SCREWWORM (OLD WORLD AND NEW WORLD)

Aetiology Epidemiology Diagnosis Prevention and Control References

AETIOLOGY

Classification of the causative agent

The New World screwworm fly (NWS), *Cochliomyia hominivorax* (Coquerel), and the Old World screwworm (OWS), *Chrysomya bezziana* (Villeneuve), are both obligate parasites of mammals during their larval stages. NWS and OWS are in the subfamily Chrysomyinae of the family Calliphoridae (blow flies) of the order Diptera (true flies). OWS and NWS are designated “the primary screwworm.” Infestation of tissue by fly larvae is known as “myiasis”.

Resistance to physical and chemical action

Temperature:	Pupae are destroyed in soil temperature below 8°C (46°F) or freezing
Chemicals/Disinfectants:	Organophosphate insecticides; carbamate and pyrethroid compounds
Survival:	Flies prefer hot, humid environments (air temperatures of 25–30°C with relative humidity of 30–70% is ideal) but can survive in suitable humid microclimates (e.g. irrigated areas) in otherwise dry conditions. In addition, availability of hosts with suitable wounds is fundamental

EPIDEMIOLOGY

Hosts

- All living warm-blooded animals can be infested by screwworm but they are most common in mammals while rare in birds
- Many cases of screwworm myiasis have been documented in humans

Sources of infection and transmission: life cycle

- OWS and NWS have a similar life cycle (differences noted below)
- Complete life cycle of NWS may take 2–3 months in colder climates
    - in temperate conditions with an average air temperature of 22°C it is completed in about 24 days
    - in tropical conditions averaging 29°C it is completed in about 18 days
- Screwworm myiasis is not easily transmitted from host to host
- Duration of life cycle of screwworms off the host (pupae, adults) is dependent on ambient temperature
- Unlike most species of blowflies, adult female screwworms do not oviposit on carrion; they lay eggs at the borders of wounds on living, injured mammals or at the edge of body orifices
- Virtually any wound is attractive, whether natural (from fighting, predators, thorns, disease, and/or tick and insect bites) or man made (from shearing, branding, castrating, de-horning, docking, and/or ear-tagging)
    - commonly infested natural wounds are: navels of newborn animals and the vulval and perineal regions of their mothers, especially if traumatised
    - OWS has been documented to lay eggs on unbroken soft skin, especially if the surface has blood or mucous
    - eggs deposited on mucous membranes may enable resulting larvae to invade undamaged natural body openings (nostrils and associated sinuses, the eye orbits, mouth, ears, and genitalia)
- Female screwworms deposit individual eggs oriented in one direction, like a tiled roof and firmly attached to each other and to the oviposition substrate
    - numbers of eggs laid per batch vary depending on various factors (e.g. fly strain, disturbance during oviposition)
        - NWS: 100–350 eggs; average first batch about 340 eggs
        - OWS 100–250 eggs; average first batch about 175 eggs

    - Females usually oviposit twice; non-egg laying visits to wound for purpose of facilitating feeding of any additional egg masses
    - subsequent batches laid at intervals of 3–4 days
- Within 12–24 hours of the eggs being laid, larvae emerge and immediately begin to feed on the wound fluids and underlying tissues; burrowing as a group, head-downwards into the wound in a characteristic screwworm fashion
    - extensive damage to tissues is the result of tearing by hook-like mouthparts; wound is enlarged and deepened
- Infested wounds often emit a characteristic odour not always apparent to humans; may be first indication that at least one animal in a group is infested
    - larval-wound odour is highly attractive to other gravid females, which lay further batches of eggs so increasing the extent of the infestation
- A severe infestation that is left untreated may result in the death of the host
- Screwworm larvae pass through three stages (or instars) each separated by cuticular moults
    - final instar forms reach maturity about 5–7 days after egg hatch
- Mature final stage larvae then stop feeding and leave the wound by falling to the ground into which they burrow and pupariate
    - larval negative-phototaxis ensures burrowing into ground for pupariation
    - pupa develops within a barrel-shaped protective structure formed by hardening and darkening of the cuticle of the mature larva (the puparium)
- On completion of development, adult flies usually emerge from the puparium in the morning and work their way up to the soil surface; they extend their wings for hardening prior to flight (2 hours)
    - Maturation of pupae to adult is temperature dependent and ranges from 7 days at 28°C to 60 days at temperatures of 10–15°C
- Males become sexually mature and able to mate within 24 hours
- Ovaries of females need to mature over 6–7 days
    - females only become responsive towards males and mate when about 3 days old
- While male screwworms mate multiple times, females only mate once. This fundamental biologic characteristic allows control by the sterile insect technique (SIT)
- About 4 days after mating, female flies are ready to oviposit and seek a suitable host to lay their eggs
- Adult male flies live for approximately 2–3 weeks in the field; feeding at flowers
- Adult female flies can survive for 30 days but average 10 days; feeding on protein (serous fluids at animal wounds and decomposing animals)
- Flight range of adult screwworm flies varies from 10–20 km (6.2–12.4 miles) in warm, humid surroundings to as much as 300 km (186 miles) in arid environs
    - much more confined (3 km) when host density higher and environment suitable

Occurrence

- The climatic requirements of the two screwworm species are very similar; their potential distributions, if unrestrained, would overlap
- Ecosystem must provide satisfactory ecological conditions and availability of hosts with open wounds
    - infested animals may be transported by various means (e.g. air, land and sea)
- The distribution of OWS is confined to the Old World; throughout parts of Africa (from Ethiopia and sub-Saharan countries to northern South Africa), the Middle East Gulf region, the Indian subcontinent, and South-East Asia (from southern China [People's Rep. of] through the Malay Peninsula and the Indonesian and Philippine islands to Papua New Guinea)
    - Hong Kong's first report of OWS was in 2000 in dogs; first human case was reported in 2003
    - Activity in the Gulf area and surrounding regions is dynamic; reports confirmed from Iran, Iraq and most recently, Yemen.
- NWS eradication programs have eliminated this myiasis from Curacao, Puerto Rico, the Virgin Islands, the United States, Mexico and in Central America, from Guatemala, Belize, El Salvador, Honduras, Nicaragua, Costa Rica, and Panama
    - Panama was recognised as free in 2006
    - Eradication programme was launched in Jamaica but eventually failed due to complex management and technical difficulties
- NWS is presently found in the northern countries of South America southwards to Uruguay, northern Chile and northern Argentina
    - Imported cases of NWS have been reported recently in Mexico, USA, and even in the United Kingdom
- NWS appeared in Libya in 1988 but was eradicated by 1991 through international efforts

For more recent, detailed information on the occurrence of this disease worldwide, see the *OIE World Animal Health Information Database* (WAHID) interface [http://www.oie.int/wahis/public.php?page=home] or refer to the latest issues of the *World Animal Health* and the OIE *Bulletin*.

DIAGNOSIS

The period of time between oviposition at a wound site and the expression of disease due to burrowing larvae can be as short as 1–2 days.

Clinical diagnosis

- Clinical presentation of screwworm is always associated with a variety of pre-established wounds and should be considered in the event of any myiasis
- Wounds may manifest draining, suppuration and/or enlargement; signs of infestation with serosanguineous discharge often accompanied by distinctive odour
- Upon closer observation of wounds:
    - egg masses around wound; “shingle-like” raft of white or cream-colored eggs
    - fully developed larvae visible by third day; upwards of 200 larvae (vertically positioned) may be contained in a wound (as many as 3000 have been found in untreated wounds)
    - larvae burrow deeply and have a “wood screw” appearance with hook-like mouth parts at tapered anterior and breathing spiracles at planar posterior; larvae grow from 2.0 mm and can reach 1.5 cm in length
        - other species of larvae may be found at surface of wound
    - concealed or pocket-type wounds with reduced openings make finding larvae difficult; especially true of infestations of nostrils, anus, prepuce and vaginal area
    - often only sign is minor movement within wound
- Suggestive of screwworm within larger maggots are paired dark pigmented, longitudinal stripes (tracheal trunks) observed by magnification, posteriodorsally through larval cuticle
- Co-infestation by other larval species which feed on dead or decaying tissue may occur
- Wounds often experience secondary bacterial infection and may enlarge to 3 cm or more in width to as much as 20 cm in depth
- Animals with screwworm myiasis often display discomfort and appear unthrifty and depressed; separate from group
    - also may manifest anorexia and reduced milk production
- Morbidity, though variable, in areas with high screwworm populations may reach up to 100% in naval wounds of newborn
    - Infestation among wildlife can reach important levels
- If untreated, animals may die within one to 2 weeks due to toxicity and/or secondary bacterial infection
    - White-tailed deer in Texas, USA, reported annual mortality rates of 20–80% in fawns

Lesions

- Screwworm, by nature, does not usually cause lesions, but it may do so, especially at natural body openings, and it can worsen existing open wounds and facilitate secondary bacterial infection
- Gross and microscopic lesions are not useful in diagnosing a screwworm infestation
- One important observation, however, is that screwworms do not feed on dead tissue or carrion; therefore
    - unlikely to be found on post-mortem examination unless animal recently expired
    - other blow fly larvae may quickly infest previous screwworm wounds thus confusing diagnosis

Differential diagnosis

Should include any myiasis or blowfly larvae which infest wounds

- *Cochliomyia macellaria* (the secondary screwworm)
- *Phormia regina*, *Lucilia sericata* and *Chrysomya megacephala*
- *Sarcophagidae* (flesh flies) especially *Wohlfahrtia magnifica*

Laboratory diagnosis

Samples

- Animals should be restrained and larvae removed from open wounds using forceps in a humane manner
    - Larvae collected for diagnosis should be removed from the deepest part of the wound to reduce the possibility of collecting non-screwworm species
- Suspect screwworm eggs or flies may also be submitted for diagnosis; eggs may be collected using a scalpel as scraper
- Larvae, eggs or flies can be conserved in vials containing 80% ethanol or isopropyl alcohol; do not use formalin
    - optimal preservation of larvae, in their natural extended state, can be made by killing them in boiling water (15–30 seconds immersion) before storage in 80% ethanol; this method had no negative effect on subsequent extraction of mitochondrial DNA, amplified by polymerase chain reaction (PCR) but it might impact other molecular technique
- Shipment of samples should consider secure packaging to an authorised laboratory; previous notification is recommended

Procedures

Identification of the agent

- Identification of the eggs and first instars of the agents of myiasis based on morphology is difficult and these stages are relatively short lived and seldom collected
- Larval specimens preserved in ethanol may be examined under a dissecting microscope at up to ×50 magnification
    - See the *OIE Terrestrial Manual* for illustrated descriptions of the parasites
- Second instars:
    - only two spiracular slits in each of the posterior spiracular plates compared with the three slits of third instars
    - second instars of NWS can be diagnosed by the presence of dark pigmentation of the dorsal tracheal trunks, for over half their length in the terminal segment
    - second instars of OWS dorsal tracheal trunks are pigmented for no more than one-third of their length in the twelfth segment
    - anterior spiracles of second instar NWS have from seven to nine branches; about four branches in OWS
    - More positive identification may be gained by rearing living, immature larvae to third instars
- Third instars:
    - both NWS and OWS have a robust, typical maggot shape, with a cylindrical body from 6 to 17 mm long and from 1.1 to 3.6 mm in diameter, pointed at the anterior end
    - fully mature larvae of both NWS and OWS develop a reddish-pink tinge over the creamy white colour of younger larvae
    - both screwworm species have prominent rings of spines around the body and these spines appear large and conspicuous under a microscope when compared with most non-screwworm species; longest averaging 130 µm
    - in NWS the spines can be either single or double pointed, but in OWS they are always single pointed and thorn-like
    - anterior spiracles of NWS each have from six to eleven well separated branches, but usually from seven to nine; OWS, the anterior spiracles each have from three to seven branches, but usually from four to six [this latter character should not be used on its own to identify OWS]
    - on the posterior face of the terminal segment of both NWS and OWS, the posterior spiracular plates all have a darkly pigmented, incomplete peritreme partially enclosing three straight, slightly oval shaped slits, which point towards the break in the peritreme
    - of greatest diagnostic value are the dorsal tracheal trunks, which extend forwards from the posterior spiracular plates and are darkly pigmented up to the tenth or ninth segment in NWS; feature is seen most easily in living larvae
    - dorsal tracheal trunks of OWS are darkly pigmented only in the twelfth segment but secondary tracheae branching off the dorsal tracheal trunks are pigmented from the twelfth segment forwards to at least the tenth segment
    - Conversely, in NWS these secondary tracheae are not pigmented, only the dorsal tracheae are; tracheal pigmentation appears almost reversed between the two screwworm species
- Differentiation of adult screwworm flies is difficult but some indicators include:
    - female screwworm flies are larger than the common housefly

    - thorax of a NWS screwworm is generally deep blue to blue green metallic colour, but can be variable from light blue to green; dorsal surface of thorax has three longitudinal dark stripes
    - thorax of OWS metallic blue, bluish-purple or blue-green, similar to NWS, but without the thoracic stripes. Adult screwworms are difficult to distinguish from other flies

Serological tests

- No standardised serological tests are presently available, nor are they indicated for diagnosis of this disease
- Experimental studies have shown that serological techniques have potential value in future investigations of the prevalence of screwworm infestations in animal populations to detect antibodies to screwworm post-infestation

For more detailed information regarding laboratory diagnostic methodologies, please refer to Chapter 2.1.10 New World screwworm (*Cochliomyia hominivorax*) and Old World screwworm (*Chrysomya bezziana*) in the latest edition of the OIE *Manual of Diagnostic Tests and Vaccines for Terrestrial Animals* under the headings "Diagnostic Techniques".

PREVENTION AND CONTROL

Sanitary prophylaxis

- For control of screwworms, the implementation of voluntary and regulatory actions can prevent the introduction of screwworms to pest-free areas
- Indirect prevention of screwworm infestation includes the avoidance of wounding procedures at the times of year when screwworm are numerous, the careful handling of livestock to minimise wounding, the removal of sharp objects (e.g. wire strands) from livestock pens, and the use of measures to reduce other wound-causing parasites, in particular ticks (e.g. by dipping and by insecticide impregnated ear-tags)
- Any animals to be transported from screwworm endemic zones should be thoroughly inspected just prior to embarkation
- Immediate treatment of all detected wounds with an approved insecticide (Organophosphate insecticides, Carbamates and Pyrethroids) should be followed by a precautionary spraying or dipping of the animals before transport
    - animals with screwworm-suspect wounds should be quarantined until treated and wounds have clearly healed
- Any vehicles that have transported screwworm positive or suspect animals should be sprayed with an appropriate insecticide
- The only proven method of eradication of NWS relies on a biological technique, the sterile insect technique (SIT); also applied experimentally to OWS
    - In SIT, male flies sterilised in their late pupal stage by gamma or x-ray irradiation are released into the wild in vast numbers
    - Any of their matings with wild females results in production of only infertile eggs which leads to a progressive population reduction and, eventually, eradication
- In field operations, SIT is supported by:
    - insecticide treatment of screwworm-infested wounds in livestock
    - strict control of livestock movement
    - quarantine of infested animals and
    - an active publicity campaign
- SIT is very expensive because of the cost of continuous production and aerial dispersion of sterile flies
    - only considered cost effective when used as an eradication strategy in situations where the geography would favour such a programme
- To prevent the spread of the screwworms beyond their present geographical distribution, strict observation of the requirements for international trade, as set out in the OIE *Terrestrial Animal Health Code*, is necessary

Medical prophylaxis

- No biological products such as vaccines currently exist; research towards development of potential vaccines is being conducted

- Organophosphate insecticides as well as carbamate and pyrethroid compounds are effective against newly hatched larvae, immature forms and adult flies
    - It is important to note that use of organophosphates and carbamates is prohibited or restricted in many countries
- Organophosphate insecticides (e.g. coumaphos, dichlofenthion, fenchlorphos) have been used for the treatment of wounds infested with OWS and NWS
    - larvae are expelled and die on ground
    - any larvae that die in the wound should be removed to prevent sepsis
- For residual protection against re-infestation, insecticides must be applied at 2–3-day intervals until the wound has healed
- 5 g of 5% coumaphos wettable powder, should be either sprinkled directly on to a wound or, more effectively, brushed into the wound as a paste after mixing with ordinary cooking oil (33 ml)
- Organophosphorus compounds may also be applied as aerosol sprays or as dusts that are puffed into the wound from plastic squeeze bottles
- Direct prevention of screwworm infestation can be achieved by spraying or dipping of livestock with coumaphos (0.25% aqueous suspension of 50% wettable powder) or other organo-phosphorus insecticides at the maximum concentration prescribed for external parasite control
- There are few recent studies that assess insecticides for screwworm treatment and control, but many older publications describe the benefits of various macrocyclic lactones especially subcutaneous injections of doramectin in preventing infestation of umbilical or castration wounds of calves, and infestation of post-parturient cows, for up to 12–14 days post-treatment
- Topical application of 10 mg/kg bodyweight of a 1% fipronil solution did not prevent oviposition by NWS, but it reduced the proportion of bulls developing active myiasis over the critical 10-day post-castration period
- Similarly, topical application of an insect growth regulator (IGR), dicyclanil, to castration wounds in cattle gave good protection (>90%) against NWS myiasis

For more detailed information regarding safe international trade in terrestrial animals and their products, please refer to the latest edition of the OIE *Terrestrial Animal Health Code*.

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The OIE will periodically update the OIE Technical Disease Cards. Please send relevant new references and proposed modifications to the OIE Scientific and Technical Department (scientific.dept@oie.int). Last updated April 2013.