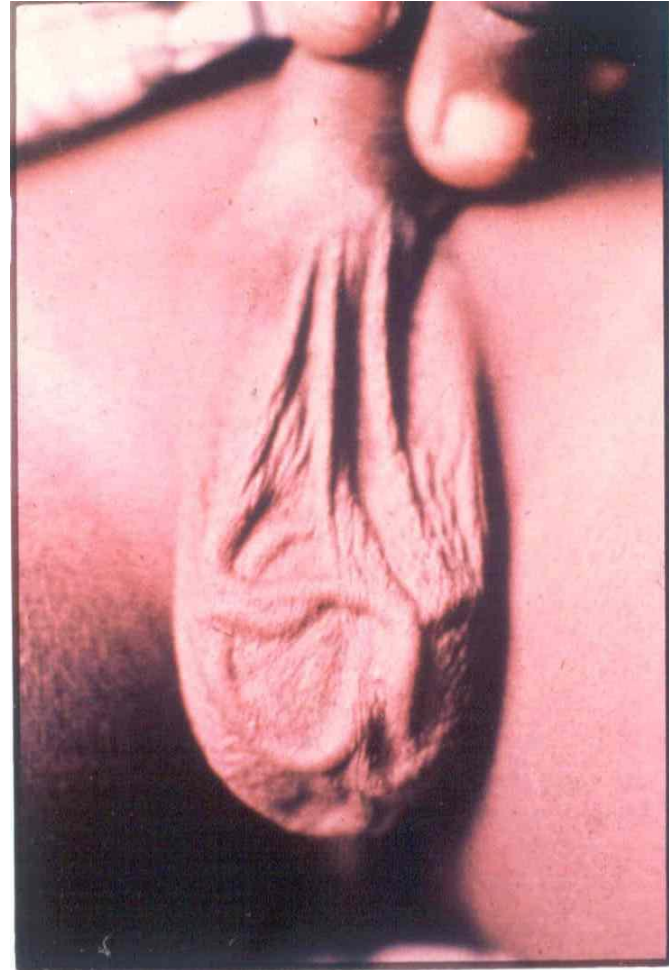
D

# Guinea Worm-Diagnosis

- No useful diagnostic technique during migratory phase.
- Serology not helpful; essentially all persons in endemic areas have antibodies.
- Definitive diagnosis by observation of ulceration with protruding worm.

# Guinea Worm-Differential Diagnosis

- Little confusion in diagnosing dracunculiasis.
- In endemic regions, presumptive diagnosis can be made based solely on the presence of a worm track.
- In nonendemic areas, positive diagnosis requires demonstration of the adult worm or L1 larvae.
- Other helminths may be mistaken for *D. medinensis*.
  - Gravid *O. volvulus* and *Mansonella streptocerca*, for instance, are in subcutaneous tissue



# **Eradication Program**

**1986 WHO declared eradication program  
for guinea worm  
Spearheaded by The Carter Center**

**Based on:**

**Simple water filtration technique**

**Larvicide to kill copepods and larvae**

**Provision of clean drinking water from safe  
source**

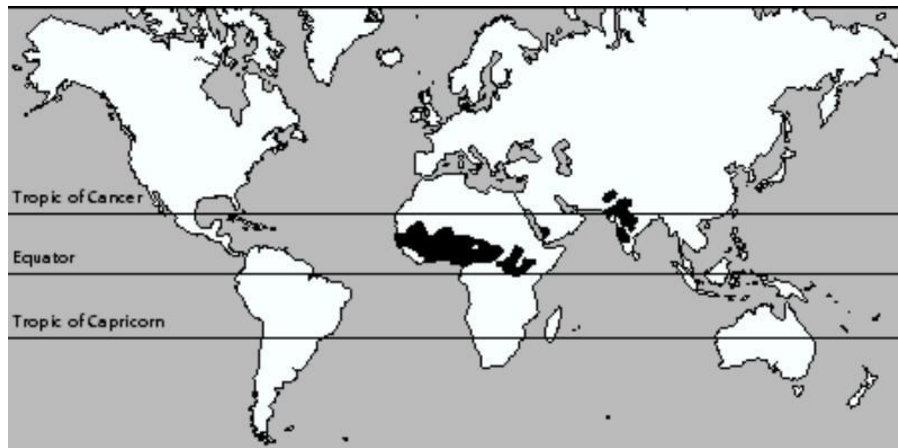
**Monitoring (“Pond Caretakers”) for infected  
persons at water sources**

# Filtration System

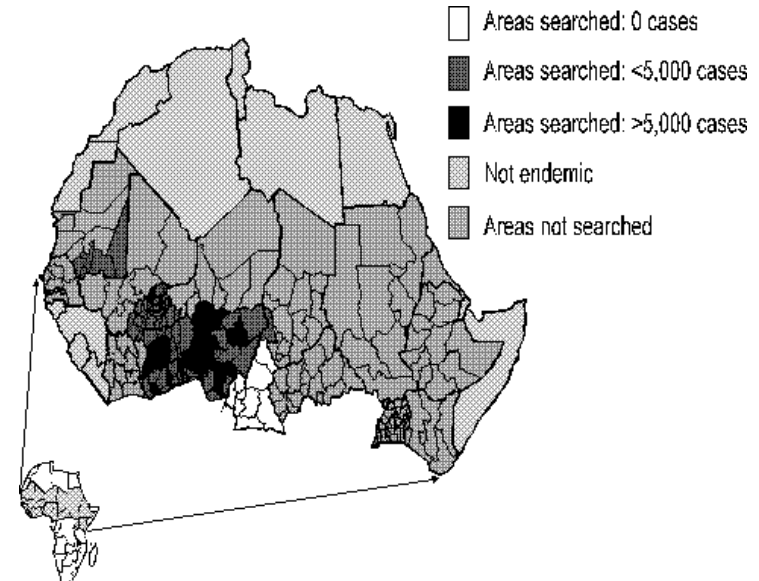


In Nkpani village, near the town of Calabar, Nigeria, a UNICEF-trained village health worker, shows a woman, holding her child in her lap, how to filter water through a muslin cloth. Filtering is essential to prevent guinea worm disease.

# Distribution of Guinea Worm: 1990

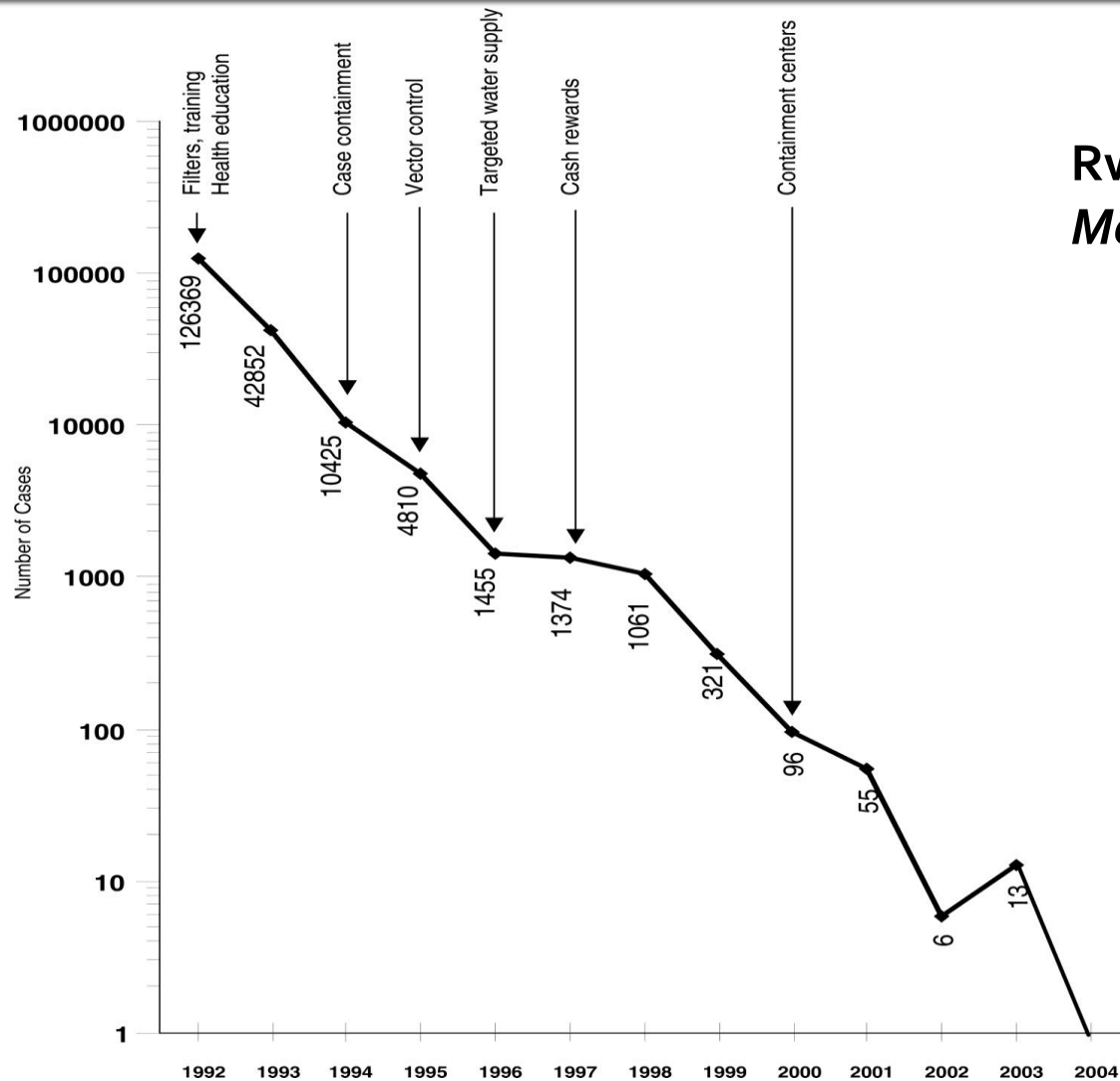


Prior to 1990's:



- Throughout North and Central Africa, Middle East and India
- About 1 million cases annually

# Uganda's Successful Guinea Worm Eradication Program



Rwakimari et al., *Am. J. Trop Med. Hyg.*, 75(1), 2006, p3-8



# Uganda's Successful Guinea Worm Eradication Program

TABLE 2. Number of reported dracunculiasis cases, by country and local intervention — worldwide, 2006\*

Country	No. of reported cases in 2006		%	Villages/Localities and interventions <sup>§</sup>							
	Indigenous	Imported		% of cases reported that were contained <sup>†</sup> during 2006	No. reporting one or more cases	No. reporting only cases imported into village <sup>‡</sup>	No. reporting only cases to indigenous village <sup>‡</sup>	% reporting monthly	% with cloth water filters in all households	% using Abate <sup>®</sup>	% with one or more sources of safe water
Sudan**	20,580	2	49	3,345	208	3,137	63	47	6	16	71
Ghana	4,134	2	75	606	260	346	100	95	66	47	98
Mali	323	6	82	88	21	67	100	100	92	24	100
Niger	108	2	83	34	16	18	100	100	100	11	100
Togo	25	4	79	10	6	4	100	100	67	50	100
Nigeria	16	0	69	10	3	7	100	100	49	69	100
Côte d'Ivoire	5	0	100	1	0	1	100	100	100	100	100
Burkina Faso	3	2	60	4	2	2	100	100	100	50	100
Ethiopia	1	2	100	3	2	1	66	33	66	33	100
<b>Total</b>	<b>25,195</b>	<b>20</b>	<b>54</b>	<b>4,101</b>	<b>518</b>	<b>3,583</b>	<b>72</b>	<b>59</b>	<b>22</b>	<b>23</b>	<b>77</b>

\* Provisional case counts.

† A case of dracunculiasis is contained if all of the following conditions are met: 1) the disease is detected before or within 24 hours of worm emergence; 2) the patient has not entered any water source since the worm emerged; 3) a volunteer has properly managed the patient, by cleaning and bandaging the lesion until the worm is fully removed manually and by providing health education to discourage the patient from contaminating any water source (if two or more emerging worms are present, the case is not contained until the last worm is pulled out); and 4) the containment process, including verification of dracunculiasis, is validated by a supervisor within 7 days of emergence of the worm.

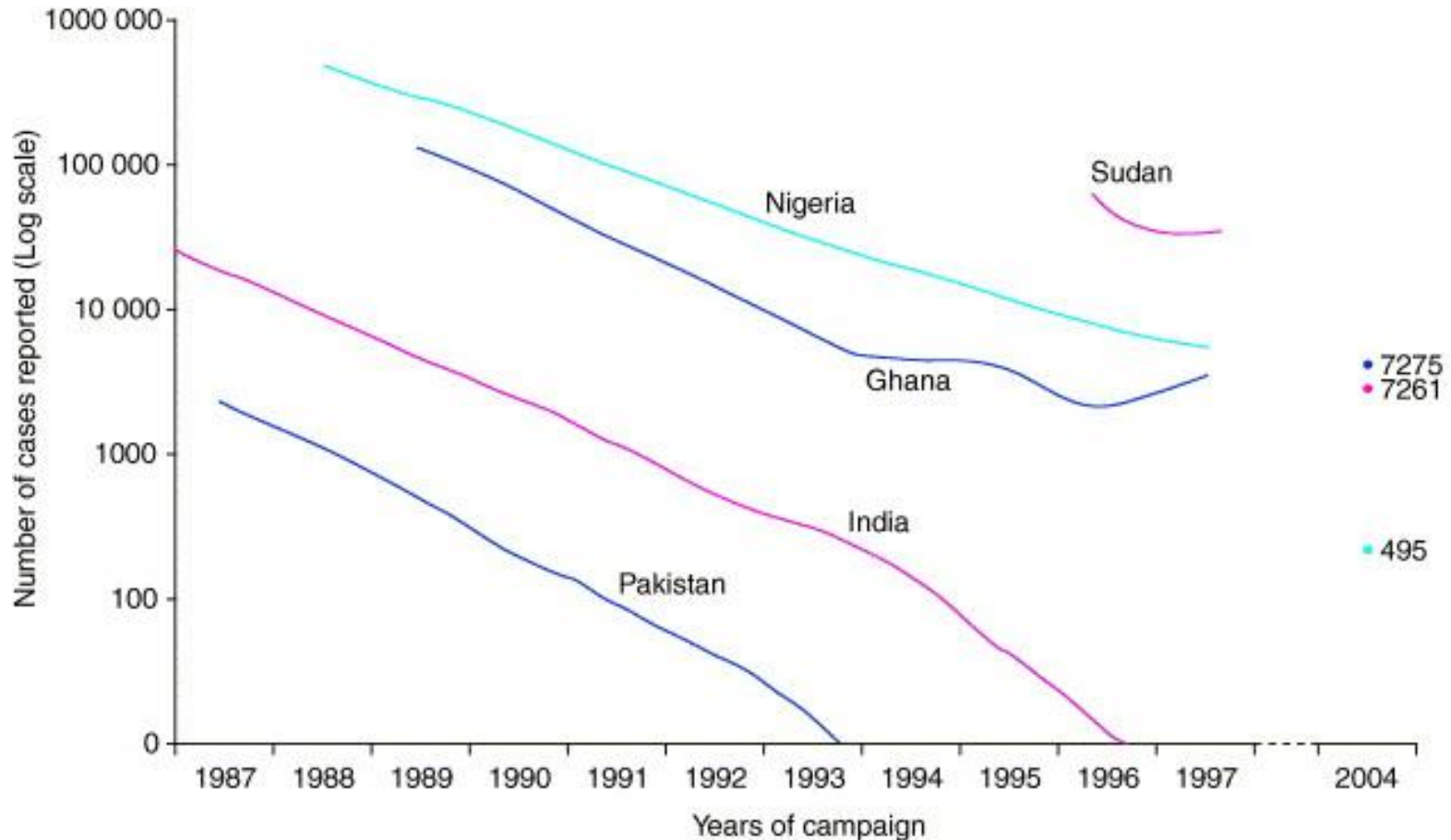
§ Interventions include distribution of filters, use of Abate<sup>®</sup>, provision of one or more sources of safe water, and provision of health education.

‡ Definitions of imported and indigenous cases as they relate to villages/localities are available at [http://www.cartercenter.org/health/guinea\\_worm/program\\_definition.html](http://www.cartercenter.org/health/guinea_worm/program_definition.html).

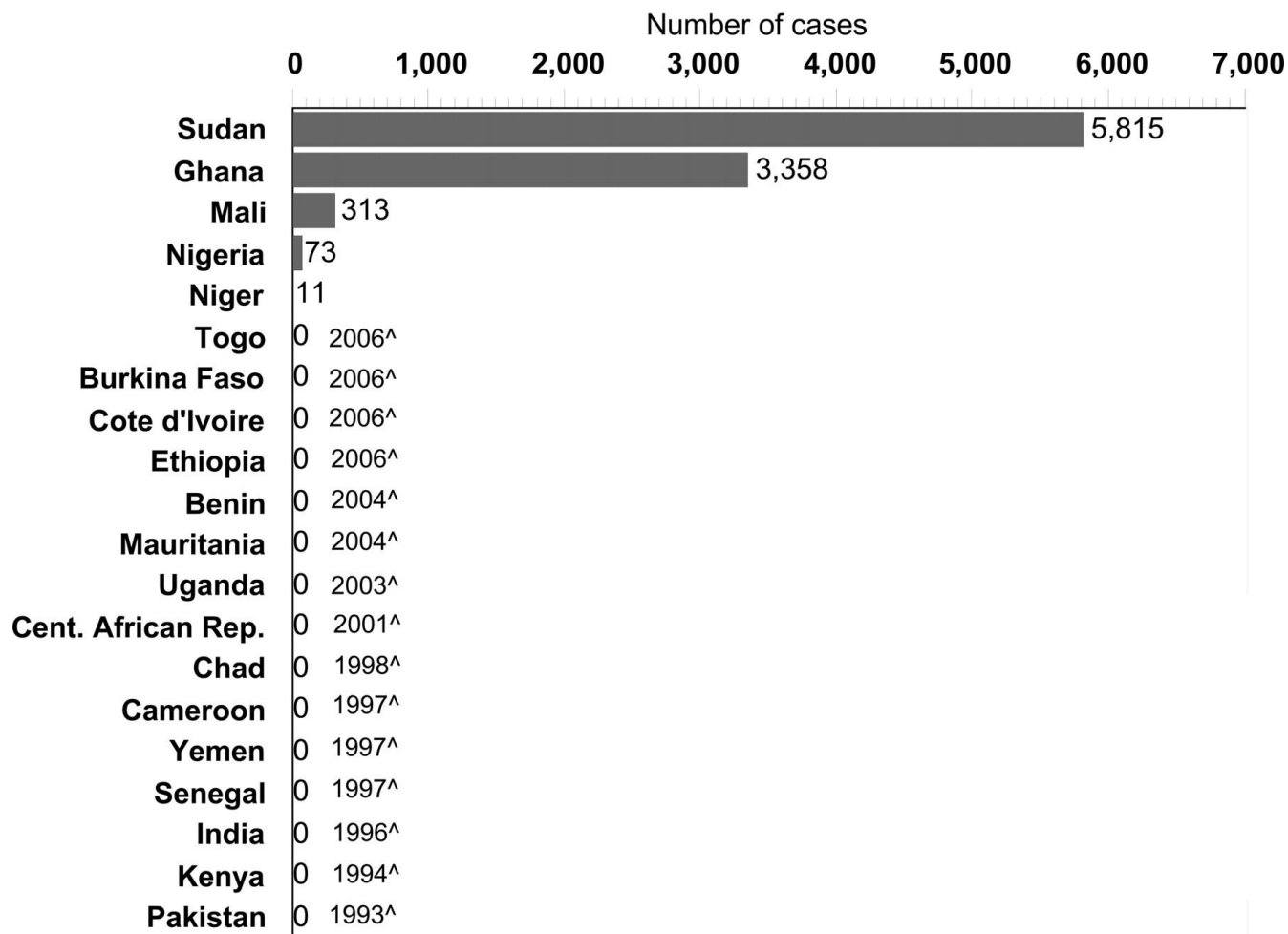
\*\* Two cases were reported by Uganda as imported from Sudan.

Rwakimari et al., *Am. J. Trop Med. Hyg.*, 75(1), 2006, p3-8

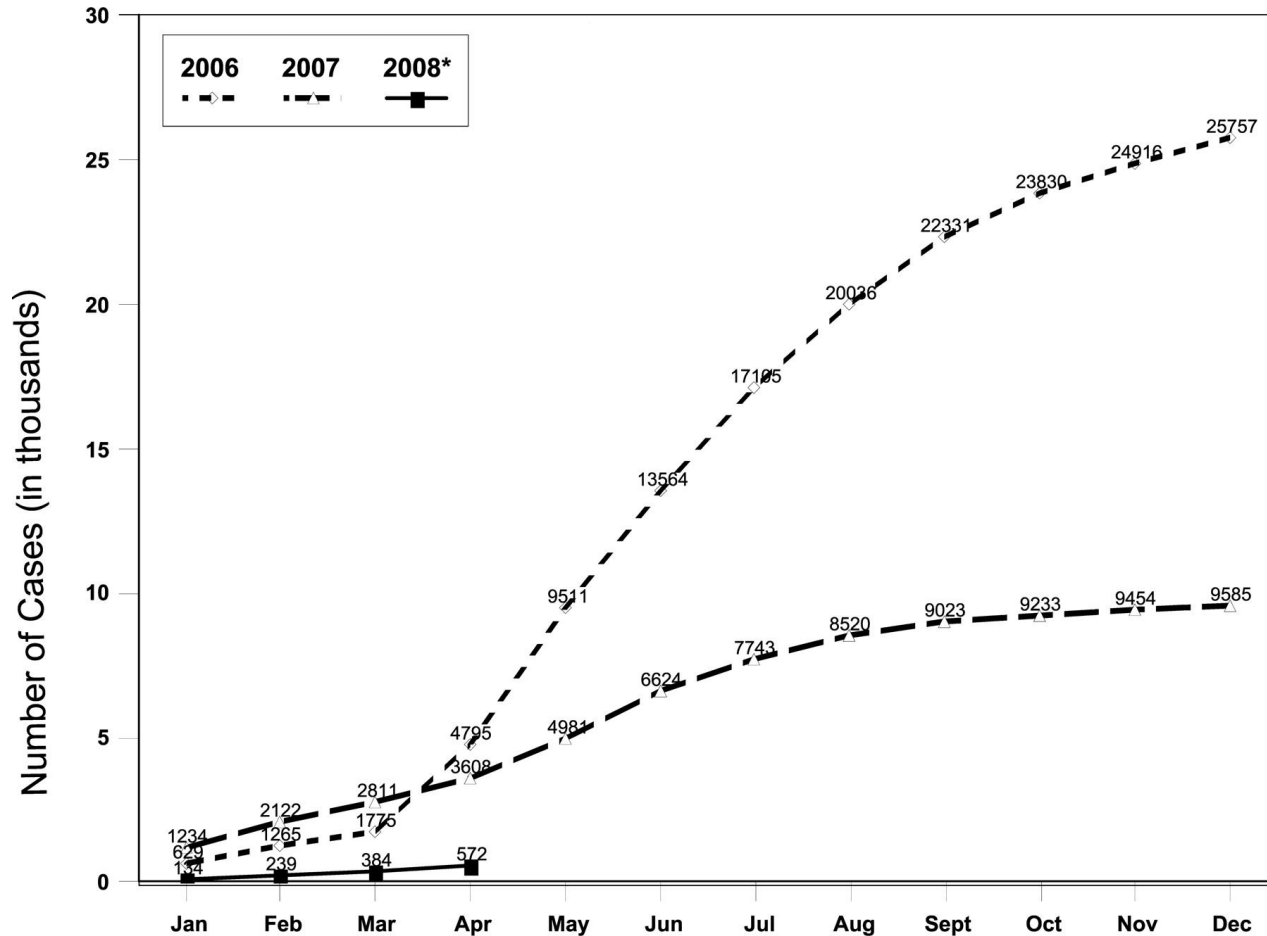
# The Final Chapter: Ralph Muller, Trends in Parasitology:2005



# Reported Cases Through April 2008



# Reported Cases Through April 2008 (Ghana)



\* January - April 2008 data is Provisional

Month

Hopkins *et al.*, 2008 Am. J. Trop. Med. Hyg.

# 'Cleaning Up' Last Cases

Surveillance is more important and cost is higher as cases decrease.

## "Cash Reward" System

Rewards:

Identifier

Ill person (cash, free care and food in PH clinic until blisters burst and worms emerge)

Village volunteer health worker

**Eradication target date: 2009**

# Program Strategies

Political will and involvement

Steadfast approach

Public-private partnerships

Inexpensive interventions

Grass root education

Innovative incentives to empower community

**If successfully eradicated:**

**2<sup>nd</sup> human disease after smallpox**

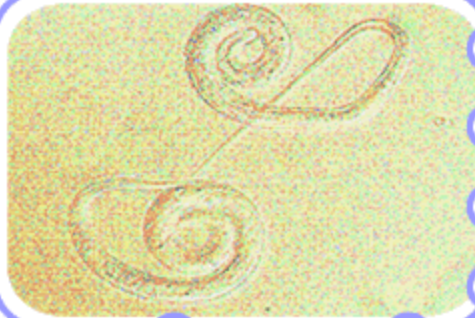
**1<sup>st</sup> human parasitic disease**

# Challenges and Obstacles

- Environment (Tropical and/or remote location)
  - Living conditions
    - Health status
    - Expectations
- Available control measures
  - Reservoir hosts
- Lack of adequate funds
  - Lack of political will

# People with too much free time

**Save the Guinea Worm Foundation**  
**...defending the world's most endangered species**



**the foundation**  
**Who speaks for the Guinea Worm?**

**the question**  
**Why are we destroying a living species?**

**the crisis**  
**Who is behind the extermination?**

**the challenge**  
**How can I help save the Guinea Worm?**

**Our publications**  
**the truth**

**join us!**  
**I want to join the struggle to save the Guinea Worm!**

<http://deadlysins.com/guineaworm/index.htm>