Worms in Fish

Rod Wootten and James Bron explain how and why

The presence of nematode or round worms in the flesh of marine fish has long been known and is perceived to be both an aesthetic and human health problem. The most abundant group are members of the genus *Anisakis* and within fish they are small, colourless worms which are found, often lightly coiled within the flesh or the viscera. Within the flesh they are often difficult to see with the naked eye. The life-cycle of the parasites is complex, as shown in Fig 1, but the main point is that the stage in the fish is a larva which will only mature if it is ingested by a cetacean (toothed whale, dolphin, porpoise) Once released in the cetacean stomach it attaches to the stomach wall and undergoes further development. When the adult stage is reached the parasite detaches from the stomach wall and lives free in the lumen feeding on the stomach contents.

The other type of worm is *Pseudoterranova*, also an anisakid and with a similar life cycle to *Anisakis*. As an adult however it is normally found in the stomach of seals.

If one of these worms is ingested alive by a human, because it finds itself within a mammal, it will attach to the stomach wall and attempt to complete its development. The larva will die before it becomes adult but it will cause a massive and very painful allergic reaction in the stomach. Providing a correct diagnosis is made, treatment is relatively straightforward and the worm can be manually removed using endoscopy. There are also reports that fish workers may become sensitised by handling parasitised fish and it may be that even ingesting dead worms can lead to sensitisation. Not surprisingly most cases of human infection concern the smaller and less easily detected, *Anisakis*, and are also concentrated in those countries where fish are eaten raw or lightly cooked (e.g. Japan). There are approximately 2000 cases annually. Few cases have been reported in the UK, where fish is usually well cooked but the recent growth in popularity of sushi poses some risk. EU regulations mean that all fish to be consumed raw must first be deep-frozen.

Although *Pseudoterranova* poses much less of a human health problem it does often lead to the rejection of fish by consumers or customs and public health officials because of its large size and red colouration.

The different life cycles of the two nematode types means that they have different geographical and depth distributions. *Anisakis*, with its cetacean final host and planktonic crustacean first host is more

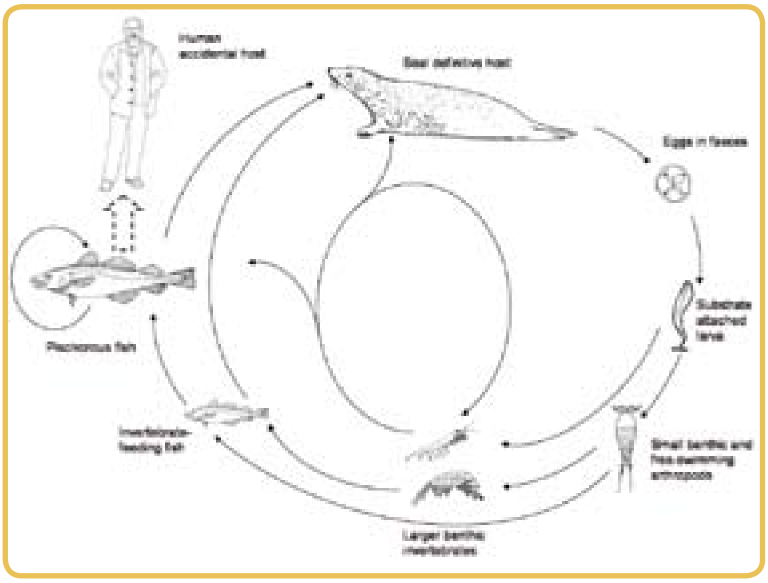

Fig 1. Diagram illustrating the life-cycle of *Pseudoterranova decipiens*. The life-cycle of *Anisakis simplex* differs from that shown in that it involves the use of cetaceans as definitive hosts and in the fact that hatched larvae are initially consumed by free-swimming arthropods such as euphausids with no involvement of benthic invertebrates.

commonly found offshore and in more pelagic feeding fish such as herring and mackerel. Our studies showed that herring and mackerel were only infected with *Anisakis*, reflecting their feeding on planktonic crustaceans, notably euphausiids which are the first host of the parasite.

Pseudoterranova on the other hand, has a more benthic and inshore habitat and is thus found in more bottom feeding fish such as cod, witch and long rough dab (Fig 2).

In 2004 there were a number of cases of consignments of monkfish, Lophius sp, from Scotland being refused entry into some European countries because of the very obvious presence of *Pseudoterranova* (Fig 3). We were commissioned by the Food Standards Agency Scotland (FSAS) to investigate the extent of infection in monkfish flesh. We also studied the occurrence of worms in cod, herring and mackerel for which there was historical data but no recent information for Scottish waters. The project was in collaboration with the Marine Laboratory, Aberdeen (Dr D Bruno) and Dr K MacKenzie. Practical work was largely carried out by Dr Allan Petrie and we were fortunate to be able to use the Marine Lab research vessel FRV Scotia to collect most of our samples. Sampling was carried out over a two year period between 2005 – 2007 and over 2000 fish, including 1075 monkfish, were examined.

Monkfish were indeed relatively widely infected with 37% of all fish parasitised with *Pseudoterranova* and 27% with *Anisakis* in the flesh. Cod also were widely infected with 38% parasitised with *Pseudoterranova* and 50% with *Anisakis*. The numbers of parasites in cod were however several times higher than in monkfish. It is not surprising that monkfish and cod were so commonly infected because this would be expected from the large proportion of fish in their diet. It is likely that

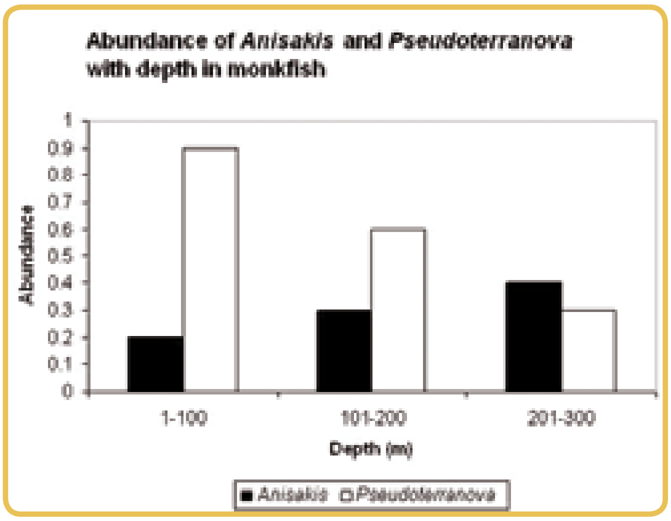

Fig 2. Graph showing abundance, i.e. mean number of worms per fish, of *Anisakis* and *Pseudoterranova* in monkfish captured at different depths. Differing depth profiles for the two species are thought to be reflective of different final host (cetacean and seal) distributions.

Fig 3. Showing a large encapsulated *Pseudoterranova* on the surface of a fish fillet, illustrative of the easily visible nature and unaesthetic appearance of some fish anisakids.

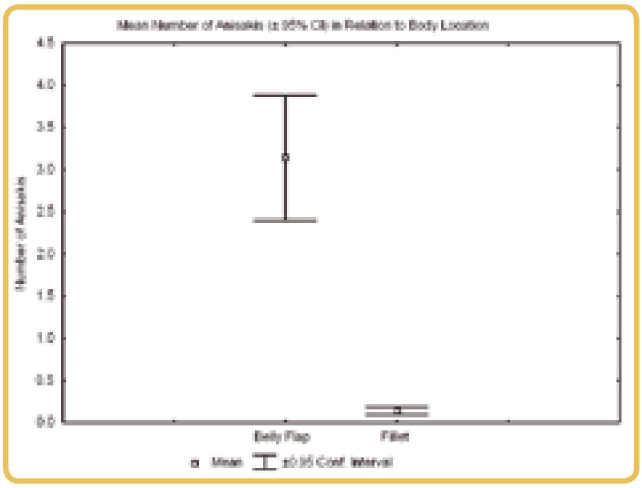

Fig 4. Graph showing mean numbers of *Anisakis* (±95% conf.) recovered from belly flaps and fillets of captured cod. The ease of migration of worms from the viscera into the belly flaps is considered to explain the observed differences.

the bulk of the worms found in monkfish and cod actually originate from already infected prey species. Experimental studies have shown that worms are quite able to enter and encyst in a new fish host if it feeds on already infected fish. We have never found *Anisakis* or *Pseudoterranova* in cultured marine fish, as long as they are fed a processed diet. A raw trash fish diet can lead to infection.

There were differences in infection according to geographical location. Thus *Anisakis* was generally most abundant in monkfish and cod from the offshore northern North Sea, whilst *Pseudoterranova* was much more abundant in coastal waters, reflecting the distribution of final hosts as described earlier.

Both *Anisakis* and *Pseudoterranova* are long-lived worms and thus it was not unexpected that larger, and therefore older fish, tended to be more heavily infected.

A potentially important question from the point of view of fish processing is where in the flesh the worms are located. In all species the great majority of *Anisakis* are located in the hypaxial muscles, or belly flaps, that enclose the abdominal cavity and viscera. *Pseudoterranova* on the other hand is found in larger numbers n the epaxial muscles, or fillets of monkfish i.e. tails. In cod roughly equal numbers are found in the fillets and flaps. (Fig 4). The reasons for this difference are unclear but might just reflect the greater size of the *Pseudoterranova* and its ability to migrate a longer distance within the fish. Interestingly, most worms are found in the muscle in the left-hand side of the fish and this is probably because of the disposition of the viscera within the abdominal cavity which means that as the parasites penetrate through the stomach wall they find less obstructions, in particular the liver, on their way to the muscle. In fact, most *Anisakis* never get to muscle, encysting around the gut mesenteries or in the liver, whilst most *Pseudoterranova* do reach the muscle. Because most worms occur in the flaps then if these are removed during processing then obviously relatively few will reach the consumer.

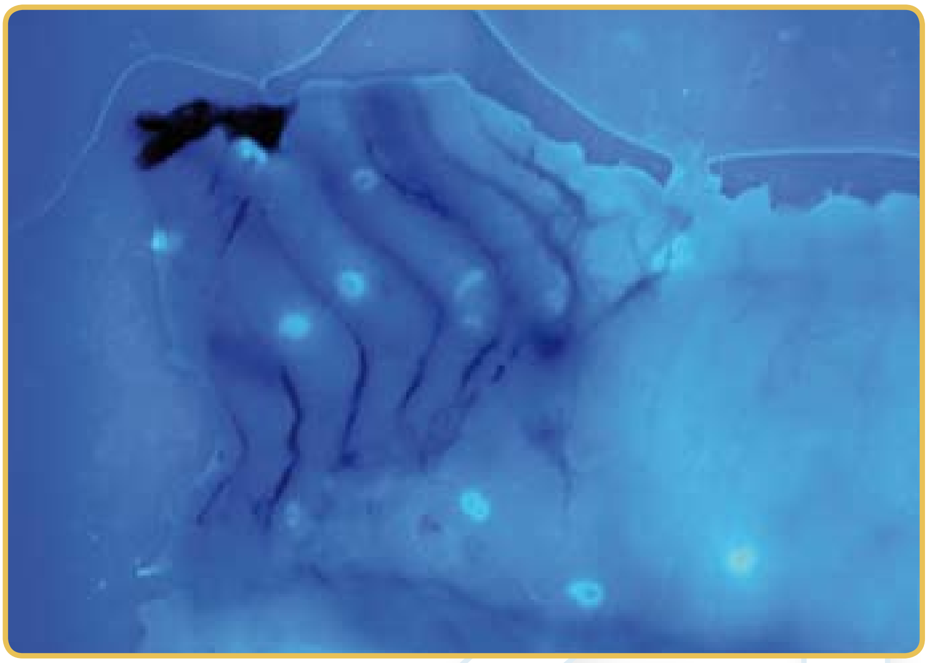

Fig 5. Showing *Anisakis* worms encapsulated in fish fillet, as revealed by illumination with an ultraviolet light source. Worms are apparent as bright inclusions within the flesh.

Detection and removal of worms is extremely difficult. A visual inspection will identify any obvious parasites and a larger proportion will be removed by "candling" or shining a bright light through the fillets. However we found that this method detected only about 15% and 40% of worms in the fillets of monkfish and cod, respectively, and was ineffectual in monkfish longer than about 30 cm. The only sure way to detect worms is the use of destructive methods, such as digestion with pepsin and hydrochloric acid, or for smaller fish such as herring and mackerel by pressing and freezing followed by exposure to uv light. These methods would only be useful as a means of sampling consignments of fish to detect the true level of infection.

Although worms are widespread in many species of fish, thorough cooking or freezing will prevent live parasites reaching the consumer. Freezing is obviously extremely important if fish is to be eaten raw or lightly processed.