Encyclopedia of Arthropod-transmitted Infections of Man and Domesticated Animals

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Onchocerciasis, animal

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Distribution

There are about 27 species of *Onchocerca* infecting animals other than humans. Onchocercal infections occur worldwide and are very common in cattle, horses, donkeys, Dromedary camels (*Camelus dromedarius*), deer (e.g. *Cervus elaphus* and *Rangifer tarandus*), antelopes and pigs, including the Warthog (*Phacochoerus aethiopicus*), mainly in the tropics but also in temperate zones up to the polar circle. Although their prevalence often exceeds 90% and simultaneous infections by several species are frequent, they are often overlooked, because they do not usually cause any great pathological changes.

Parasite

Adult worms, so-called 'macrofilariae', live in nodules either in or under the skin, where they can be palpated on the living animal (these nodules must be distinguished from *Demodex* cysts and swellings caused by tick bites) or are attached to the fasciae of the muscles. However, there are other *Onchocerca* species that live more or less free in the surrounding connective tissue of the ligamentum nuchae or gastrolienale or along the tendons of the joints of the legs. These are only seen at slaughter. *Onchocerca armillata* lives in the intima of the aorta wall of ruminants, but also forms nodules attached to the outer wall.

The skin-dwelling microfilariae are only occasionally seen in the blood (cf. *Setaria* species (see Setariosis)). Transmission is restricted to areas where the vectors, zoophagic and especially boophagic species (e.g. bovid feeders) of the genus *Simulium* and *Culicoides*, prevail. These insects do not usually enter animal quarters and stables, but bite out of doors. Onchocerciasis therefore mainly affects animals kept in pastures and declines increasingly with keeping animals indoors.

Bovine onchocerciasis

Ten *Onchocerca* species have been described worldwide from cattle (Table 1 and Fig. 1), and co-infections of up to four or more species can occur in the same host. Adult worms are either located in well-developed nodules in and under the skin (often attached to fasciae of the thoracic or dorsal muscles) or lie more loosely in the connective tissue surrounding the ligaments and tendons of the neck, the lower legs or the intestine. Other species live in flat nodules attached to bones (tibiotarsal joints) or in the aorta wall (Fig. 2).

In contrast to human onchocerciasis, most bovine *Onchocerca* species seem better adapted and cause very few pathological changes in their natural hosts. Large numbers of microfilariae in the skin (>10 mg^{-1}) may lead to inflammation (mostly when they die), but skin irritation is also caused by the bites of the vectors; in fact, *Simulium* toxicosis can be severe and even lethal to cattle.

Aorta lesions are frequent in old cattle infected with *O. armillata* and are usually associated with calcifications and nodulations, involving arteriosclerosis, arteritis and aneurism formation.

Nodules of *Onchocerca ochengi* (Fig. 2A–C) and *Onchocerca gibsoni* in the skin decrease the value of hides for tanning. Their presence in large numbers on the carcasses of slaughtered animals (e.g. *Onchocerca dukei* in cattle, *Onchocerca fasciata* in camels) or nodular lumps on the lower legs are considered unsightly. However, there is no risk for human consumption. Although *Onchocerca* nodules are easy to differentiate from tuberculosis nodules (at least when cut open), they may be incorrectly diagnosed by inexperienced meat inspectors, so that carcasses are unnecessarily condemned.

Table 1. Some *Onchocerca* species of domesticated animals and location of their adult worms. Frequent species, characteristic for the host genus, are in bold characters.

Host	*Onchocerca* species, location	Vector	Distribution
Cattle	***O. gutturosa***, LN, TTL	*Culicoides* species *Simulium* (?)	Worldwide
	O. armillata, AW	?	Africa, Asia
Bos taurus	***O. lienalis***, LGL, SJ	*Simulium ornatum*	Europe, Australia
Humpless cattle	***O. stilesi***, J&B	?	North America
	O. gibsoni, SCN, brisket	*Culicoides*	South-East Asia, Australia
	O. denkei, SCN, dorsal	?	Afrotropical (Senegal, Ndama cattle)
	O. suzukii	*Simulium bidentatum*	Japan
Bos indicus	***O. ochengi*** (syn. *dermata*),	*Simulium damnosum* s.l.	Afrotropical
Zebu cattle	IDN, SCN, inguinal, pectoral		
	O. dukei, SCN, pectoral	*Simulium bovis*	Afrotropical (savannah)
Bubalus bubalis	***O. cebei*** (syn. *sweetei*), SCN, IDN,	*Culicoides*	Asia, Australia
Water buffalo	pectoral		
Horse	***O. reticulata***, TTL, forelegs	*Culicoides*	America, Europe
	O. cervicalis, LN	*Culicoides*	America, Europe
	O. bohmi, in arteries and veins	?	Europa (Austria)
	O. gutturosa, LN	*Culicoides variipennis*	America, Europe
Donkey	***O. raillieti***, SCN, LN	*Culicoides* ?	
	O. cervicalis, LN	*Culicoides*	Tropical Africa
	O. gutturosa, LN	*Culicoides* or *Simulium*	

Camel	***O. fasciata***, SCN, neck, shoulder	*?*	Arabia, south-west Asia, Australia,
Camelus dromedarius	*O. gutturosa*, LN	*Culicoides*	Africa, Asia
Sheep	*O. gutturosa*, LN	*Culicoides*	Worldwide
	O. armillata, AW	*?*	Tropical Africa, Asia
	O. gibsoni, SCN, brisket, stiffle, hip	*Culicoides*	Australia
Suidae			
Sus scrofa jubatus	***O. dewittei***, TTL	*?*	Malaysia
Phacochoerus aethiopicus	*O. ramachandrini*, TTL	*Simulium damnosum* s.l.	Cameroon, savannah (warthog)
Goat	*O. armillata*, AW	*?*	Asia

AW, aorta wall (posterior part of female in the intima, anterior part in nodule attached to aorta outer wall); LN, ligamentum nuchae; LGL, attached to the ligamentum gastrolienale; SCN, subcutaneous; IDN, intradermal nodules containing a single female and, on average, one male worm; SJ, in thin capsule attached to the stiffle joint; TTL, tibia-tarsal ligaments; J&B, nodules attached to joints and bones on lower legs.

Equine onchocerciasis (horse and donkey)

The pathology caused by microfilariae and adult worms is more frequently seen in horses and has been described from North America, Britain, Central Europe and Australia. Microfilariae of *Onchocerca cervicalis* are the cause of remittent dermatitis in the head and nuchal region (sweet itch). Equine periodic ophthalmia, moon-blindness and conjunctivitis have been attributed (not unanimously) to the presence of microfilariae in the eyes.

Inflammatory reactions around nodules in the ligamentum nuchae lead to fistulous withers and, more rarely, to poll-evil (possibly in connection with brucellosis). Stiffness of the joints has been reported and is likely to be due to the calcification of nodules (e.g. *Onchocerca reticulata*) inside the joint capsules or along the tendons of the lower leg.

Other animals

Although bovids and equines remain the most common animals to be infected with onchocercal worms, camels, sheep, rarely goats (Table 1) and wild animals are sometimes infected.

Zoonosis

The accidental infection of humans by an animal *Onchocerca* species (most probably *O. gutturosa*) has been reported from North America, Europe and Japan, but never from any of the tropical areas, endemic for human filariae, where such infections must certainly also occur but are more difficult to recognize.

Differential diagnosis

Onchocerca infections of living animals are identified to species by the morphology of the microfilariae from the skin (Fig. 3) rather than by examination of adult worms (as only nodules in the skin can be removed surgically). Multiple infections by several filaria species are very common. The location of microfilariae and adult worms in the skin and body is more or less species-specific (Fig. 1), but may vary with the biting behaviour of the local vector and also depends on the adult worm load. In very heavy infections worms also invade less characteristic areas on the body. Microfilariae usually accumulate in those body sites that are favoured feeding sites of the vectors. Moreover, maximum microfilarial numbers are observed at times, seasonally and diurnally, when maximum numbers of black-flies bite. Skin microfilarial densities peak in young or middle-aged animals when transmission is high, while the adult worm load continues to increase. Newborn calves can carry a few maternal microfilariae, but their own new infections can

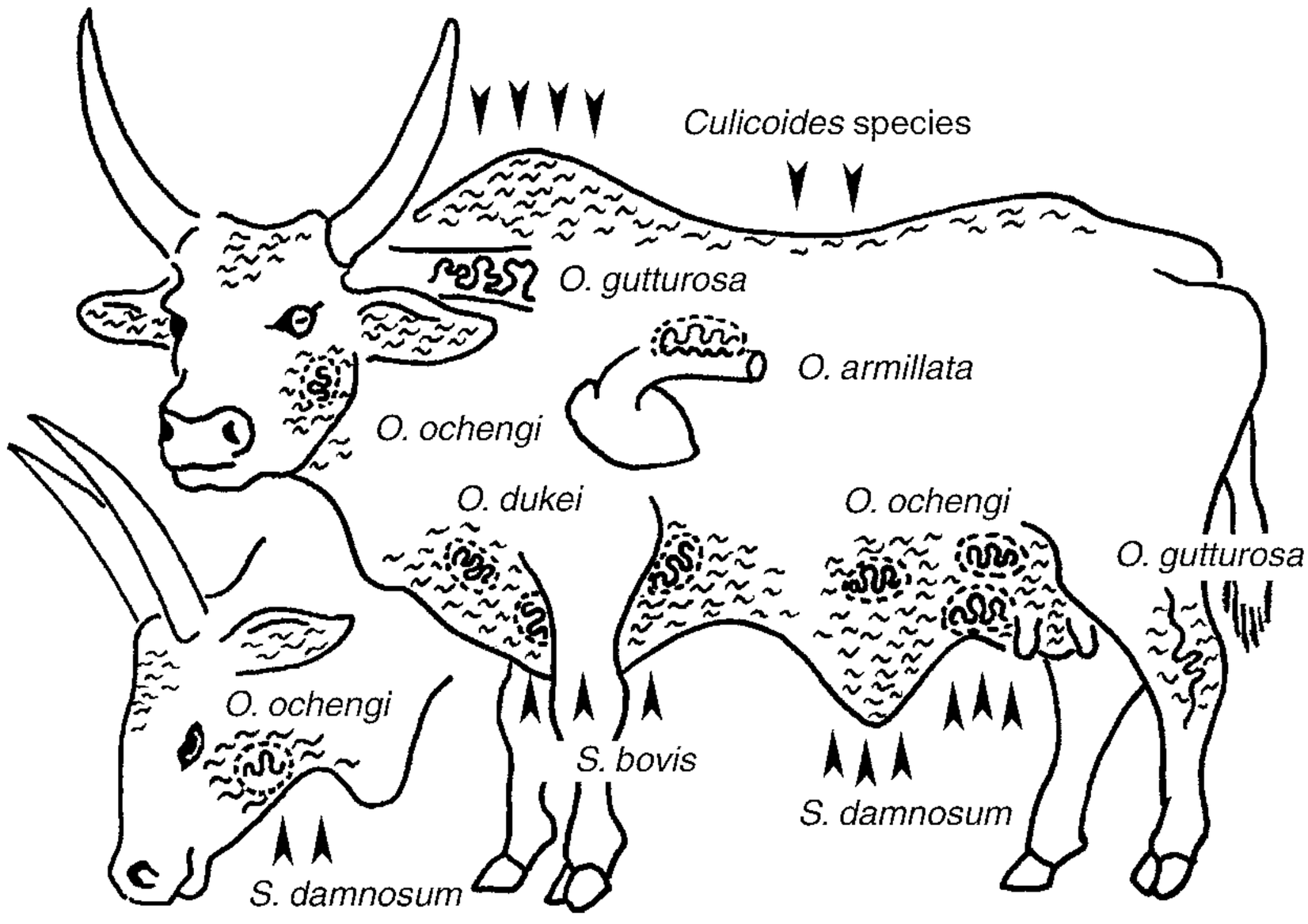

Fig. 1. Location of *Onchocerca* adult worms (ᔓ), microfilariae (~) and biting behaviour of *Simulium* and *Culicoides* vectors (⋀⋁) on cattle. Nodule-forming species are encircled.

become patent after only 6–9 months. *Onchocerca armillata* microfilariae are often difficult to find in older cattle, though the prevalence can be over 90%. The life expectancy of adult worms is high (up to 10 years, or longer).

Microfilariae differ morphologically in their length, diameter, shape (Fig. 3) and

Fig. 2. (A) Intradermal nodules of *O. ochengi* in the ventral skin of a heavily infected cow in Cameroon. (B) Freshly isolated nodules of *O. ochengi* from the slaughter-house: subcutaneous lumps of nodules (diameter 3–8 mm) occur in the udder, but, regardless of population density, each nodule is clearly separated and contains just one female worm. (C) Collagenase-digested nodules of *O. ochengi*; each nodule contains one female and on average one male worm. Young worms are whitish, transparent and later turn yellow to brownish before they calcify. (D) Ligamentum nuchae from cattle with *O. gutturosa* (at tip of needle). Worms are best recognized with transparent or reflected light, when the cuticular striae are visible at 10× magnification. (E) Air-dried aorta wall from cattle with *O. armillata* (partially calcified). Parts of worm (total length of female 20–60 cm) and calcifications are easily visible when the aorta is left in the sun to dry so that it becomes transparent.

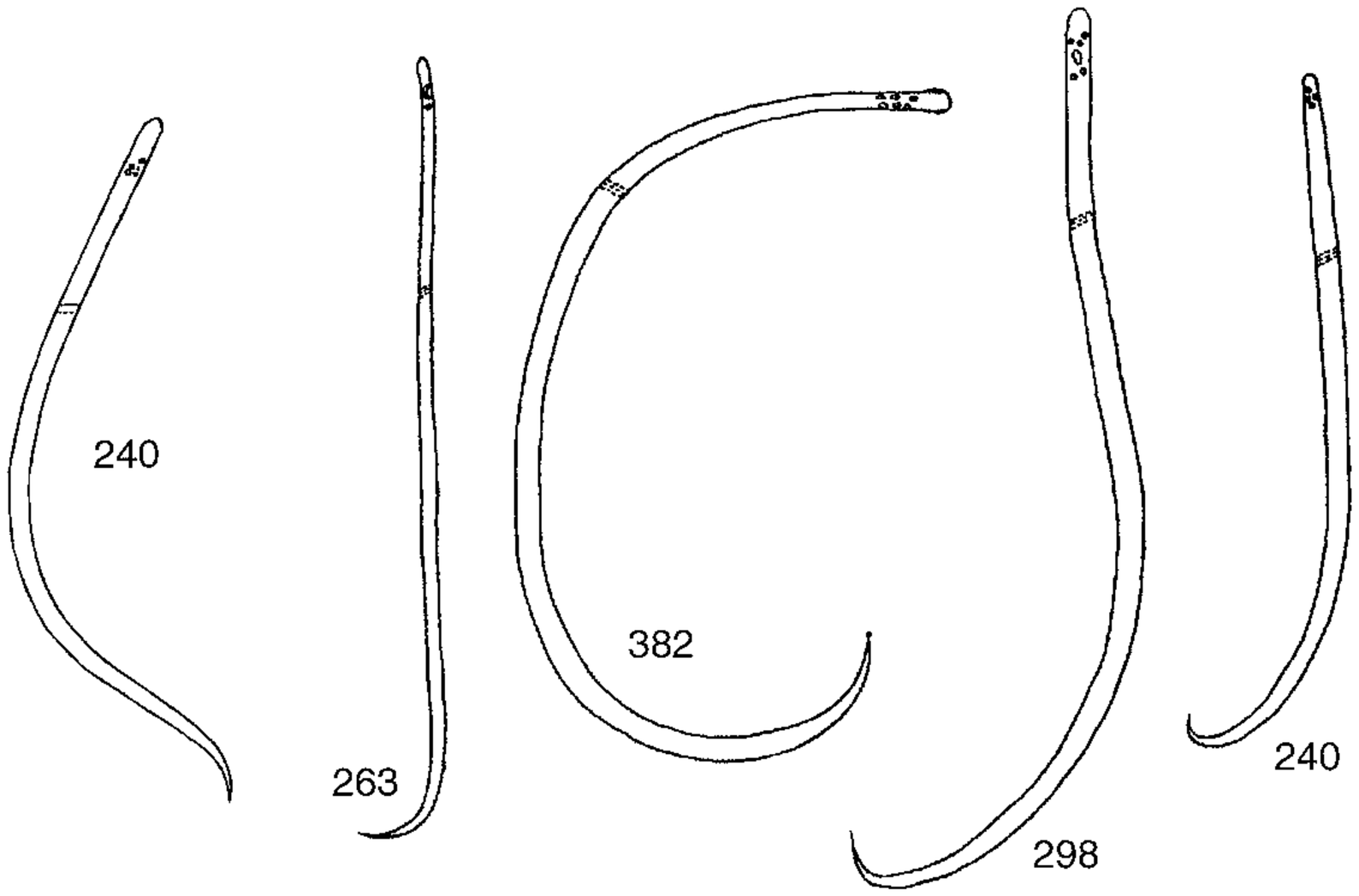

Fig. 3. Identification of microfilariae. Typical shape of freshly heat-inactivated or dead microfilaria in water. Note the length of larvae (lengths given in µm), the diameter and shape of the anterior and posterior ends and the bend of the body and tail.

movements. Adult worms are distinguished by their cuticular structures, form and dilatation of the anterior end (*O. gutturosa*, for example, is characterized by a swelling in the anterior part of the body). Male worms typically carry spiculae and papillae at the posterior end. Live adult filariae can be isolated from their nodules by collagenase digestion (0.5% collagenase A in Rosewell Parc Memorial Institute tissue culture medium (RPMI) for 24 h at 35°C, under aerobic conditions) or squeezed out mechanically – this works well with males, but females usually break into pieces, although the intrauterine microfilariae can be collected from them for identification. Old nodules often contain only debris of degenerate and calcified worms.

Skin biopsies

These can be taken from the live animal or at the slaughter-house. From the shaved skin, small superficial biopsies (3–5 mm^2, 5–30 mg weight) are taken with a scalpel blade. They are incubated in a drop of water, saline or tissue culture medium and kept for up to 24 h at 35°C. Microfilariae start wriggling out within a few minutes and are easily recognized at low magnification (×20–100) under a compound, or preferably a dissecting, microscope. Under optimum conditions, about 80% of the larvae leave the biopsy within 24 h. Larger skin biopsies (6 mm punches have often been used) should be avoided because most of the microfilariae will fail to emerge. Several snips should be taken from various body parts of each animal (inguinal region, head, ears, back, thorax, legs), both because of the highly aggregated distribution of skin microfilariae and to account for the species-specific location of microfilariae (Fig. 1).

Live microfilariae show characteristic species-specific movements, which vary from strong and quick entanglements to slow bendings. Their length and morphology are studied after heat inactivation (e.g. by gently heating up a slide with microfilariae with a gas-lighter), and this is best done with specimens in water, not saline, so as to avoid shrinkage. Staining with Giemsa or haemalum should be done on single microfilariae transferred to a small drop of water on a microscope slide and left to dry quickly. The head of the microfilariae (shape, diameter and hook), as well as the shape of the tail (length, form of tip, nuclei), should be examined at high magnification (×500–1000).

Treatment

It is usually unnecessary to treat infected animals, because the microfilariae do not cause much harm and the adult worms cannot be killed without risking the life of

the animal. Avermectins (ivermectin, doramectin or moxidectin) are highly efficient against microfilariae, but, as in the treatment of human onchocerciasis (see Onchocerciasis, human), there is a potential risk of dangerous reactions when other concomitant filarial infections are present. Nodules in the ligamentum nuchae or in the lower legs of horses can be removed surgically.

Control of transmission

Vector control is rarely possible or even necessary, except in the tropics, where *Simulium* also transmits human onchocerciasis (see Onchocerciasis, human). Keeping animals in shelters or dark stables into which simuliid vectors will not enter is highly effective in reducing transmission, but is less so against *Culicoides* species. Insect repellents, such as diethyltoluamide (DEET), applied to the skin give some protection against biting, but only for a few hours.

Selected bibliography

Bain, O. (1981) Le genre *Onchocerca*: hypothèses sur son évolution et clé dichotomique des espèces. *Annales de Parasitologie* (*Paris*) 56, 503–526.

Ottley, M.L., Moorhouse, D.E. and Holdsworth, P.A. (1985) Equine and bovine onchocerciases. *Veterinary Bulletin* 55, 571–588.

Renz, A., Enyong, P. and Wahl, G. (1994) Cattle, worms and zooprophylaxis. *Parasite* 1 (suppl.), 4–6.

Wahl, G., Achu-Kwi, M.D., Mbah, D., Dawa, O. and Renz, A. (1994) Bovine onchocercosis in North Cameroon. *Veterinary Parasitology* 52, 297–311.

Onchocerciasis, human

John B. Davies

Commonly known as 'river blindness' because the disease is associated with river valleys, where the simuliid (black-fly) vectors breed, and the disease can cause blindness. Also known as 'onchocercose' (French) and 'oncocercosis' (Spanish). Sometimes known in Africa as craw craw, a West African name describing an itchy skin. The disease remains endemic in 34 countries and an estimated 17.7 million people are infected, of which 270,000 are blind and another 500,000 have severely impaired vision.

Distribution

About 95% of all cases occur in Africa, mostly in West and Central Africa, with limited foci in East Africa from Ethiopia to Tanzania and with isolated pockets in Malawi, Sudan and southern Yemen, possibly extending into Saudi Arabia. In the Americas onchocerciasis is found in localized areas of southern Mexico, Guatemala, Brazil, Venezuela, Ecuador and Colombia (Fig. 1). (There is evidence that the disease was probably introduced into the Americas during the slave trade.)

Parasite

Onchocerca volvulus (Nematoda: Onchocercidae). Male (3–5 cm long, 0.13–0.2 mm diameter) and female (30–50 cm long, 0.25–0.4 mm diameter) worms live in subcutaneous tissues, often forming tangled masses of threadlike worms in fibrous nodules. Adult females can live for up to 17 years, the mean being about 10 years. The female worm is ovoviviparous and from maturity she produces large numbers of minute sheathless microfilariae (200–300 μm × 10 μm), which migrate to the host's skin. The appearance of microfilariae in the skin occurs about 15–18 months after infection, and their presence is usually accompanied by clinical symptoms. Microfilariae live free in the skin for about 2 years.

Onchocerciasis is not a zoonotic disease, although natural infections with *O. volvulus* have been reported once in a Spider monkey (*Ateles geoffroyi*) in Central America and in a Gorilla (*Gorilla gorilla*) in Africa. Chimpanzees (*Pan troglodytes*) can be infected experimentally.