# Pseudamphistomum Truncatum.

## An Investigation into the distribution of Bile Fluke eggs, in Otter Spraint on the Somerset Levels.

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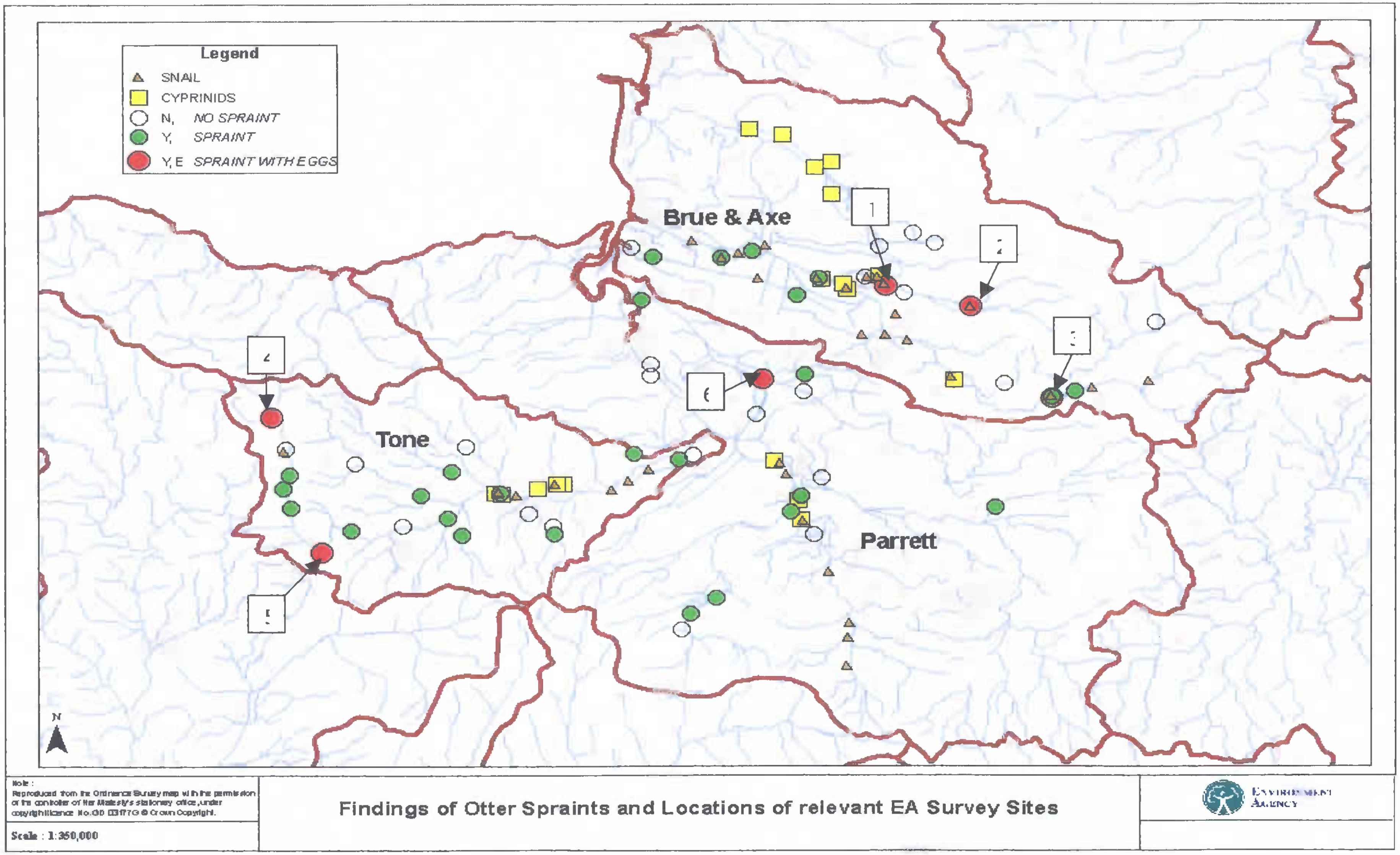


Figure 3.7: Findings of otter spraints and sample sites for the first and second intermediate host

## Abstract

The European otter (*Lutra lutra*) has a history of catastrophic decline in the second half of the 20th century. Since the species was legally protected, populations are increasing again, but their numbers are still in a vulnerable state. An unknown parasite was discovered in a dead otter of the Somerset Levels in 2004, the parasite's identity was subsequently confirmed as the opisthorchiid fluke, *Pseudamphistomum truncatum*. During the summer of 2007 a study on the Somerset Levels was carried out by collecting 53 spraints from three areas, the Brue-Axe, Tone and Parrett catchments. Spraints were analysed for presence of eggs of this parasite using the McMaster Floatation Technique. The aim was to discover whether or not there is a relationship between the different catchment areas and egg abundance. The statistical analysis using the Kruskal-Wallis test did not show a significant difference between the areas surveyed. The first and second intermediate hosts of this zoonotic fluke are also in abundance throughout the whole study area. In light of the fact that the area contains large numbers of both intermediate hosts the interpretations of the findings should be made with caution. It has become clear that the fluke's interaction with other species (including the otter) is a highly complex system which needs further investigation in the future. This is the first study of its kind, therefore it is possible that only the main problems have been highlighted and there may be further implications, thus suggestions and recommendations have been made which will hopefully lead to long term positive management of the species in question.

## Chapter 1 - Introduction

A very rare fluke of the opisthorchiid family, *Pseudamphistomum truncatum* has been discovered recently in the gall bladders and bile ducts of otters of the Somerset Levels (Simpson *et al.*, 2005). A wide range of parasites have been studied in great detail, but only little is known about *P. truncatum*, the subject of this study (Schuster *et al.*, 1999; Schuster *et al.*, 2000; Kaewkes, 2003; Simpson *et al.,* 2005). The study investigates the impact of the otter's typical behaviours on the life cycle of *P. truncatum* as well as other biotic and abiotic factors affecting the establishment of this rare fluke.

The River Brue and the River Axe drain two sides of a large low-lying basin, which flows into the sea. They lay parallel to each other and are connected through ditches. The River Tone has a relatively steep gradient and therefore it has a high flow of water for a lowland river (EN, 1998). The Parrett catchment lies in a more arable part of the Levels and the water movement is slow. The lower reaches of the Parrett are tidal; its flows into the sea at Burnham on Sea (EN, 1997).

The Environment Agency (EA) is undertaking a long term study on otter carcasses with the help of Cardiff University and the Veterinary Investigation Centre in Cornwall (EA, 2007), where for example, PCB, OC and heavy metal concentration in the liver tissues of otters are being assessed. That is how the bile fluke *P. truncatum* was discovered the first time. When unusual lesions are found, the organs are more thoroughly investigated (Simpson, V.R., 2007, pers. comm.) and some otters had abnormal gall bladders. Hence, further investigation resulted in the finding of adult flukes in the bile ducts of otters. Not only otters were infested but also the American mink (*Mustela vison*). Simpson *et al.* (2005) stresses the fact that all animals came from the same area, the Somerset Levels. Figure 1 shows the locations where dead otters with confirmed fluke infection were found (red crosses). Therefore it was assumed that the parasite had been introduced through a freshwater fish, in this case the sunbleak (*Leucaspius delineatus*), which was introduced as an ornamental species in Hampshire in the 1980s. The first reported case of an otter with an abnormal gall bladder was in 2000 in Dorset. This led to the assumption that the parasite has its origin in this fish species. Sunbleak were released by mistake into the Somerset Levels and were first recorded there in 1990. Additionally, this species is native to Russia, as is the fluke, therefore Simpson *et al.* (2005) assumed a strong connection.

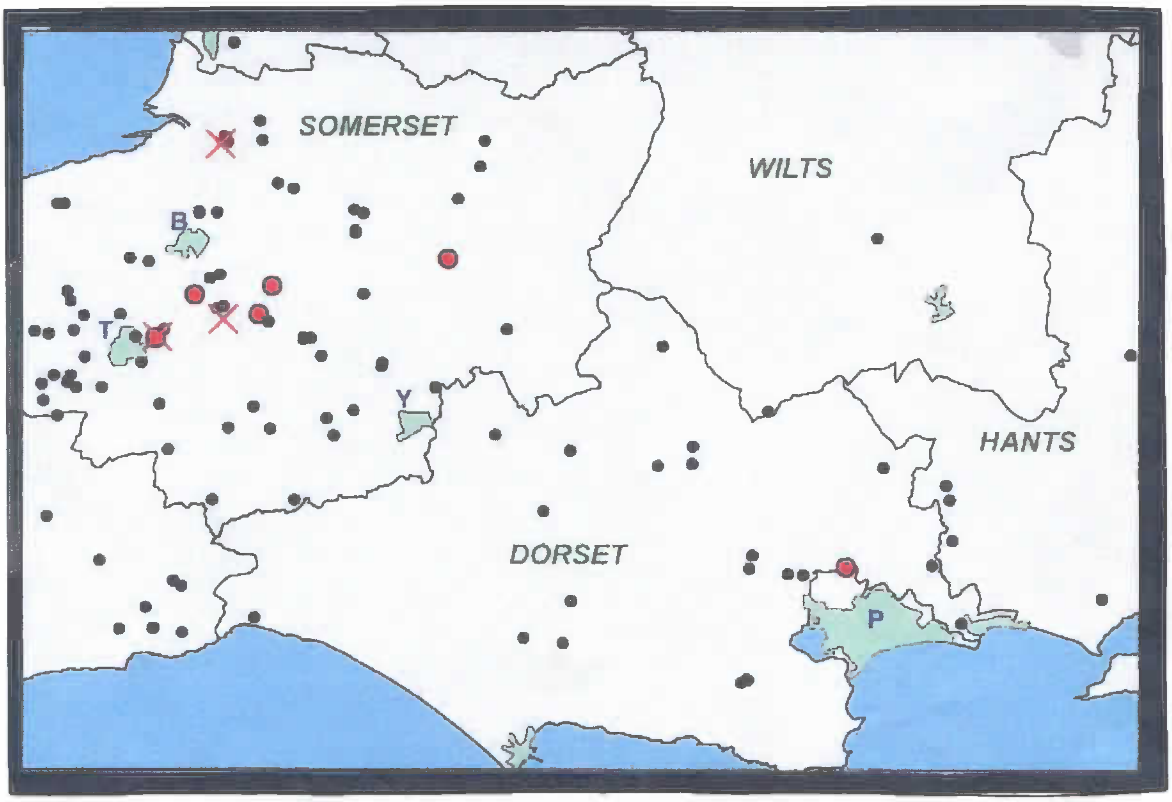


Figure 1: The red crosses represent otters with confirmed fluke infection, red circles represent otters with abnormal gall bladders. The first reported case was in Dorset, near Poole (right bottom corner) (from Simpson *et. al.*, 2005)

**The parasite P. truncatum**

In broad terms a parasite gets its food at the expense of its host. It consumes either fluids like blood, contents of the intestine or tissue (Wilson, 1979). *P. truncatum* uses two intermediate hosts before it finishes its life cycles in the final host. According to Burt (1970) this life cycle is obligate. Hence, the host species can direct and limit distribution, morphology and physiology of the parasite (Stunkard, 1970). For liver flukes, the availability of the susceptible snail species is crucial and therefore the parasite is mostly found in areas inhabited by the particular snail (Chai, Murrell and Lymberg, 2005). In case of *P. truncatum* the first intermediate host is the common freshwater snail *Bithynia tentaculata* and the second one is a range of fish of the cyprinid family (Schuster *et al.,* 1999; Schuster, Wanjek and Schein, 2001; Kaewkes, 2003).

Almost all bile flukes have a similar ontogeny. Schuster (2002) describes it as follows: Ovoviviparous eggs are deposited in the bile duct of the final host. From there they reach the intestines with the bile and are excreted with the faeces. Figure 2 shows the life cycle of a bile fluke (*O. vivverini)* which is transferable to *P. truncatum* (Kaewkes, 2003).

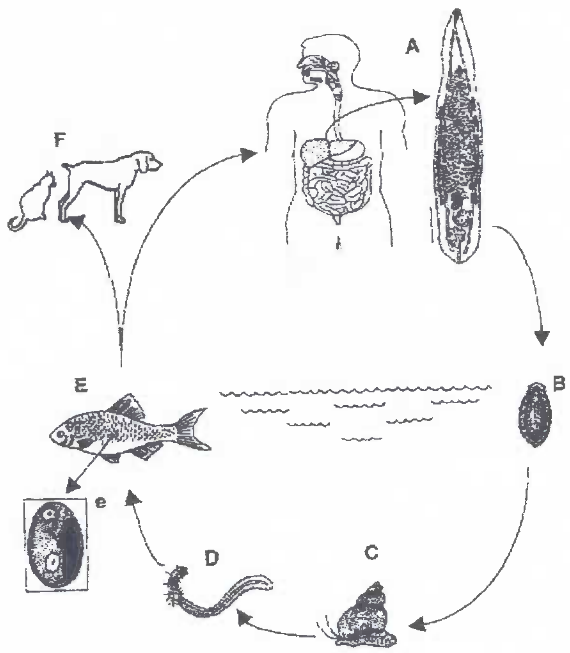


Fig.2: Life cycle of O. viverrini (from Kaewkes, 2003): A = adult

worm in the ducts, B = embryonated egg, C = Bithynia snails as first intermediate host, D = cercaria, E = cyprinid fish as second intermediate host and metacercaria (e), F = final host (mammals or humans)

For further development the eggs have to enter a freshwater body and need to be ingested by a *Bithynia* snail (Kaewkes, 2003). In its gut the ciliated miracidia hatch and moves into the hepatopankreas. Here a sporocyst develops and decay into germinal sacs in which the development into rediae takes place. In the rediae cercariae develop and leave the snail (Schuster, 2002). They possess light sensitive organs which enable them to discriminate between dark and light. First they follow the light, which means they move to the water surface and subsequently let themselves sink to the bottom of the water body.

During that vertical migration they might get in contact with a suitable fish species. This takes place during the summer. Schuster (2002) explains this with the water temperature: at 16°C - 18°C cercariae are able to survive up to 48 hours. Knowledge about the time when cercarial transmission takes place is strategically important for intervention into the transmission cycle (Chai, Murrell and Lymberg, 2005). Lafferty and Kuris (1999) suggest that a parasite can be “fished out” by keeping the second intermediate host under a density threshold for the augmentation of a parasite.

The cercaria attaches to the fish’s skin and penetrate the mucus membrane. A special secretion allows intrusion into the muscle tissue. Here the cercaria covers itself with secretion of cystic glands and develops into a metacercaria. Schuster (2002) points out that this development takes a couple of weeks because it is associated with morphological changes. The final host gets infected by the ingestion of that fish. During the peptic digestion the encystic metacercaria unhinges from the surrounding tissue. Than young flukes migrate against the bile flow into the gall ducts of the liver of the final host and develop here, depending on the species, within 2 – 4 weeks into adult flukes.

**The first intermediate host – *Bithynia tentaculata***

*B. tentaculata* is a very common species in lowland Europe (Kerney, 1999). It is one of twelve other British molluscs that occur in fresh water (Lilly, 1953). It prefers well oxygenated hard water in standing or slow moving large water bodies and is rarely found in small water bodies but sometimes in small streams (Macan, 1977). Hill-Cottingham surveyed aquatic snails over the whole Somerset Levels and she found no evidence of regional decline of *B. tentaculata* (Hill-Cottingham, P., 2007, pers. comm.). Therefore fluke infections with abundant first intermediate hosts should be more frequent.

**The second intermediate host – cyprinid fish**

Most cyprinids are known to the public under their common names barbel (*Barbus barbus*), tench (*Tinca tinca*), carp (*Cyprinus carpio*), rudd (*Scardinius erythrophthalmus*), roach (*Rutilus rutilus*), dace (*Leuciscus leuciscus*), bitterling (*Rhodeus sericeus*), minnow (*Phoxinus phoxinus*) and gudgeon (*Gobio gobio*) (Winfield and Nelson, 1991). Cyprinids can be found in almost every freshwater habitat from still lakes to torrential rivers and Winfield and Nelson (1991) point out that they can withstand temperature ranges between 0 - 40°C. Some species are even tolerant to high salinity. The EA (2008) states that roach is prone to parasites and disease. In the past they have suffered from a severe bacterial infection and they are often infected with the tapeworm *Ligula intestinalis* which can cause reduced breeding success and high mortality. On the continent roach also suffers of high parasite burden. In Eastern Germany they are often infested with metacercaria of the opithorchiid fluke *O. felineus* and *M. bilis* (Hering-Hagenbeck and Schuster, 1996) and also *P. truncatum* has been found in their muscle tissue, albeit in very low numbers (Schuster, Wanjek, Hering-Hagenbeck, 1998; Schuster, Wanjek and Schein, 2001). It is not clear whether the roach is a regular prey of the otters of the Somerset Levels.

**Otter diet on the Somerset Levels**

All studies about otter diet show that their main food is fish, which always makes the bulk item found in spraints. NE (2007) estimates the daily amount of fish eaten by otters is 15 % of their body weight. What is taken differs dramatically because it is directly correlated with presence or absence of particular species. Wise, Linn and Kennedy (1981) found roach (*Rutilus rutilus*) and Jenkins and Harper (1980) found eels and salmonids as the predominant food. It is however generally agreed that otter eat what is abundantly available, which means they eat the fish that is more abundant rather than any preferred species (Chanin, 1993; Chanin, 2003). This fact might have severe implications for the otters of the Somerset Levels with regard to availability of particular prey.

Unfortunately there is no recent published study about the dietary preferences of the otters of the Somerset Levels. The last published work stems from Webb (1975) who found eel (*Anguilla anguilla*) and threespine stickleback (*Gasterosteus aculeatus*) as the preferred food item. At that time eels were ubiquitous and found in 68.9 % of spraints (= 591 of 858 spraints in total). Cyprinid remains accounted only for 19 % (= 163 spraints).

The eel population of Europe has been declining since the 1970s and this is still an ongoing process. The eel population on the Somerset Levels is also experiencing a drastic decline since the 1970s as described by Farr-Cox (1996). He reports about the documented drop of young eels (elvers) beginning in the early 1980s possibly due to the effects of global warming on marine currents, migration obstructions, parasite infestation and habitat degradation.

**Fishery surveys on the Somerset Levels**

Each year the North Wessex Ecological Appraisal Team of the EA surveys certain sites of river catchments. This is part of the National Fisheries Monitoring Programme (NFMP). The annual survey helps to define long-term trends of fish populations (EA, 2006, 2006a, 2006b, 2006c). In 2006 cyprinids were found in all catchments. Table 1 shows fishery survey results of the EA for cyprinids for the years 2003 – 2006 for all the catchments of this study (EA, 2006, 2006a, 2006b, 2006c). The table shows clearly that the parasite-prone roach is fairly abundant in the survey areas, especially in the slow flowing catchments Brue-Axe and Parrett, where more fluke eggs where found than in the other study area, the Tone catchment with its faster flowing tributaries. Additionally, as mentioned before, especially in absence of eels, the otter's main food item could be roach.

Table 1: Survey results of cyprinid fish counts by the EA for 2006 (from EA 2006, 2006a, 2006b, 2006c)

| **Brue catchment** | | | | | |
|---|---|---|---|---|---|
| Grid Ref. ST | 53540 34380 | 45840 41790 | 44040 42550 | 48160 42800 | 45590 42170 |
| Chub | 0 | 86 | 17 | 7 | 8 |
| Dace | 0 | 18 | 8 | 1 | 0 |
| Roach | 34 | 181 | 51 | 15 | 8 |
| Gudgeon | 0 | 29 | 5 | 8 | 0 |
| Rudd | 1 | 0 | 0 | 0 | 2 |
| Tench | 0 | 0 | 0 | 0 | 0 |
| Minnow/ Sunbleak | 0 | 0 | 0 | 0 | 8 |
| Mirror Carp | 0 | 0 | 0 | 0 | 0 |
| **Axe Catchment** | | | | | |
| Grid Ref. ST | 44740 49540 | 43560 51720 | 38840 54880 | 41250 54450 | 44750 52290 |
| Chub | 0 | 1 | 0 | 4 | 0 |
| Dace | 0 | 0 | 2 | 0 | 0 |
| Roach | 26 | 89 | 89 | 31 | 137 |

| | | | | | |
|---|---|---|---|---|---|
| Gudgeon | 0 | 0 | 3 | 0 | 0 |
| Rudd | 0 | 0 | 0 | 0 | 1 |
| Tench | 0 | 0 | 0 | 0 | 0 |
| Minnow/ sunbleak | 0 | 0 | 0 | 0 | 0 |
| Mirror Carp | 0 | 0 | 0 | 0 | 0 |

| **Tone catchment** | | | | | |
|---|---|---|---|---|---|
| Grid Ref. ST | 20460 25040 | 20960 24970 | 23580 25410 | 25330 25750 | 24953 25738 |
| Chub | 4 | 7 | 147 | 4 | 158 |
| Dace | 8 | 4 | 47 | 0 | 71 |
| Roach | 3 | 3 | 44 | 0 | 174 |
| Gudgeon | 2 | 8 | 13 | 0 | 18 |
| Rudd | 0 | 0 | 0 | 0 | 0 |
| Tench | 0 | 0 | 0 | 0 | 0 |
| Minnow/ sunbleak | 0 | 0 | 0 | 0 | 0 |
| Mirror Carp | 0 | 0 | 0 | 0 | 0 |
| **Parrett catchment** | | | | | |
| Grid Ref. ST | 45140 16570 | 42360 24490 | 42550 22910 | 40540 27780 | |
| Chub | 0 | 2 | 17 | 7 | |
| Dace | 0 | 1 | 0 | 0 | |
| Roach | 0 | 39 | 25 | 26 | |
| Gudgeon | 0 | 1 | 0 | 0 | |
| Rudd | 0 | 0 | 0 | 0 | |
| Tench | 0 | 0 | 0 | 0 | |
| Minnow/ Sunbleak | 0 | 1 | 4 | 0 | |

| | | | | | |
|---|---|---|---|---|---|
| Mirror Carp | 0 | 0 | 0 | 0 | |

**American mink (*Mustela vison*)**

Mink are also a species that occur on the Somerset Levels and in places (e.g. Shapwick Heath Nature Reserve) they are considered a threat to the resident water vole (*Arvicola terristris*) population (MacPherson, J., 2007, pers. comm.). Belonging to the same family, the mustelids, mink share a lot of characteristics with the otters.

**Mink diet**

A lot of studies about the otter's diet also include dietary studies of mink because the two species often live in the same habitat and therefore share its resources. Mink like the water; hence fish makes a substantial part of their diet (DEFRA, 2005). But the same principle as for the otter seems to apply here: the mink's diet depends on availability of prey species in connection with habitat and season. As mink are also affected by *P. truncatum* and as the species has a wide ranging dispersal behaviour, this can have important implications for the speed and distance of the spread of this recently introduced parasite. It can be assumed that exploiting the same food source than the otter could be the reason that mink from the Somerset Levels also infected with *P. truncatum* as the examination of Simpson *et al.* (2005) revealed. The extensive study by Wise, Linn and Kennedy (1981) identified the most important fish prey for the mink in Devon was roach, which is a very abundant species of the Somerset Levels.

**Material and Methods**

**The Brue-Axe catchment**

The River Brue and the River Axe drain two sides of a large low-lying basin, which flows into the sea. They lay parallel to each other and are connected through ditches. That is why the two river systems were surveyed together and considered as one catchment. The lower reaches of the Axe are tidal, but the River Brue is not because a system of sluices along its course excludes it from being tidal (EN, 1997).

**The Tone catchment**

The River Tone has a relatively steep gradient and therefore it has a high flow of water for a lowland river (EN, 1998). The water quality of the River Tone is relatively high and so is the water quality of its tributaries. As it can be seen from Figure 2.1, the Tone catchment is not entirely in the 10 metres contour line of the Somerset Levels, but otters do not know where the borders are and so it was decided to survey the whole catchment.

**The Parrett catchment**

The Parrett catchment lies in a more arable part of the Levels and the water movement is slow. The lower reaches of the Parrett are tidal; its flows into the sea at Burnham on Sea (EN, 1997).

Based on data from the Somerset Wildlife Trust (SWT) Otter Group 54 sites were randomly chosen. The aim was to find 50 spraints in total and 15 survey sites in each catchment (= total of 45) were selected first. After having surveyed these sites, not enough spraints were found. Therefore three more sites per catchment were randomly selected.

The aim of the study was to find out whether or not the distribution of fluke eggs in otter spraints was localised or spread over all three catchments under investigation. The survey was carried out from 31 July to 3 October 2007 in three different catchment areas of the Somerset Levels; the Brue-Axe catchment, the Parrett catchment and the Tone catchment. In each catchment 18 sites were visited (total n = 54) and altogether 53 spraints could be collected. Sprainsts were never collected twice from the same site. James

Williams from the SWT Otter Group was attending the surveys for advice and safety reasons.

**Processing the spraints**

The preparation of the spraints and examination under the microscope was carried out according to requirements of the McMaster Floatation Technique using slides having special counting chambers. The eggs float to the surface of the upper glass of the counting chamber, whereas other remains sink to the bottom of it. Using a microscope, the chambers are searched focused on the eggs. To prepare the spraints for examination a mixture of spraint, distilled water and salt solution needed to be well shaken until all the faecal matter had broken down. The liquid was left to settle for a few minutes. This enables the eggs to flow to the surface. A pipette was then used to take some liquid from the mixture surface of the measuring cylinder which was then applied on the counting chamber.

**General findings**

With 25 (= 47.17 %) spraints, there were more than double of the number of spraints found in the Tone catchment than in the Brue-Axe catchment with 11 spraints (= 20.75 %). The Parrett with 17 spraints (= 32.08 %) lies in between the two. Eggs were found in three spraints from the Brue-Axe, one spraint from the Parrett and three spraints from the Tone catchment. Overall, seven spraints out of 53 (= 13.2 %) were positive for fluke eggs. Figure 3.1 shows the relation of egg-free spraints and egg-infested spraints in each catchment.

**Mean number of eggs in the faeces of each catchment**

Figure 3 reflects the mean number of eggs/g faeces for each catchment. Here the Brue-Axe catchment shows the highest number with 227.3 eggs/g faeces. The Parrett catchment has the lowest number of eggs/g faeces with 31.3 and the Tone catchment lies in between the two with 68.1 eggs/g faeces.

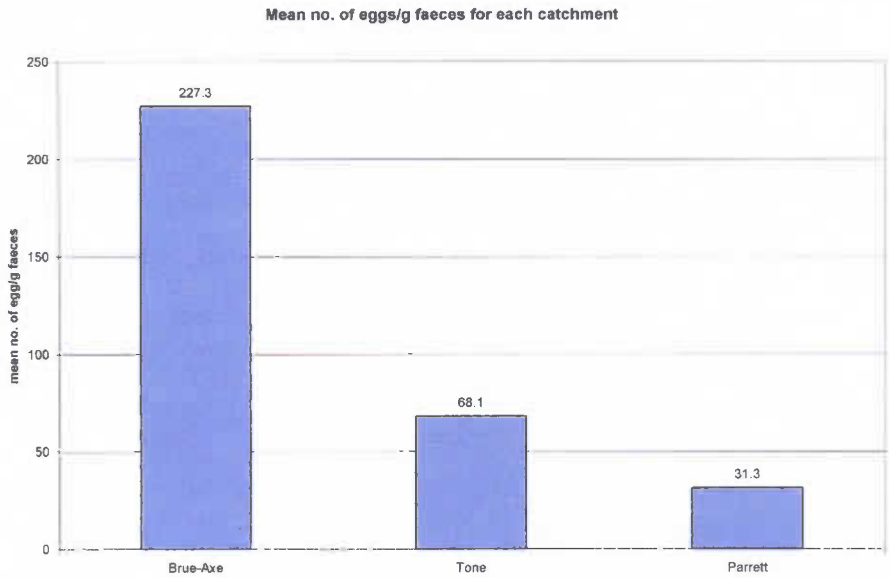


Figure 3: Mean number of eggs/g faeces for the individual catchments

**Results visualised on the catchment map**

All spraint locations are plotted on the map in Figure 3.7 indicating also the sample sites for Bithynidae and cyprinids, also highligthing all important sites with a numbered box, which are referred to in the discussion. Cyprinids and Bithynidae snails are also present in all catchments according to surveys by the EA. Figure 3.7 shows the following results:

In the Brue-Axe catchment all sites with spraints positive for eggs are also sites where snails of the Bithynidae family were sampled. Sample sites for cyprinds are all in close vicinity.

In the Tone catchment the positive fluke eggs sites are further away from sample sites for Bithynidae. In the eastern part where many Bithynidae and cyprinid sites overlap, no spraints at all or only egg-free spraints were found respectively.

In the Parrett catchment the only spraint positive for fluke eggs is downstream of an area where sample sites of Bithynidae and cyprinds are in close proximity to each other.

As separate document

Figure 3.7: Findings of otter spraints and sample sites for the first and second intermediate host

# Chapter 4 - Discussion

## 4.1 General interpretation of findings

Having found fluke eggs in all three catchments shows that the parasite has spread over the whole area indicating that *P. truncatum* has a suitable habitat in all three survey areas.

### Interpretation of findings in Brue-Axe catchment

In the Brue-Axe catchment with 11 the least number of spraints were found but in relation to the other two catchments the most eggs in faeces were present.

At Godney Farm (1) the spraint with the exceptionally high egg burden was found. Sample sites for Bithynidae snails and cyprinds are in close vicinity. These are ideal circumstances for the establishment of a digenean parasite (Schuster, 2002). If this combination of all three hosts in the area is sustainable, the chances for transmission and for the parasite becoming endemic in the region are very high (Chai, Murrell and Lymberg, 2005).

Whitelake (2), where another fluke positive spraint was found is very close to Godney Farm. Bithynidae snails were sampled here and the next site where cyprinids are found is not far away and on the same water course, so the same favourable conditions are present. Additionally, the two sites are very close to each other. It might be that the two spraints are from the same otter, having its territory along that water course.

The third spraint was from Weirstone (3). At this site the River Alham flows into the River Brue. Bithynidae were sampled in the same spot and the next sample site for Bithynidae and cyprinids are not far away further downstream. The author considers this as equally favourable conditions for establishment of the parasite.

**Interpretation of findings in Tone catchment**

The highest number of spraints (25) were found in the Tone catchment. At Clatworthy Reservoir (4) two spraints positive for fluke eggs were found. A Bithynidae site is close by. The nearest known sites for cyprinids however, are a long distance away, in Taunton. It does not mean that cyprinids are not present in the surrounding water courses, only because they haven't been sampled there. But the steep and fast flowing nature of the water courses is more suited to salmonids than cyprinids (Williams, J.L.R., 2008, pers. comm.).

The second site with a positive spraints was Greenham Bridge (5). There are also no sample sites for the two intermediate host species in close proximity. However, this site is closer to Taunton, where both intermediate host species have been sampled. Both sites lie directly on the River Tone, which means that there is a direct connection between the two sites. Contaminated spraints can easily be washed down from the reservoir towards the region of host presence.

The faster flowing tributaries of the Tone might not be the ideal habitat for *B. tentaculata* (Ellis, 1926; Kerney, 1999) but Clatworthy Reservoir, being a still water, is.

**Interpretation of findings in Parrett catchment**

The only spraint positive for fluke eggs found in the Parrett catchment was at Greylake (6), directly at a sluice at the King Sedgemoor Drain, an artificial side arm diverting the River Cary from the River Parrett into the sea (Williams and Williams, 2003). No sample sites for Bithynidae or for cyprinids are in close proximity. However, both intermediate host species are present further upstream. Again, here are ideal conditions for digeneans. An otter could have easily got infected and deposited its spraint further downstream. The presence of the crucial first intermediate host (Chai, Murrell and Lymberg, 2005) is very substantial further upstream.

**Connectivity of water courses**

The River Tone is directly connected to the River Parrett. They join each other at Burrow Bridge. Therefore, migration of host species from the one catchment to the other is most likely and proliferation of infested spraints can also be expected.

The Brue-Axe catchment however, is not directly connected to the Parrett catchment. It is self contained and lies between the Mendip Hills in the northwest and the Polden Hills in the southwest. An otter would have to cross a ridge to get to the next water course. Looking at the map, it seems that all three host species are more concentrated and closer together, and because of the more isolated location of the Brue-Axe catchment one could assume that the parasite had its origin in this part of the Somerset Levels. Also, most eggs were found there despite being the site of lowest spraint abundance.

## Implications for the Fluke: Abundance of the host species - *Bithynia tentaculata*

Bithynidae family can be found and have been sampled by the EA in all three catchments. This could be expected because of its general abundance not only in Europe (Ellis, 1926; Kerney, 1999). Hill-Cottingham has sampled the species all over the Somerset Levels (Hill-Cottingham, P., 2007, pers. comm.) Environmental conditions might not ideal in all three catchments but Wiese (1991) points out that the species is very adaptable and for instance in faster flowing water it simply does not grow to its normal size.

The fact, that *B. tentaculata* is a more sedentary species than the cyprinid fish is not of great significance, because after a metacercaria has left the snail it can travel with the current of the river, invading its second host a long distance away from its release of the snail and the motile fish can transport it even further.

To the west of the Somerset Levels the species can only be found in very few places. Further west towards Exmoor the landscape is dominated by major moorland rivers. They are faster flowing with unstable eroding banks and provide little instream vegetation (EN, 1997a). Therefore the water is more energetic and does not suit the basic habitat requirements for *B. tentaculata*. This is a limiting factor and it can be expected that it prevents further spread of the snail and therefore of *P. truncatum* to the western part of the country.

## Implications for the Fluke: Abundance of the host species - Cyprinid fish

The cyprinid family is present in all three catchments with roach being the most frequent species recorded by the EA in 2006. This is underpinned by Phillips and Rix (1985) who identify roach as the most common lowland species in England.

The preference of otters for eels (Webb, 1975) has been discussed earlier and so has the problem of the declining eel population of the Somerset Levels (Farr-Cox, 1996). The findings of past studies that otter eat what is most available (Chanin, 1993; Chanin, 2003) would suggest that roach is a species that is often taken. The EA usually does not test fish for parasite burdens, when carrying out the fishery surveys. This was only done at the time, when Simpson *et al.* (2005) assumed that the parasite was introduced with the imported ornamental fish species, the sunbleak. This test was carried out at the Centre for Environment, Fisheries and Aquaculture Science (CEFAS) laboratory in behalf of the BBC and the EA only assisted with the capture (Way, G. 2008, pers. comm.). The results were negative, but it was a very small and localised sample, so the result has to be regarded as inconclusive (Williams, J.L.R, 2008, pers. comm.).

**Implications for the Fluke: Abundance of the host species - The otter**

The otter is present over the whole Somerset Levels. It is not clear how large the populations are, despite thoroughly carried out surveys every year by the Otter Group of the SWT (Williams, J.L.R., 2007, pers. comm.). Being a solitary animal with a large home range does not make it a good reservoir species for the digenean fluke. Also home ranges are usually larger when population densities are small. However, the otter's behaviour of depositing spraints close to the water edge (Schuster, 2002) and the fact of feeding nearly exclusively on fish (Chanin, 2003) make them a vector species.

**Uncertainties and difficulties in interpretation of findings**

There are no limiting factors that could confine the parasite to a restricted area of the Somerset Levels. Due to the ubiquitous distribution of *B. tentaculata* and the cyprinid family over the whole study area it is impossible to contain the occurrence of the fluke to a particular area.

The geographical situation with its interconnecting network of rivers, rhynes, ditches and drains which act as arteries of the Somerset Levels and its functions 1) drainage of flood water in winter and 2) water supply for stock drinking in summer (EN, 1997) increases the possibility of migration of all species involved in the life cycle of the fluke. With the otter travelling large distances there is a risk spreading fluke eggs into new areas where they can encounter both intermediate hosts and become established. Chanin (2003) points out that during the time food travels through the gut of the otter, it can travel many kilometres. Hence, because the place of infection and the place of finding fluke eggs are not in close proximity, no assumptions about the origin of infection can be made (Schuster, 2002).

**Recommendations for future work**

The author is of the opinion that in order to find out, whether or not a particular fish species can negatively influence the otter population of the Somerset Levels, it needs to be found out which prey items contribute most to their diet in all seasons. Under the light of the findings of properties of the intermediate host species, especially more focus and thorough research should be carried out on the cyprinids.

Therefore the following recommendations are given:

- Additionally to the post mortem examinations already in place it should also be look at the stomach contents of otters for prey identification to correlate findings to the presence of flukes.
- Life cycle and ecology of *P. truncatum* need to be studied in much greater detail.
- Examination of all fish species, not only the cyprinids, for metacercaria in the muscle tissue.

- If a particular fish species can be identified as the carrier of metacercaria of *P. truncatum* this can have implications for the further management of that particular species.
- Depending on the results of the examinations, biosecurity of fish farms could become important.
- The numbers of mink over the Somerset Levels should be controlled and kept on a low level in order to avoid the long distance dispersal of juveniles for their territory establishment.

**Conclusion**

During the practical field work the author has gained a lot of knowledge and experience not only about the species of concern, (the otter), but also about the connections and implications of habitat management and its impact on the animals in a habitat over a longer period of time.

Although the study might experience a better result that allows scientific interpretation when using more efficient techniques and a larger sample size, the author would not repeat it in the same manner. Having gained that knowledge about the parasite-host-relationship and the circumstances on the Somerset Levels, the author would start the survey from a completely different angle, beginning with the examination of the fish species. The outcome would than influence further decision making.

Changing certain habitat management practises might be not avoidable but at this point it cannot be estimated what impact this will have on the commercial sector. A change in fish management might have an impact on stakeholders of the fisheries, for example if the population of the fish species identified as the second intermediate host should be kept under the threshold level for the establishment of the metacercariae at the crucial time of the year (Lafferty and Kuris, 1999).

If the eel can be ruled out as a potential second intermediate host the establishment of freshwater protected areas (Cucherousset *et al.*, 2007) for that species might restore its population and focuses the otter and mink away from other fish prey back to the eels and this would also mean a disruption in the life cycle of the fluke.

*P. truncatum* can have food hygienic importance because it belongs to the group of opisthorchiids that can infect humans and therefore has relevance as a zoonotic pathogen (Schuster, Wanjek and Hering-Hagenbeck, 1998). So far, the fish species in question are not being eaten by humans in the UK but changing eating habits due to immigration of people from eastern countries can pose a threat to these groups (Belcher and Newell, 2005). However, infections in humans can easily be avoided by not eating raw or undercooked fish (Schuster, 2002) and there are vaccines for humans available which are at the moment also tested for the application on pets (Schuster *et al.*, 2007).

At the present stage, it is not known how detrimental the effect of *P. truncatum* on the otter (and other wildlife) can be (Simpson *et al.*, 2005). But vulnerable species like the otter need to be protected and prevention is better than cure. It is generally accepted that opisthorchiid flukes negatively influence the immune system of their hosts (Lafferty and Kuris, 1999; Schuster, 2002) and each additional environmental stressor can make the final host more vulnerable. With the otter as a species that does not breed every year (NE, 2007) the impact of *P. truncatum* could lead to a further decrease in their numbers.

This is a target for governmental and non-governmental organisations and affords a functioning network, demanding expertise of differently skilled personnel. Monitoring the development of the strategy over a substantial period of time is crucial to measure the progress. If the parasite, *P. truncatum*, can be successfully suppressed or eradicated, which future post mortems will show, this strategy (adapted as necessary) can be applied to other areas and other species.

Hopefully the results of this investigation could demonstrate the potential risk of the parasite for the otter and other species and gives an impetus to what can be achieved for the safeguard of the otter. In addition it is hoped that this investigation will precipitate debate about similar issues affecting other species to act more quickly and seek out effective solutions.

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