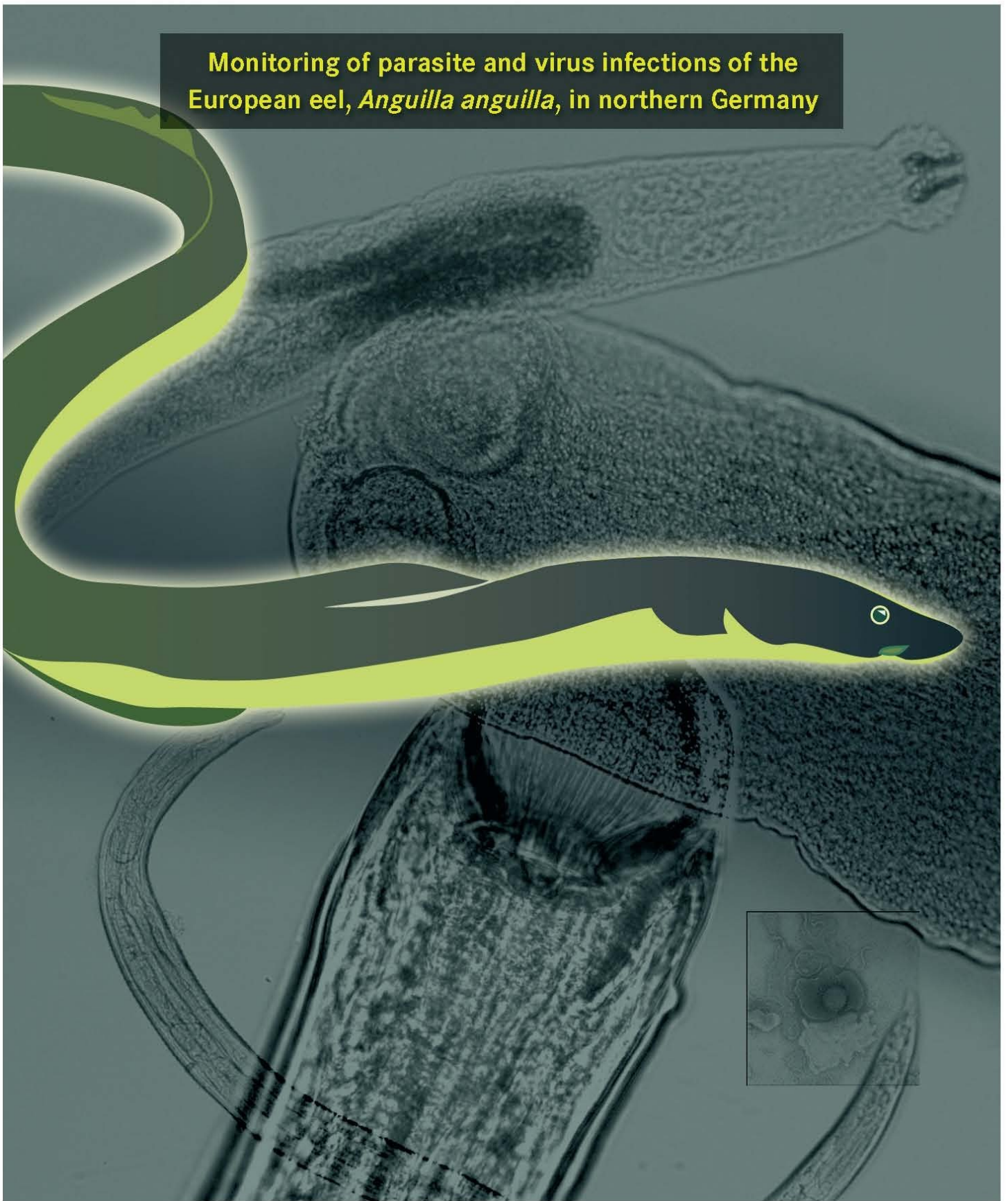


**Monitoring of parasite and virus infections of the
European eel, *Anguilla anguilla*, in northern Germany**



DISSERTATION

zur Erlangung des Doktorgrades

der Mathematisch-Naturwissenschaftlichen Fakultät
der Christian-Albrechts-Universität zu Kiel

vorgelegt von Eva Jakob

Kiel, Juli 2009

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SUMMARY

The aim of this thesis was to examine metazoan parasite communities and viral infections of European eel, *Anguilla anguilla*, from fresh water, brackish and marine localities in northern Germany. The here collected data shall help to evaluate the suitability of the studied localities for potential restocking purposes regarding the presence of pathogens.

In **Chapter I** a comparative examination of the metazoan parasite communities of the European eel was conducted including measures of parasite diversity characteristics. Special focus was given on the prevalence and intensity of infection with the invasive swim bladder nematode *Anguillicoloides crassus* and the gill monogenean *Pseudodactylogyrus* spp.

In all, 29 parasite species/taxa were found in 170 eels from six different sample sites. Parasite communities of European eels clearly exhibit the habitat preferences of their hosts, salinity-dependent specificities, and a clustering into fresh-water, brackish, and marine groups. The highly pathogenic parasite species *Anguillicoloides crassus* and *Pseudodactylogyrus* spp. were found at all sampling sites in fresh water and brackish water, with high prevalence. Therefore, the common practice of catching glass eels in river estuaries for restocking solely in inland waters as management measure for stock recovery should be critically considered.

To set a baseline for future trend analyses and biodiversity considerations an updated and comprehensive literature review on prevalence and distribution of parasites of the European eel in European waters was conducted (**Chapter II**). The resulting checklist provides evidence for 161 parasite species/taxa from 30 countries. Special consideration was given to the distribution of the swimbladder nematode *Anguillicoloides crassus*. A map and table of first reported records as well as a survey map indicating all published localities of *A. crassus* documented in the checklist are provided.

In **Chapter III** the prevalence of virus infections in European eels from natural habitats with differing salinity regimes were evaluated. Out of the 140 examined eels, HVA was detected in two of the five investigated water bodies with an overall infection prevalence of 2%. Virus infection was only detected by direct PCR testing, whereas none of the three HVA PCR-positive eels showed any clinical sign of disease. However latent infections of HVA were found in the investigated water bodies and as proven for the first time, also in a marine habitat (Helgoland) of northern Germany. The only reliable method for the verification of viral genome in latent herpesvirus infections is by PCR examination. For the verification of even low virus copy numbers in asymptomatic carriers, a more sensitive detection method was developed (**Chapter IV**). This method was tested on eel samples from two freshwater localities in northern Germany, Lake Pönitz (n=16) and River Elbe (n=30). But even with this high sensitive nested-PCR, HVA positive eels were only detected in 2 eels from Lake Pönitz (**Chapter IV**). Hence, the rate of HVA infection seemed to be quite low among northern German eel stocks. But the source of infection is present in at least three of the seven studied localities (**Chapter III & IV**) and under favourable conditions for virus replication like high water temperature or stress a reactivation and further dispersal of HVA might be induced.

ZUSAMMENFASSUNG

Ziel dieser Arbeit war es die metazoischen Parasitengemeinschaften und Virusinfektionen des Europäischen Aals, *Anguilla anguilla*, aus Süßwasser, Brackwasser und marinen Habitaten Norddeutschlands zu untersuchen. Die erhobenen Daten sollen helfen die untersuchten Gewässer auf ihre Eignung als potenzielle Besatzstandorte in Bezug auf Pathogene zu evaluieren.

In **Kapitel I** wurden die metazoischen Parasitengemeinschaften des Europäischen Aals vergleichend untersucht und zusätzlich Diversitätsindizes zur Charakterisierung der Artengemeinschaften erhoben. Besonderer Fokus wurde auf den Befall mit dem Schwimmblasen-Nematoden *Anguillicoloides crassus* und den Kiemen Monogeneen *Pseudodactylogyus* spp. gelegt. Insgesamt konnten 29 Parasitenarten/Taxa aus 170 Aalen von sechs verschiedenen Standorten nachgewiesen werden. Die Parasitengemeinschaften der Aale spiegeln die Habitatspräferenzen ihrer Wirte wider, weisen salinitätsbedingte Spezifitäten auf und clustern sich in Süß-, Brack- und Salzwassergruppen. Die eingeschleppten und pathogenen Parasitenarten *Anguillicoloides crassus* und *Pseudodactylogyus* spp. wurden für alle Süß- und Brackwasser Standorte mit hohen Prävalenzen nachgewiesen, nicht jedoch für den marinen Standort. Die gängige Praxis Aale ausschließlich in Binnengewässer zu besetzen, sollte aufgrund des fehlenden Auftretens dieser Pathogene in reinen Salzwasserstandorten kritisch überdacht werden. In **Kapitel II** wurde eine umfassende Literaturrecherche zum Vorkommen und Verbreitung der Parasiten des Europäischen Aals in Europäischen Gewässern vorgenommen. Mit der erstellten Checklist wurde eine Grundlage erarbeitet, die zukünftigen parasitologischen Studien als Hilfsmittel dienen soll. Insgesamt konnte der Nachweis für 161 Parasitenarten/Taxa des Aals aus 30 Europäischen Ländern erbracht werden. Hierbei wurde besonders auf die Verbreitung von *Anguillicoloides crassus* eingegangen. Es wurde sowohl eine Karte und Tabelle mit Erstnachweisen für diese Art erstellt, als auch eine Übersichtskarte mit allen in der Checklist aufgeführten Untersuchungsgebieten in denen *A. crassus* nachgewiesen wurde.

Des Weiteren wurden 140 Aale von 5 Standorten auf ihren Befall mit *Herpesvirus anguillae* (HVA) hin untersucht (**Kapitel III**). HVA positive Aale konnten für zwei Standorte mit einer Prävalenz von 2% nachgewiesen werden. Dabei konnte das Virus bei diesen klinisch unauffälligen Aalen ausschließlich via PCR Diagnostik detektiert werden. Somit konnten latent infizierte Aale identifiziert werden und HVA erstmalig für einen marinen Standort beschrieben werden. Damit der Nachweis auch von sehr geringen Mengen Virus DNA in der Wirtszelle möglich ist, wurde die sensitivere Methodik der nested-PCR für das Aal-Herpesvirus entwickelt (**Kapitel IV**). Aale von zwei Süßwasserstandorten, Pönitzer See (n=16) und Elbe (n=30), wurden mit dieser Methodik untersucht, jedoch konnte auch mit dieser hoch sensitiven nested PCR nur 2 HVA positive Aale aus dem Pönitzer See nachgewiesen werden. Anhand dieser Ergebnisse scheint die Belastung mit *Herpesvirus anguillae* in norddeutschen Gewässern eher gering zu sein. Allerdings ist das Virus in latenter Form in drei der sieben untersuchten Gewässer vorhanden und somit eine Quelle für potenzielle Verbreitung und Ausbrüche vorhanden.

CONTENT

SUMMARY	v
ZUSAMMENFASSUNG.....	vii
CONTENT	ix
GENERAL INTRODUCTION	1
AIM AND OUTLINE OF THIS THESIS	11
CHAPTER I.....	13
Salinity dependence of parasite infestation in the European eel <i>Anguilla anguilla</i> in northern Germany.....	13
CHAPTER II.....	23
A checklist of the protozoan and metazoan parasites of European eel (<i>Anguilla anguilla</i>).....	23
CHAPTER III	77
Monitoring of <i>Herpesvirus anguillae</i> (HVA) infections in European eel, <i>Anguilla anguilla</i> (L.), in northern Germany	77
CHAPTER IV.....	83
Detection of <i>Herpesvirus anguillae</i> (HVA) in European eel by nested-PCR	83
GENERAL DISCUSSION	89
REFERENCES.....	95
ANNEX.....	113
LIST OF PUBLICATIONS	115
DANKSAGUNG	117
CURRICULUM VITAE	119
ERKLÄRUNG	123

GENERAL INTRODUCTION

The genus *Anguilla*

Freshwater eels of the genus *Anguilla* are fascinating animals with a unique way of living which set them apart from other fish species. The question of origin and reproduction of eel attracted already Aristotle in 350 BC who assumed, "(...) eels come from the entrails of the earth (...)" (van Ginneken & Maes, 2005). Since Johannes Schmidt, a Danish biologist, who attempted the first expeditions to the estimated spawning grounds in the Sargasso Sea in the 1920th, researchers try to replace myths and speculations with biological evidence. Due to the decline of the three main exploited anguillid species *Anguilla anguilla* (European eel), *A. rostrata* (American eel) and *A. japonica* (Japanese eel), the protection and management of eels is not longer just in focus of biologist, but also of fishermen, fish farmers, conservationists and even politicians.

All freshwater eel species have a catadromous, semelparous life cycle in common, comprising a continental phase of the growth stages, a spawning migration to deep sea areas of tropical/subtropical ocean waters, and a larval drift by ocean currents back to the continental shelves (Tesch, 2003). To date 16 species and 3 subspecies are known for the genus *Anguilla* worldwide (Tesch, 2003; Watanabe, 2009). The onset of speciation is estimated some 20 million years ago and led to the evolution of 3 geographically confined clades: Atlantic (2 species), Oceanian (3 species) and Indo-Pacific (12 species) (Minegishi et al., 2005; Watanabe, 2009).

The focus of this thesis is on the European eel (*Anguilla anguilla* Linnaeus, 1758). The European eel together with its closely related sister species, the American eel (*Anguilla rostrata* LeSueur, 1817) forms the Atlantic clade, distributed in the North-Atlantic Ocean. Adult silver eels of both species share the Sargasso Sea (23-30° N; 48-74° W) as spawning area (Tesch, 2003). But despite a very likely temporal and spatial overlap of spawning of European and American eels, their larvae get distributed to their respective continents, driven by a so far unknown mechanism (van Ginneken & Maes, 2005).

The European Eel, *Anguilla anguilla*

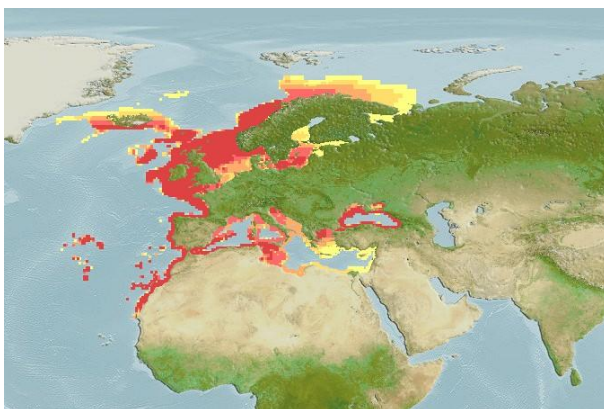


Figure 1 Distribution of European eel. Source aquamap.

European eels are distributed throughout the coasts of Europe with a range from the North Cape in Northern Norway to the north-western part of the African coast including the Baltic Sea, North Sea, Atlantic and Mediterranean Sea and adjacent freshwater systems (Tesch, 2003) (Figure 1). The life cycle of European eels (Figure 2) incorporates two long-distance migrations across the North-Atlantic Ocean of approximately 5000-6000 km. The partially mature adult silver eels leave the continental waters and migrate within 6-7 months along the Canary and North-equatorial currents to their spawning grounds in the Sargasso Sea (Figure 3) (van Ginneken & Maes, 2005). Female silver eels (body length ≥ 50 cm) with sufficient energy reserves (Svedäng & Wickström, 1997) start their spawning migration from the European coast between September and November, whereas the smaller

male silver eels (approximately 40 cm) depart around August (Usui, 1991; Tesch, 2003). Leptocephalus larvae appear between February and July of the following year. They migrate

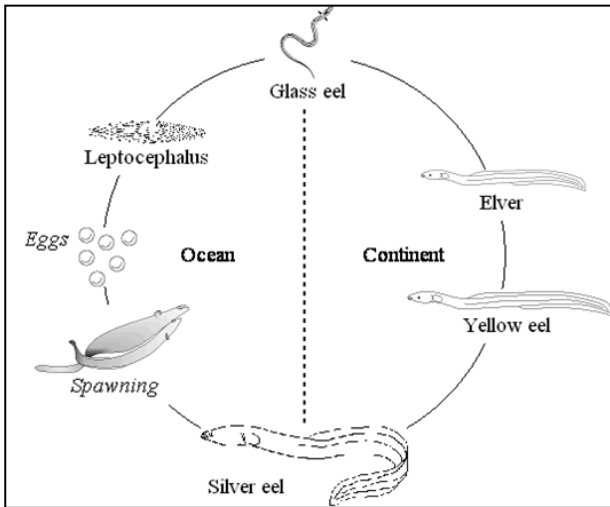


Figure 2 Life cycle of European eel. Source: Dekker, 2000.

passively by the Gulf Stream and the North Atlantic Drift and reach the European and North African coastlines approximately 2 years after hatching (Kettle & Haines, 2006). By reaching the continental waters the larvae metamorphose to glass eels and transform into yellow eels by entering the river systems. The growth phase of the yellow eels can last for several years and differs systematically between habitats (Svedäng & Wickström, 1997). The transition from the growth phase into the migratory phase should be considered as a

step-wise process, which can be arrested at various stages. Further, it is most probable that eels are realizing more than one migration attempt (Svedäng & Wickström, 1997). Age and length at maturation show large geographical variation and a positive correlation between distance from spawning area and mean length whereas a negative correlation between distance and mean age could be observed (Vøllestad, 1992). The mean age at maturation, averaged for the European eel distribution area, for female eels is 8.73 years with a mean length of 623.2 mm and for male eels 5.99 years at mean length of 405.6 mm (Vøllestad, 1992). Adaptations for the oceanic migration and maturation during the silvering process are indicated morphologically as well as physiologically. These adaptations include changes in coloration of the skin, increased eye diameter and pectoral fin length, regression of the intestinal tract (decrease of the Gut-

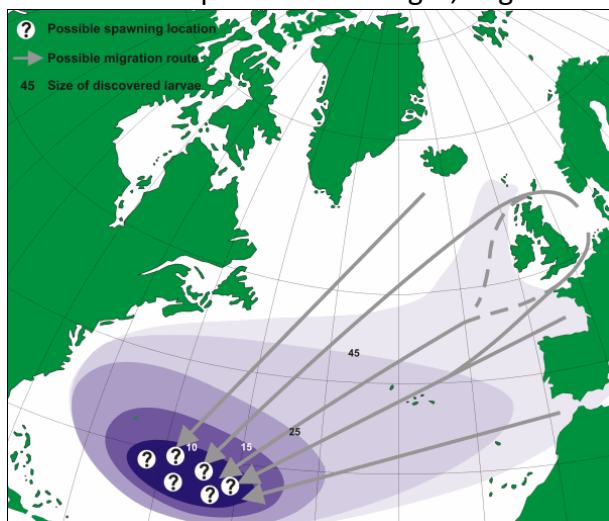


Figure 3 Eel migration and possible spawning location. Source:www.eeliad.com.

Index) and gonadal development (increase of Gonado-Somatic Index). It is still in doubt, whether migrating European eels form one single, and randomly mating population (panmixia hypothesis). Molecular evidence for isolation-by-distance (Wirth & Bernatchez, 2001) and the identification of three distinct spawning groups located in Northern Europe, Western Europe and Mediterranean Sea (Maes & Volckaert, 2002) seem to reject this hypothesis. However, the results of Dannewitz et al. (2005) and Palm et al. (2009) again support the panmixia hypothesis by finding genetic heterogeneity only being present between temporally separated cohorts.

The eel decline and potential causes

Over the last decades a decline in eel recruitment can be observed for European eel (up to 99%) as well as for Japanese eel (around 90%) and for American eel populations (Stone,

2003). The exact causes for the decline are still unknown, but a combination of anthropogenic and natural factors affecting the eel at different life stages, are assumed.

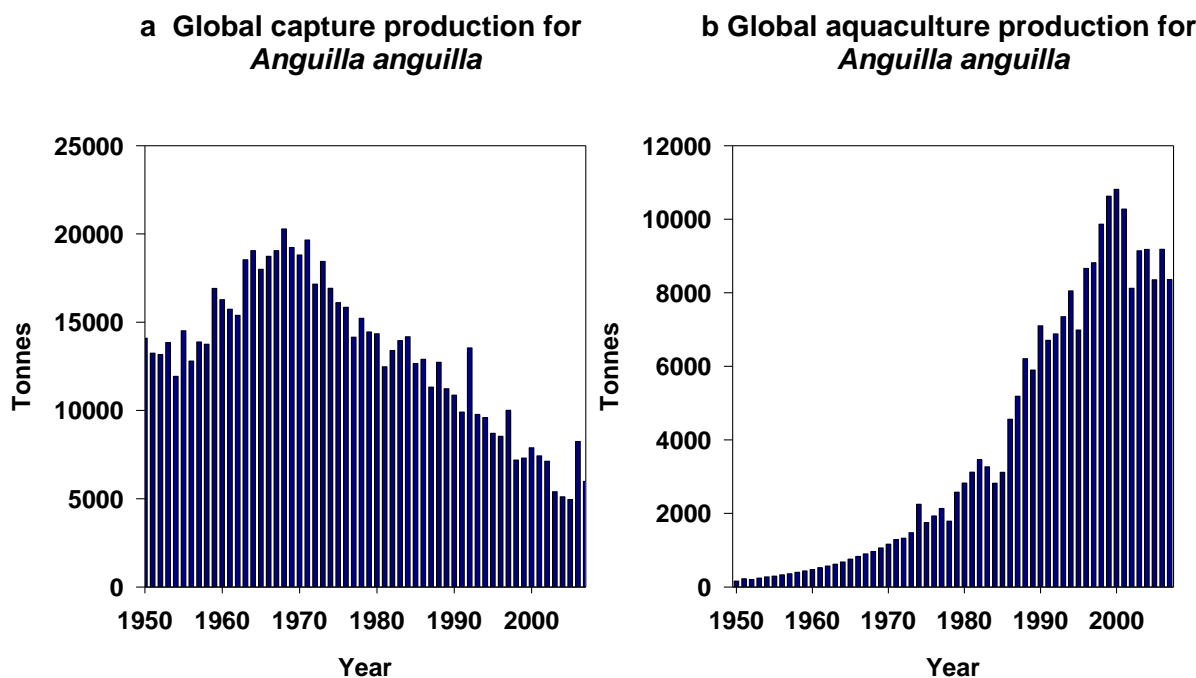


Figure 4 Global capture (a) and aquaculture (b) production for *Anguilla anguilla*. Source: FAO, 2008.

Fishing pressure exists on all continental stages of the European eel. The exploitation by commercial fishermen as well as by anglers varies locally and is generally a small scale artisanal fishery, but supplies the world market (Dekker, 2003b). Landings of European eel decreased remarkably according to FAO capture production data from 1950 to 2007 (**Figure 4a**) with maximum landings of 20278 t in 1968 to 5980 t in 2007 (FAO, 2009). However, aquaculture production (**Figure 4b**) of European eel in Europe increased since 1950 from 160 t to 8356 t in 2007 (FAO, 2009). Together with Asian countries, farming of European eel currently supplies approximately 45 000 t/year, which is >80% of the world's consumption of this species (Nielsen & Prouzet, 2008).

Glass eel fishery is present along the Atlantic coast of Portugal, Spain, France, Morocco and the Bristol Channel in the UK, whereas fishery on yellow eels exists throughout the distribution area and on silver eels mainly in the Baltic Sea and Northern Ireland (Ringuet et al., 2002). The highest market value in eel fishery has the glass eel trade with a price of 750 EUR/kg in 2008 (Briand et al., 2008). Only a small proportion of the caught glass eels (7.5-15% in 2007) are used for restocking purposes in Europe (ICES/EIFAC, 2008) and approximately the same amount for direct consumption, mainly in Spain (Dekker, 2003b). But the majority is used for aquaculture in Asia (Dekker, 2003b) and consequently lost for the spawning stock. **Habitat loss** as a result of wetland reclamations during the last century destroyed approximately 50-90% of suitable habitats for eel (Feunteun, 2002). Further, **migration barriers** like river dams disrupt the accessibility of river systems and inhibit upstream migration when fish passes are missing (Ringuet et al., 2002). For downstream migrating silver eels the turbines of hydro-electric power plants form a considerable threat with assessed mortality rates of 16-26% (Winter et al., 2007). **Contaminations of aquatic habitats** with organic pollutions such as dioxin-like polychlorinated biphenyls (PCBs) are considered as a contributing factor to the current collapse of European eel. PCBs are lipophilic contaminants that accumulate in the lipid stores of the respective organism and

are known to induce embryonic malformations in fish and fish-eating birds (Palstra et al., 2006). In female European eels most of the fat reserves (up to 52%) are transported into the gonads during maturation and are incorporated together with the contaminants in the oocytes (Palstra et al., 2006). Palstra et al. (2006) detected in their study critical PCB levels in most gonads of wild European eels from different localities and suggested a deleterious effect on embryonic development and therefore impairing successful reproduction. Furthermore, contaminations also seem to induce a **decrease in lipid levels** which has been observed in a long term study on yellow eels from Belgium and the Netherlands (Belpaire et al., 2008). For a successful spawning migration and gonad development eels need to have sufficient fat reserves of at least 20% of their body weight (Svedäng & Wickström, 1997). Therefore, the low fat content in yellow eels is considered as an essential factor for the stock decline (Belpaire et al., 2008; ICES/EIFAC, 2008). Natural factors like **oceanic and climate changes** in the Sargasso Sea may also impair the reproduction and larval survival of European eels as well as American eels (Friedland et al., 2007; Bonhommeau et al., 2008). Friedland et al. (2007) detected a significantly negative correlation between the North Atlantic Oscillation (NAO) and long-term variations in glass eel catches of the European eel in the Netherlands (Den Oever recruitment index – DOI). They suggested that NAO forced changes in fronts and currents in the Sargasso Sea have an impact on the location of spawning areas and larval transport. Another aspect related to climate-driven processes, like global warming, is the decrease in global primary production of about 6% since the early 1980s (Bonhommeau et al., 2008). The food availability of leptocephali in the spawning areas and during oceanic migration, which is thought to be dissolved organic matter and particulate organic matter, seem to be dependent on marine primary production (Bonhommeau et al., 2008). It is further hypothesized that an increase in sea surface temperature, as a result of global warming, leads to a decrease in marine production and therefore affecting the food availability of leptocephali (Bonhommeau et al., 2008). These interdependencies were proofed by highly positive correlation between primary production and glass eel recruitment for European eel, American eel as well as Japanese eel (Bonhommeau et al., 2008). The aspect of oceanic and climate changes could give an explanation of the simultaneous decline in recruitment of the two Atlantic eel species as well as for the Japanese eel, which is affected by El Niño events (Friedland et al., 2007; Bonhommeau et al., 2008). However, until now the knowledge about the incidence of the marine phase of anguillid eels is very fragmentary and rather speculative in order to evaluate the importance of oceanic and climate changes (Friedland et al. 2007; ICES/EIFAC, 2008). **Predating birds** are also considered as a natural mortality factor for eels, especially the predation pressure of cormorants on eels inhabiting shallow fresh, brackish and marine waters (Brämick & Fladung, 2006; Carss, 2006). Until now only rough estimates exist on the dimension of eel mortality caused by cormorants. Cormorants are not evenly distributed throughout the aquatic habitats and their impact on eel stocks is mostly dependent on the size of breeding colonies (Brämick & Fladung, 2006). The estimated cormorant predation lies in the range of 15-42% of the commercial catches and should therefore be considered in investigations of eel population dynamics (Brämick & Fladung, 2006; Carss, 2006). European eels also suffer from various **parasitic and viral diseases** (see also sections eel parasitology and eel virology for detailed information). The most eminent eel parasite is the invasive swim bladder nematode ***Anguillicoloides crassus***. Heavy infections with *A. crassus* severely impair the functionality of the swim bladder as a hydrostatic organ and may therefore affect the spawning migration of eels (Kennedy, 2007). Infections with ***Herpesvirus anguillae*** (HVA)

and **Eel Virus European X** (EVEX) are considered to be the most significant viral threats for immunosuppressed European eel due to their high pathogenicity (van Ginneken et al., 2004, 2005). Stressful conditions like high fish density, high water temperatures, pollution, and the long-term spawning migration can be indicative for immunosuppression and virus reactivation leading to pathological alterations and even mortality (Haenen et al., 2009; Scheinert & Baath, 2004; van Ginneken et al., 2005).

Management considerations

In answer to the alarming stock situation the EU released in 2007 a regulation with the objective of protection and sustainable use of the European eel stock (Council Regulation EC, 2007). According to this regulation the anthropogenic mortalities should be reduced and all member states have to develop eel management plans for their river basin districts to achieve this objective (Council Regulation EC, 2007). For the regeneration of the European eel stock, an escapement to sea of at least 40% of the biomass of silver eel, defined as the best estimate of the theoretical escapement if the stock had been completely free of anthropogenic influences, shall be allowed. Furthermore, 35% of eel less than 12 cm in length caught in 2009 should be reserved for stocking to suitable habitats, rising to 60% by 2013 (Council Regulation EC, 2007). The potential benefits or risks of restocking for an enhanced silver eel production and stock regeneration are still in scientific debate, because of limited quantitative information on survival and mortality rates of stocked eels (ICES/EIFAC, 2008). The ICES Advice of 2008 (ICES, 2008) points out numerous risks arising with restocking which should be considered in the management plans and raise concerns over large scale stocking as a remedy for stock recovery. Stocking activities often involve translocation of eels and might lead to decreased genetic variability, biased sex-ratios, disruption of migration behaviour and spread of diseases and parasites (ICES, 2008). These risks may best be avoided by stocking with glass eels from a natural state and not with on-grown eels from aquaculture. Furthermore, the eel should be included in the European fish disease prevention policy in order to minimize the risks of transfer of diseases associated with stocking (ICES/EIFAC, 2008).

PARASITOLOGY

Parasitism is a highly successful life history strategy defined as a close relationship of two organisms, in which one - the parasite - lives on or in another - the host - deriving benefit from it (Rohde, 2005). Furthermore, parasitism is part of the natural selection process that shape the present form and biology of individuals and forces organisms to develop defence mechanisms (Littlewood, 2005). Hence, it appears as an important driver of biodiversity (Hudson et al., 2006). Parasites are an important, but often disregarded integral part of every ecosystem (Marcogliese, 1995) representing approximately 40% of known species on earth (Dobsen et al., 2008). In developing morphological and physiological characteristics, parasites are perfectly adapted to life on (ectoparasite) or in their host (endoparasite), performing either a direct (only one host) or an indirect (several hosts) life cycle (Dogiel, 1964). It can be distinguished between three types of hosts: (i) the definitive host harbouring the sexually mature parasite stage, (ii) the intermediate host harbouring the immature, developing parasite stages, and (iii) the paratenic host, harbouring the larval forms that do not develop within the host (Rohde, 2005).

Fish parasitology

Fish parasites play an important role in the aquatic biodiversity and estimates suggest up to 100000 species of marine fish parasites (Rohde, 2002). Differences in parasite diversity of specific regions or habitats are influenced and regulated by abiotic factors like temperature (Poulin & Rohde 1997; Rohde, 1993), salinity (Möller, 1978; Zander, 1998), depth of water (Palm, 1999) as well as by biotic factors like food (Klimpel et al., 2003a, b), availability of intermediate and definitive hosts (Lile, 1998) and host migration (Walter et al., 2002). Especially helminthic fish parasites (trematodes, cestodes, nematodes and acanthocephalans) with their complex indirect life cycles are susceptible for these factors. The knowledge of parasite life cycles can be a useful tool for ecological studies. Parasites can reflect their hosts feeding behaviour (Campbell et al., 1980, Williams et al., 1992, Palm, 1999) and are useful indicators for environmental stress like pollution and eutrophication (Palm & Dobberstein, 1999). In fishery biology they can be used for fish stock separation as well as indicators for migratory behaviour of fish (MacKenzie, 1983) and are indicative of changes in ecosystem structure and function (Marcogliese, 2004). However, parasites also have the potential to affect their hosts' behavior, growth, fecundity, and even lead to mortality (Marcogliese, 1995).

Eel parasitology

The overall scientific interest in eel and the search for potential causes of its decline also resulted in an increasing number of parasitological studies. Investigations from different sampling sites and habitat types including fresh-, brackish-, and marine water bodies were performed from all over Europe, like Poland (Orecka-Grabda & Wierzbicka, 1994; Seyda, 1973), Russia (Rodjuk & Shelenkova, 2006), Denmark (Køie, 1988a, b), the British Isles (Kennedy, 1993, 1997), Ireland (Conneely & McCarthy, 1986), Belgium (Schabuss *et al.*, 1997), Italy (Di Cave *et al.*, 2001; Kennedy *et al.*, 1997, 1998), Spain (Aguilar *et al.*, 2005; Outeiral *et al.*, 2001, 2002), Portugal (Saraiva *et al.*, 2005) and Germany (Reimer, 1987; Sures & Streit, 2001). All these studies provide evidence that

especially the helminth communities (**Figure 5**) in European eel are of high similarity in composition and structure, but show salinity-dependant specificities. To further investigate the changes in parasite species composition of eel in relation to salinity, a comparative examination on parasite communities of eels from fresh water, brackish water, and marine localities of northern Germany was performed in the present study (**Chapter I**). Of special interest is the distribution and impact of the invasive parasite species of the European eel. In most cases, invasive species are harmful for their new host due to the lack of protective immune defence in the latter (Taraschewski, 2006). The host-parasite relationship is usually a long term co-evolutionary adaptation process leading to low parasite abundances causing only low damage in the host (Taraschewski, 2006). But, this is not the case for invasive parasite species entering a new host. Especially the invasive and highly eel pathogenic swim

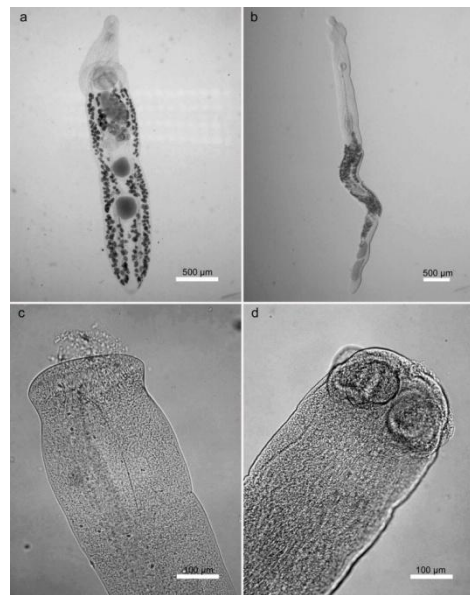


Figure 5 Typical parasites of the European eel. (a) *Podocotyle atomon*, (b) *Dero- pristin inflata*, (c) *Bothriocephalus clavi- cepts*, (d) *Proteocephalus macrocephalus*.

bladder nematode *Anguillicoloides crassus* has been identified as a possible threat to the European eel stock (Kennedy, 2007). This nematode was formerly referred to as *Anguillicola crassus*, until it was recently transferred to the genus *Anguillicoloides* (Moravec, 2006). *Anguillicoloides crassus* is originally endemic to East Asia in its native host *Anguilla japonica* (Japanese Eel), where it causes no damage (Nagasawa et al., 1994). This parasite was introduced in the early 1980s from south-eastern Asia into western European water bodies as a result of uncontrolled intercontinental transfer of live eels for human consumption (Køie, 1991). An updated overview of the distribution of *Anguillicoloides crassus* since the 1980s was part of a comprehensive review of literature about eel parasites within this thesis (**Chapter II**). The abundance of *Anguillicoloides crassus* is only limited by cold-water temperature ($\leq 4^{\circ}\text{C}$) (Knopf et al., 1998) and high salinity ($\geq 50\%$ of seawater) (Kirk et al., 2000). To evaluate the impact of salinity on prevalence and intensity of infection with *A. crassus* eels from water bodies with a different salinity regime were investigated (**Chapter I**). The life cycle of *A. crassus* in European eels involves a wide range of copepod and ostracods as intermediate hosts (Kirk, 2003; Moravec et al., 2005) as well as prey fishes, aquatic snails, insect larvae and amphibians as paratenic hosts (Moravec & Škorikova, 1998). Infection with *A. crassus* can cause numerous pathological and physiological alterations of the swim bladder due to the sanguivorous feeding habit of the parasite. Effects include thickening, inflammation and fibrosis of the swim bladder wall (Würtz & Taraschewski, 2000) as well as alterations of the gas secretion into the swim bladder (Würtz et al., 1996) and reduced swimming endurance (Palstra et al., 2007). In extreme cases, the lumen can be completely filled with nematodes (**Figure 6**). Thus, heavy infections with *A. crassus* reduce the functionality of the swim bladder as a hydrostatic organ and may severely impair the ability of eels to migrate to their spawning grounds in the Sargasso Sea (Kennedy, 2007).

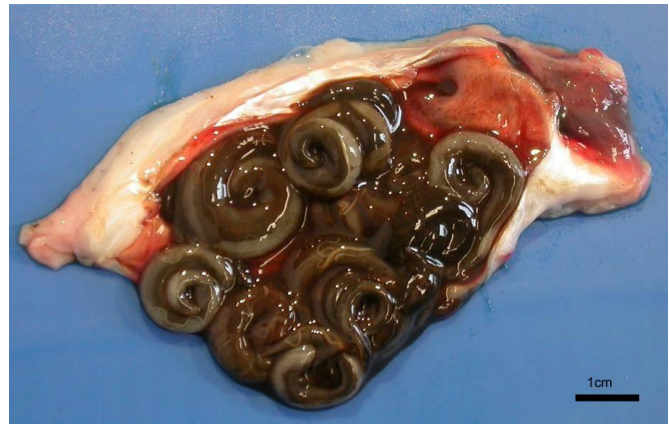


Figure 6 Heavily infected swim bladder with *A. crassus* of an eel caught in the Kiel Bight.



Figure 7 *Pseudodactylogyrus bini*.

The two monogenean species *Pseudodactylogyrus anguillae* and *P. bini*, (**Figure 7**) also originated from the Japanese eel, were introduced at the same time as *A. crassus* to central Europe via eel trade (Køie, 1991). Their distribution among wild eel stocks in Europe, as well as prevalence and intensity of infection in relation to salinity were analysed in this thesis (**Chapter I & II**). Both species co-occur in European eels even on the same individual host (Buchmann et al., 1987), are very similar in their morphology and difficult to distinguish from each other. They are oviparous and have a direct life cycle with an optimal temperature for reproduction around 25–30°C (Køie, 1991). *Pseudodactylogyrus anguillae* is tolerant to reproduce in salinities up to 20 [psu] and can be found in freshwater and brackish water localities, whereas *P. bini*

appears to be more restricted to freshwater (Køie, 1991). They both feed on mucus and epithelial cells on the eels' gill surface (Køie, 1991). The large hamuli of *P. anguillae* cause bleeding and damage to the gill tissue and the smaller hamuli of *P. bini* induce extensive tissue reactions (Buchmann et al., 1987). However, eel mortality caused by these parasites has not yet been reported in the wild (Kennedy, 2007), but have caused heavy losses in intensively cultured eel stocks (Buchmann et al., 1987), where the parasites find optimum conditions for reproduction (Køie, 1991).

VIROLOGY

A virus can be defined as an obligate intracellular parasite which totally depends on a host cell for replication (Carter & Saunders, 2007). A virion, the extracellular state of single virus particle, consists of a protective protein capsid which contains the viral genome either as RNA or DNA (Carter & Saunders, 2007). Viruses are an ubiquitous part of cellular organisms (Koonin et al., 2006), can infect all life forms, populate almost every ecosystem (Lawrence et al., 2009), are the most abundant type of biological entity (Edwards & Rohwer, 2005) and a reservoir of the greatest genetic diversity on Earth (Suttle, 2005). Viral infections are a major cause of diseases and mortality in a range of organisms, and thus an important evolutionary driver (Suttle, 2007).

Fish virology

Fish viruses are found to be the primary initiators of diseases (Möller & Anders, 1983). However, the pathogenic potential of a virus largely depends on the individual health status of the host and on environmental conditions (Möller & Anders, 1983). Virus-induced diseases and mortalities rarely occur in free-living fishes (Möller & Anders, 1983) but mainly when fish are under stressful conditions (van Ginneken et al., 2004), which is especially the case in intensive aquaculture (Haenen et al., 2009). In teleost fish, herpesviruses are the most commonly encountered DNA viruses (Hedrick et al., 1990), whereas only a small fraction causes severe infections (Wolf, 1988). However, some of the important fish viruses causing high mortalities and economic losses in fish farms belong to the family Herpesviridae like the Channel Catfish Virus (CCV), Koi Herpes Virus (KHV), three different types of salmonid herpesviruses as well as *Herpesvirus anguillae* (HVA) (Roberts, 2001). Herpesviruses are closely related and highly adapted to their host species, which is indicative for a long-term co-evolutionary process and success (Davison, 2002). They are characterized by a modest pathogenicity in their natural settings (Davison, 2002) and causing severe infections mainly in immunosuppressed individuals (Roberts, 2001). A peculiarity of herpesviruses is their ability to establish latent infections, a lifelong persistence in the host organism (Minarovits et al., 2006). The latency phase proceeds without any signs of clinical symptoms but viral replication can be reactivated in stressed immune suppressed hosts with the possibility of a recurring clinical disease (Roberts, 2001). In order to avoid viral disease outbreaks and high fish mortality in aquaculture, juvenile fish often get purposely infected with the respective virus. This kind of controlled infection by cohabitation, either with infected fish or virus contaminated water, autovaccinate the cultured fish species and seem to be a common practice in eel aquaculture (ICES/EIFAC, 2008) and was practiced in koi (*Cyprinus caprio*) aquaculture in Israel (Meyer, 2007). However, this practice produce latently infected carrier fishes, which makes virus detection difficult and the infection often remains unnoticed. These outwardly healthy fishes pose an epidemiological threat for

farmed as well as wild fish stocks (ICES/EIFAC, 2008), when they are transferred between aquaculture farms, or introduced into ponds or natural waters.

Eel virology

To date various viruses have been isolated from the European eel, including: (i) the rhabdoviruses EVA (Eel Virus America) and EVEX (Eel Virus European-X), (ii) the birnaviruses IPNV (Infectious Pancreatic Necrosis Virus) and EVE (Eel Virus European), and (iii) the herpesvirus HVA (*Herpesvirus anguillae*). Among these, EVEX and HVA gained most attention and are considered as contributing factors for the worldwide decline of eel populations (van Ginneken et al., 2005).

The rhabdovirus EVEX is a single stranded RNA virus, with a bullet-like form (Sano et al., 1977). It was first isolated in 1977 in a shipment of European eel from France to Tokyo and was named after its European origin (Sano et al., 1977). EVEX infections are manifested by haemorrhagic diathesis, skin lesions, anorexia and lethargy (Haenen et al., 2009). In a simulated spawning migration experiment, virus-positive eels died after a swimming distance of 1000-1500 km, whereas virus-negative eels swam 5500 km (van Ginneken et al., 2005). Therefore, van Ginneken et al. (2005) consider the long-term migration as a major stressful event for eels. EVEX was recently found in farmed and wild European eels from the Netherlands, Italy and Morocco, as well as from wild *Anguilla dieffenbachi* from New Zealand (van Ginneken et al., 2004). However, only the eels from Italy showed clinical signs of disease (van Ginneken et al., 2004). Studies on virus prevalence in populations of yellow- and silver eels in the German rivers Rhine and Mosel and in various Bavarian water bodies indicate a minor role of EVEX infections in these water bodies, but a major impact of HVA (Lehmann et al., 2005, Scheinert & Baath, 2004, 2006).

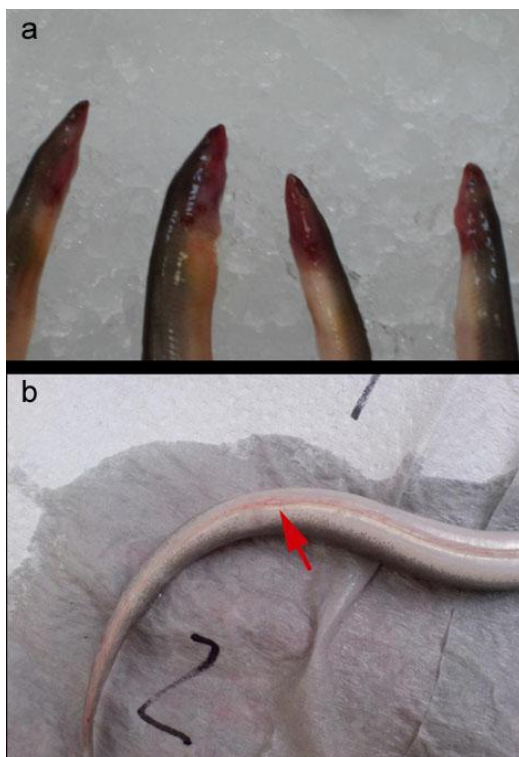


Figure 8 HVA infected eels. a „redhead disease“, b haemorrhagic fin lesions. Source: S. Bergmann (a), M. Fabian (b).

HVA is an enveloped double stranded DNA-virus with an icosahedric morphology (Davidse et al., 1999). HVA was first isolated in 1985 from Japanese and European eels from a Japanese eel farm (Sano et al., 1990). Eel suffer from HVA infection often show intensive haemorrhages all over the head and mouth, the so-called “redhead” disease (**Figure 8a**). Additional symptoms are haemorrhagic lesions of fins (**Figure 8b**), tissue, and abdominal skin, congestion and destruction of gill filaments as well as pathological alterations of spleen, liver, and kidney (Davidse et al., 1999; van Nieuwstadt et al., 2001).

As a herpesvirus, HVA has the ability to persist and establish a latent infection in eel (van Nieuwstadt et al., 2001). Indicators for virus reactivation are most likely a combination of multiple stress factors like high water temperatures, low oxygen concentrations, high fish density within a habitat or in culture, bad water quality, pollution, and lack of feeding (Scheinert & Baath, 2004; Haenen et al., 2009). During the latent phase the production of infectious virus particles is suppressed and

verification by serological methods or via cell culture is not possible (Cohrs & Gilden, 2001). For the detection of virus DNA even in eels with latent infections or asymptomatic carriers Rijsewijk et al. (2005) established a HVA PCR. Based on this PCR protocol a more reliable and sensitive nested-PCR was developed as part of this thesis (**Chapter IV**). *Herpesvirus anguillae* (HVA) is known to be present in cultured eels in several countries world-wide, like Japan (Sano et al., 1990), Taiwan (Ueno et al., 1992; Chang et al., 2002) and the Netherlands (Davidse et al., 1999; van Nieuwstadt et al., 2001; Haenen et al., 2002) where even elvers for restocking were found to be virus positive (van Ginneken et al., 2004). More recently, HVA was also detected in eels from natural freshwater habitats in the Netherlands (Haenen et al., 2002) and Germany (Lehmann et al., 2005; Scheinert & Baath, 2004, 2006). To evaluate the abundance of virus positive eels in natural waters of northern Germany, eels from different localities were investigated in this study (**Chapter III**). Outbreaks of HVA infections in wild eel were mainly observed during hot summer month, when water temperatures reaches 20°-30°C (Scheinert & Baath, 2004). This equates to the optimal temperature for virus replication of HVA, ranging between 20°- 26°C (Sano et al., 1990; Davidse et al., 1999). Some authors (Davidse et al., 1999; Lehmann et al., 2005) consider HVA as the most significant viral threat for the European eel due to its high pathogenicity in farmed as well as in wild eels (Scheinert & Baath, 2004, 2006). Especially restocking of latently infected eels can be considered as a large threat as they can introduce the virus into so far pristine habitats.

AIM AND OUTLINE OF THIS THESIS

The general focus of this thesis was to determine the health status of European eels from different habitats in northern Germany. Therefore, a comparative examination of the parasite and virus infections of eels sampled from rivers, lakes, the Baltic Sea and North Sea, was conducted to evaluate the influence of the respective locality on composition of parasite communities and the presence of virus diseases. Information derived from the collected data are valuable, to characterize the suitability of a habitat for restocking purposes.

This thesis is divided into the following chapters:

Chapter I

Salinity dependence of parasite infestations in the European eel, *Anguilla anguilla*, in northern Germany

In this study, a comparative examination was carried out for the first time on metazoan parasite communities of eels from fresh water, brackish water, and marine localities of northern Germany. Special focus was given on the swim bladder nematode *Anguillicoloides crassus* and the gill monogenean *Pseudodactylogyrus* spp. with the aim to provide basic information on the risks of restocking programmes solely focusing on fresh-water sites.

Chapter II

A checklist of the protozoan and metazoan parasites of European eel (*Anguilla anguilla*)

The aim of this literature review was to summarize all published data on the parasite fauna of the European eel to an updated and comprehensive checklist to set a baseline for future trend analyses and biodiversity considerations. Especially the distribution of the swim bladder nematode *Anguillicoloides crassus* was taken into account. A map and table of first reported records as well as a survey map indicating all published localities of *A. crassus* documented in the checklist are provided.

Chapter III

Monitoring of *Herpesvirus anguillae* (HVA) infections in European eel, *Anguilla anguilla* (L.), in northern Germany

In Chapter III the prevalence of HVA infections in European eels from natural habitats was analysed. For the first time eels from water bodies with a different salinity regime were collected to evaluate the spread of HVA infections in freshwater, brackish and marine habitats in northern Germany.

Chapter IV

Detection of *Herpesvirus anguillae* (HVA) in European eel by nested-PCR

The present study was undertaken to develop a more reliable and sensitive method for the detection of HVA with a high probability even in latently infected eels.

Therefore a nested-PCR was developed and verified with samples from feral European eels from two freshwater localities in northern Germany (River Elbe and Lake Pönitz).

CHAPTER I

Salinity dependence of parasite infestation in the European eel *Anguilla anguilla* in northern Germany

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Abstract

The aim of the study was to examine metazoan parasite communities of European eels (*Anguilla anguilla*) in fresh-water, brackish water and marine localities in northern Germany. In all, 29 parasite species/taxa were found in 170 eels: eight digeneans, one monogenean, five cestodes, ten nematodes, two acanthocephalans, and three crustaceans. Measures of diversity characteristics of the helminth communities included species richness, Shannon's diversity index and its evenness, and the Berger–Parker dominance index. The highest species diversity and lowest dominance values were calculated for the helminth communities of eels from the two Baltic Sea localities. Parasite communities of European eels clearly exhibit the habitat preferences of their hosts, salinity-dependent specificities, and a clustering into fresh-water, brackish, and marine groups. The highly pathogenic parasite species *Anguillicoloides crassus* and *Pseudodactylogyrus* spp. were found at all sampling sites in fresh water and brackish water, with high prevalence. Basic information is provided on the risks of restocking programmes solely focusing on fresh-water sites.

Introduction

After some three decades of decreasing catches and a dramatically reduced recruitment of glass eels to the European coast, the European Commission released a regulation (Council Regulation EC, 2007) with the objective of protection and sustainable use of the stock of European eels (*Anguilla anguilla*). All member states are obliged to develop eel management plans for their river basin districts, designed to reduce anthropogenic mortalities. One of the measures proposed to implement such a management plan successfully is restocking of juvenile eels to suitable habitats. However, the suitability of waterbodies for the production of healthy spawners is not only influenced by fishing pressure and connectivity to the open ocean, but also by the occurrence of diseases and parasites. Most studies on the parasite fauna of the European eel have been carried out in fresh-water environments (e.g. Conneely & McCarthy, 1986; Kjøie, 1988a; Kennedy, 1993, 1997; Schabuss et al., 1997; Kennedy et al., 1998; Sures et al., 1999; Di Cave et al., 2001; Aguilar et al., 2005; Kristmundsson & Helgason, 2007). Investigations on the parasite fauna of European eels in marine habitats (Outeiral et al., 2001, 2002; Kristmundsson & Helgason, 2007) are scarce. Only a few comparable studies

actually focused on changes in the parasite composition of eels in relation to salinity (Seyda, 1973; Kjøie, 1988b; Orecka-Grabda & Wierzbicka, 1994). The most detailed and quantitative analyses, including diversity indices, were carried out by Kennedy et al. (1997) on eels from four lagoons along the Tyrrhenian coast near Rome, and by Di Cave et al. (2001) on eels from Italian Adriatic coastal lagoons. Those studies showed that the helminth communities of Mediterranean eels are similar in composition and community structure to fresh-water habitats, although they differ in their generally reduced species diversity and the dominance of single parasite taxa. Therefore, those authors hypothesized a general trend of declining species richness and diversity with increasing salinity for European eels (Kennedy et al., 1997). Comparable data for the closely related American eel (*Anguilla rostrata*) are largely missing, because the few similar investigations dealt more with the effects of geographic distance (Barker et al., 1996) on parasite species richness and diversity, irrespective of the influence of salinity. Here, we carried out a comparative examination for the first time on metazoan parasite communities of eels from fresh-water, brackish water, and marine localities of northern Germany, focusing on the swimbladder nematode *Anguillicoloides crassus* and the gill monogenean *Pseudodactylogyrus* spp. These eel parasites were introduced into western European water bodies as a result of uncontrolled intercontinental transfer of live eels for consumption (Kjøie, 1991), and they are considered serious pathogens (Kennedy, 2007). Infection with *A. crassus* reduces the functionality of the swimbladder as a hydrostatic organ and is feared to influence the ability of eels to migrate to their spawning grounds in the Sargasso Sea (Kennedy, 2007). *Pseudodactylogyrus* spp. appear to cause less pronounced effects in wild eels, but they can cause economically important losses in eel farms (Kennedy, 2007). After an investigation of the Sr/Ca ratio in the otoliths of eels from fresh water and the sea, Tsukamoto et al. (1998) concluded that eels should be regarded as facultatively catadromous, with ocean residents considered to be a distinct ecophenotype. Those authors further hypothesized that only eels that grow in the sea contribute to eel recruitment, because none of the 19 maturing silver eels caught in the ocean in their investigation were derived from fresh-water migrants. By investigating the salinity dependence of parasite infestation in the European eel, we aimed to test the ecophenotype hypothesis of Tsukamoto et al. (1998) and to provide basic information on the risks of restocking programmes solely focusing on fresh-water sites.

Material and methods

Sample collection and measurements

In all, 170 eels from six different sample sites in northern Germany (Figure I-1) were taken from commercial fishers' fykenets between April and October 2006, including two fresh-water localities (Lake Plön and River Eider), three brackish localities of the western Baltic Sea (near Maasholm, the Kiel Bay near Friedrichsort, and the Fehmarn Belt), and one marine locality (the Helgoland coast). The salinity of the brackish water localities ranged between 15 and 26, and of the marine locality between 32 and 35. Eels were transported on ice to the laboratory and kept frozen at -40°C until examination. For each eel, body mass (M), total length (L_T), pectoral fin length (L_{PF}), and vertical and horizontal diameters of both eyes were measured, and the mean eye diameter (E_D) was calculated (Table I-1). Eels were dissected and gonad mass (M_G), liver mass (M_L), and gut mass empty weight (M_{GU}) were determined (Table I-1). The gonadosomatic index ($I_G = 100 M_G M^{-1}$), hepatosomatic index ($I_L = 100 M_L M^{-1}$), gut index ($I_{GU} = 100 M_{GU} M^{-1}$), and Fulton's condition factor ($K = 10^5 M L_T^{-3}$) were calculated

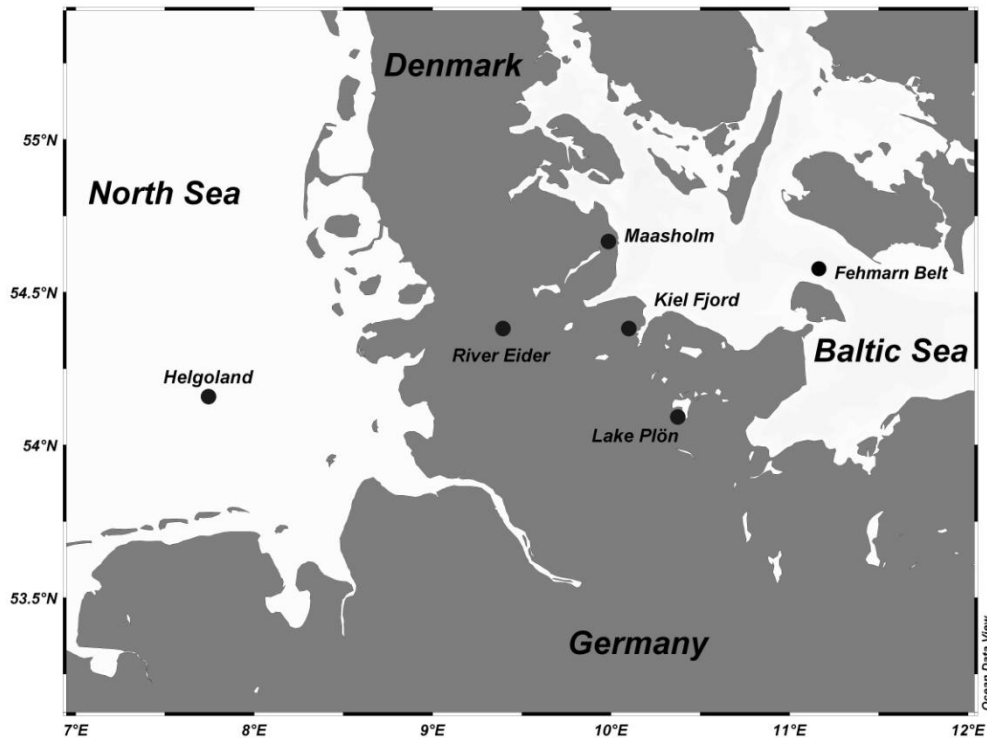


Figure I-1 Sampling sites for eels in northern Germany from the fresh-water Lake Plön and River Eider, the brackish Friedrichsort (Kiel Fjord), Maasholm, and Fehmarn Belt, and the marine locality Helgoland. Map source: Ocean Data View; Schlitzer, 2007.

(Table I-1). A “silver index” (Durif and Elie, in press), based on the external body measurements L_T , M , L_{PF} , and E_D , was applied to classify eels into six groups of maturation. These groups represented growth phases of undifferentiated stage I and female stage II (FII) eels, a pre-migrant stage (FIII), and migrant stages (FIV, FV, MII) for male (M) and female (F) eels. Parasitological examination Eyes, skin, fins, gills, nostrils, and the mouth cavity of each eel were examined for ectoparasites. Eyes and gills were removed and placed in separate Petri dishes with physiological saline, then examined under a stereomicroscope. To study the internal organs for endoparasites, each eel was dissected and its body cavity and mesenteries examined for encysted or encapsulated parasites. All internal organs were placed in separate Petri dishes in physiological saline, then examined. The swimbladder was examined macroscopically for the presence of pre-adult and adult *A. crassus* in the lumen, and for pathological alterations of the tissue. Larvae were counted by pressing the swimbladder between the lid and the base of a Petri dish under the stereomicroscope. Heart, liver, and spleen were examined by pressing the tissue between the lid and the base of a Petri dish under the stereomicroscope. Stomach and intestinal contents were mixed with saline and examined separately under a stereomicroscope. All isolated parasites were fixed and preserved in 70% ethanol. Acanthocephala were transferred to distilled water to induce an eversion of the proboscis before fixation. For identification, Digenea, Nematoda, and Acanthocephala were transferred into 100% glycerine (Riemann, 1988). Cestoda were stained in acetic carmine, dehydrated in a graduated ethanol series, cleared with methyl-salicylate, and mounted in Canada balsam. The parasitological terminology used follows Bush et al. (1997): prevalence (P) is the number of hosts infected with one or more individuals of a particular parasite species divided by the number of hosts examined (expressed as a percentage); intensity (of infection, I) is the number of individuals of a

particular parasite species in a single infected host (expressed as a numerical range), and mean intensity (m_i) is the mean number of individuals of a particular parasite species per infected host in the sample. Analyses of parasite community structure were carried out at a component level (Holmes and Price, 1986). Measures used to describe component community structure of the helminth parasites (including Monogenea) were species richness (s), Shannon's diversity index (H') and evenness (E), and the Berger–Parker dominance index (d). Formulae for each of these variables were (Magurran, 1988):

$$H' = -\sum p_i \ln p_i ,$$

where p_i is the proportion of individuals of each species in the sample to the total number of individuals in the sample (n_i/N);

$$E = \frac{H'}{H_{\max}} ,$$

where $H_{\max} = \ln s$, s being the total number of species in the sample (the species richness);

$$d = \frac{N_{\max}}{N} ,$$

where N_{\max} is the number of individuals of the most abundant species, and N the total number of individuals at each site.

Table I-1 Mean values (\pm s.d.) of total length (L_T), body mass (M), pectoral fin length (L_{PF}), mean eye diameter (E_D), Fulton's condition factor (K), gonadosomatic index (I_G), gut index (I_{GU}), and hepatosomatic index (I_L) for eels from two fresh-water (F), three brackish (B), and one marine (M) locality.

Parameter	Lake Plön (F)	River Eider (F)	Friedrichsort (B)	Maasholm (B)	Fehmarn Belt (B)	Helgoland (M)
L_T (cm)	91.7 \pm 6.7	49.7 \pm 11.9	63.9 \pm 9.6	71.5 \pm 7.4	84.6 \pm 5.0	59.4 \pm 8.5
M (g)	1 641.4 \pm 357.9	301.2 \pm 297.9	486.2 \pm 357.9	748.2 \pm 174.1	1 327.4 \pm 221.7	356 \pm 174.1
E_D	10.24 \pm 1.01	5.43 \pm 1.37	6.28 \pm 1.03	6.52 \pm 0.55	9.03 \pm 0.63	5.97 \pm 0.96
L_{PF}	42.86 \pm 3.67	20.23 \pm 6.56	24.53 \pm 3.95	28.24 \pm 3.73	37.11 \pm 3.47	22.19 \pm 3.57
K	0.21 \pm 0.03	0.2 \pm 0.03	0.17 \pm 0.02	0.19 \pm 0.03	0.22 \pm 0.02	0.16 \pm 0.02
I_G	1.27 \pm 0.24	0.18 \pm 0.24	0.68 \pm 0.47	0.73 \pm 0.28	1.38 \pm 0.22	0.57 \pm 0.27
I_{GU}	1.26 \pm 0.27	3.34 \pm 0.43	1.92 \pm 0.49	1.97 \pm 0.68	0.82 \pm 0.31	2.46 \pm 0.51
I_L	1.29 \pm 0.15	1.69 \pm 0.39	1.23 \pm 0.33	1.35 \pm 0.35	1.10 \pm 0.16	1.22 \pm 0.26

Statistics

A median test (Kruskal–Wallis ANOVA) was used to compare the values of median intensity of infection with *A. crassus* and *Pseudodactylogyrus* spp. of eels among the different localities. To test the effect of *A. crassus* and *Pseudodactylogyrus* spp. infection on the condition indices I_G , I_L , I_{GU} , and K of the eels, a correlation analysis was performed. In all tests, we defined statistical significance as being at the 5% level. Statistics were performed using STATISTICA Version 6. To visualize similarities in parasite communities of eels at the various localities, a hierarchical cluster analysis (complete linkage) was performed using Primer Version 6.1.6. The data for this analysis used arcsine-transformed prevalence of infection values.

Results

Parasite community composition and structure

In all, 29 metazoan parasite species/taxa (eight digeneans, one monogenean, five cestodes, ten nematodes, two acanthocephalans, three crustaceans) were observed in 170 eels from the six northern German habitats investigated (Table I-2). The most prevalent parasite taxa in fresh water were cestodes and nematodes, but in the sea, eels were infested mainly with digeneans. Parasite species richness (s), including Crustacea, was highest in eels caught from the Fehmarn Belt (brackish) and from Lake Plön (fresh water), with 16 and 13 species/taxa, respectively (Table I-2). Eels from the River Eider and from the brackish waters near Maasholm harboured 11 species/taxa each, followed by Kiel Bay near Friedrichsort (brackish) with 9 species/taxa, and the marine site near Helgoland with 7 species/taxa (Table I-2). The diversity characteristics of the helminth component community structure revealed high parasite species diversity and low dominance values in eels from the three brackish localities (Table I-3). The most diverse community was detected in the eels from Maasholm ($H' = 1.83$), with highest evenness ($E = 0.76$) and lowest dominance ($d = 0.27$) values. The diversity indices of the helminth parasite community of Helgoland ($H' = 0.56$) and River Eider eels ($H' = 0.55$) were the lowest, whereas their dominance values were highest. Both communities were dominated by a single parasite species: Helgoland eels by the digenean *Lecithochirium rufoviride*, and River Eider eels by the monogenean *Pseudodactylogyryus* spp., verified by high Berger–Parker dominance values of 0.80 and 0.88, respectively. Only two localities, the fresh-water site at the River Eider and the brackish site near Friedrichsort, were dominated by the monogenean genus *Pseudodactylogyryus*, and the other localities by digeneans (Table I-3). Cluster analysis of parasite prevalence data reveals a clear habitat specific composition and a clustering into fresh-water (Lake Plön and River Eider), brackish (Friedrichsort, Maasholm, and Fehmarn Belt), and marine (Helgoland) groups (Figure I-2).

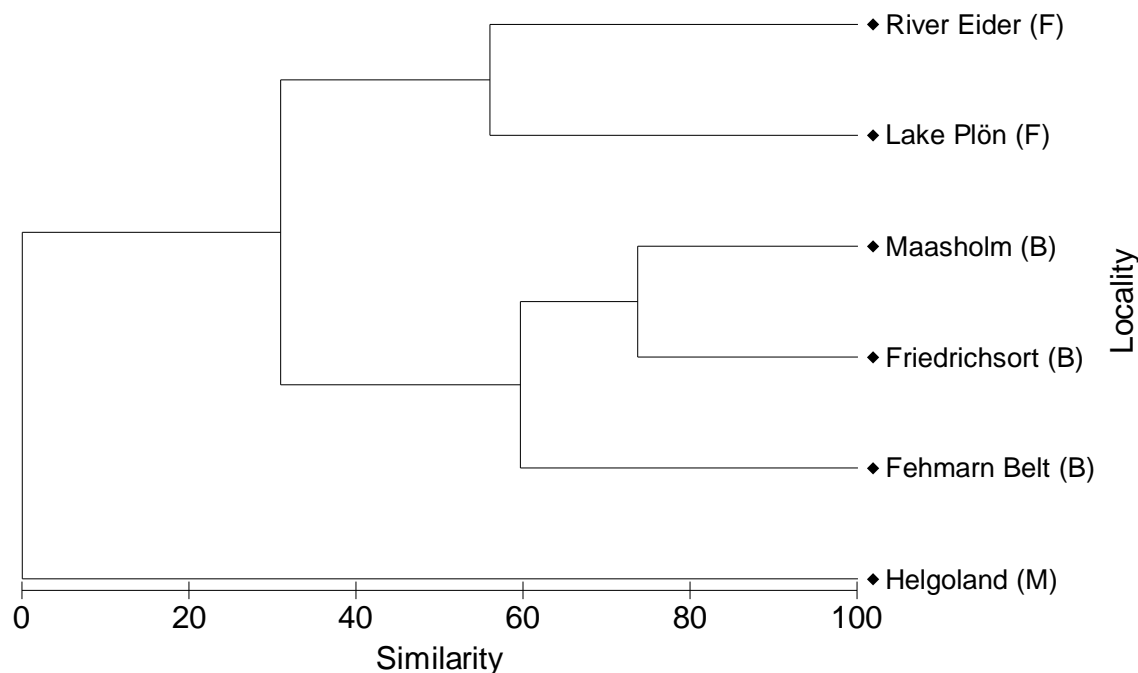


Figure I-2 Hierarchical cluster analysis of similarity between all studied localities based on their parasite communities. B, brackish; F, fresh water; M, marine.

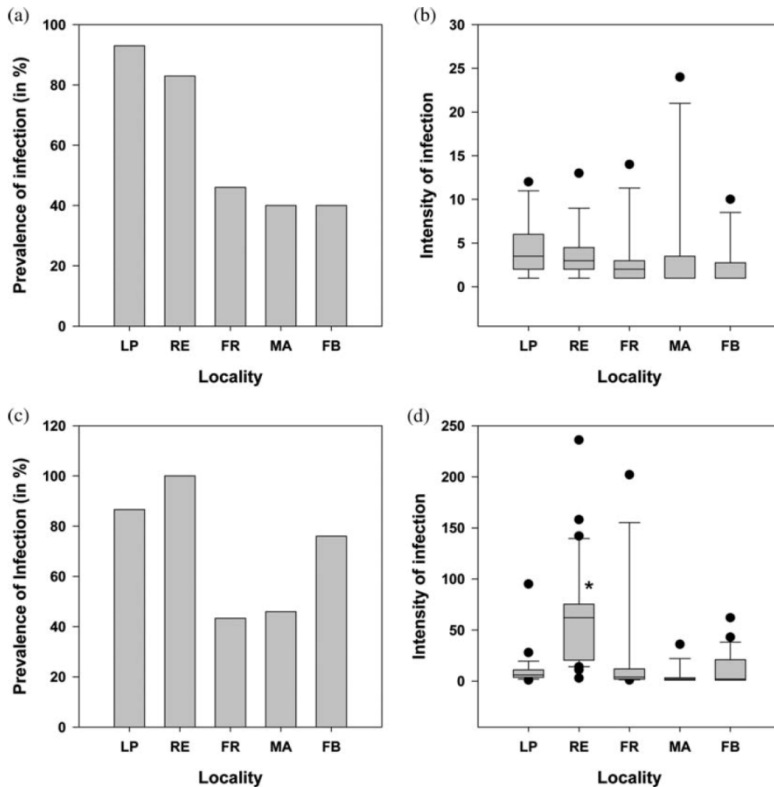


Figure I-3 Prevalence and intensity of infection for (a and b) *Anguillicoloides crassus*, and (c and d) *Pseudodactylogyrus* spp. for the fresh water Lake Plön (LP) and River Eider (RE), and the brackish Friedrichsort (FR), Maasholm (MA), and Fehmarn Belt (FB). Box plots show the median values for intensity of infection (line within the box), the boundaries of the boxes indicate the 25th and 75th percentiles, the whiskers above and below the box the 90th and 10th percentiles, and the filled circles the outlying points. The asterisk indicates a significant difference in intensity of infection ($p > 0.05$, median test).

from the River Eider ($d = 0.88$) and Friedrichsort ($d = 0.59$; Table I-3). A correlation analysis of infection with *A. crassus* as well as with *Pseudodactylogyrus* spp. related to I_G , I_L , I_{GU} , and K revealed no relationship ($p < 0.05$).

Eel maturation stage

Maturation stage determination revealed 15 undifferentiated stage I eels, 65 female stage II eels (growth phase), 29 pre-migrating female stage III eels (pre-silver stage), 60 migrating female stage IV eels, 1 migrating female stage V eel, but no male eels. The distributions of the maturation stages at each locality differ (Table I-4). Eels from Lake Plön and Fehmarn Belt were the most developed, with mean LT values of 91.7 and 84.6 cm, respectively (Table I-4). The samples consisted of ~90% female stage IV eels. The River Eider eels were the most undifferentiated and the smallest, with 40% stage I and a mean LT of 49.7 cm (Table I-4).

Anguillicoloides crassus and *Pseudodactylogyrus* spp. *Anguillicoloides crassus* was more prevalent in fresh water ($P = 83.3\text{--}93.3\%$) than in brackish ($P = 40\text{--}46\%$) or marine ($P = 0\%$) water (Figure I-3a). There was no significant difference in the mean intensity of infection with *A. crassus* ($p = 0.06$) between eels caught at the different localities (Figure I-3b). *Pseudodactylogyrus* spp. showed the same trend and was isolated with high prevalence in fresh water ($P = 86.6\text{--}100\%$), moderate to high in brackish water ($P = 43.3\text{--}76\%$), and was not detected in the sea (Figure I-3c). A significantly higher intensity of infection with *Pseudodactylogyrus* spp. was detected for the River Eider eels ($p < 0.05$; Figure I-3d). The Berger–Parker dominance index revealed *Pseudodactylogyrus* spp. as the dominant species in eels

Table 1-2 Composition of parasite communities with information on prevalence (P, percentage of eels infected), mean intensity (mI, mean number of parasite individuals per infected host), and intensity (I, number of parasite per infected host) of infection in eels from the fresh-water (F) localities Lake Plön and River Eider, the brackish (B) localities Friedrichsort, Maasholm, and Fehmarn Belt, and the marine (M) locality Helgoland.

Locality	Lake Plön (F)			River Eider (F)			Friedrichsort (B)			Maasholm (B)			Fehmarn Belt (B)			Helgoland (M)		
	Length range (in cm)	Sample size	No. of parasite species, s	81-106	37-82	45-81	58-96	73-95	40-73	30	11	9	30	16	7	20	7	
	Stage	S/G	mI	I	P %	mI	I	P %	mI	I	P %	mI	I	P %	mI	I	P %	
Digenea																		
<i>Diplostomum spathaceum</i>	L	G	5.2	1-15	10	1.3	1-2	-	-	-	3.3	4	4	2.0	3.5	1-8	-	
<i>Lecithochirium rufoviride</i>	A	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	90	
<i>Helicometra fasciata</i>	A	G	-	-	-	-	-	-	-	-	-	-	-	-	-	-	80	
<i>Podocoryle atomum</i>	A	G	-	-	-	-	-	33.3	4.3	1-11	43	10.84	1-56	2.0	4.3	2-8	5	
<i>Deropristis inflata</i>	A	S	-	-	-	-	-	40	10.8	1-64	46	9.74	1-56	36.6	34.6	1-180	20	
<i>Brachyphallus crenatus</i>	A	G	-	-	-	-	-	-	-	-	-	-	-	6.66	12.5	11-14	-	
<i>Plagioporus</i> sp.	A	-	63.3	109.7	1-1630	-	-	-	-	-	-	-	-	-	-	-	-	
Digenea indet.	A	-	-	-	-	-	-	-	-	-	3.3	1	1	-	-	-	5	
Monogenea																		
<i>Pseudodactylogyx</i> spp.	A	S	86.6	11	1-95	100	64.3	3-236	43.3	26.2	1-202	46	4.78	1-36	7.6	11.26	1-62	
Cestoda																		
<i>Proteocephalus macrocephalus</i>	A	S	86.6	5.7	1-19	50	3.1	1-8	16.6	5.2	1-18	13.3	2.75	1-5	3.3	5.8	1-12	
<i>Bathrioccephalus claviceps</i>	A	S	60	2.3	1-5	46	3	1-9	-	-	-	-	-	-	1.3	1	1	
<i>Tetraphyllidea</i> indet. (<i>Scolex pleuronectis</i>)	L	G	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	
<i>Proteocephalus</i> sp.	A	-	43.3	6.6	1-19	-	-	-	-	-	-	-	-	-	-	-	-	
Cestoda indet.	A	-	13.3	1.3	1-2	3.3	1	1	3.3	1	1	-	-	-	3.3	1	1	
Nematoda																		
<i>Eustrongylides mergorum</i>	L	G	53.3	2.1	1-4	-	-	-	-	-	-	-	-	-	10	4.3	1-8	
<i>Contracaecum</i> sp.	L	-	20	2.2	1-4	-	-	-	13.3	1	1	23	6.14	1-26	33.3	5.4	1-2	
<i>Hysterothylacium aduncum</i>	A	G	-	-	-	-	-	-	-	-	-	-	-	-	3.3	4	10	
<i>Camallanus lacustris</i>	A	G	83.3	22.2	1-79	13.3	7.5	1-21	3.3	1	1	-	-	-	10	1.3	1-2	
<i>Anguillicola crassus</i>	A	S	93.3	4.7	1-12	83.3	3.76	1-13	40	3	1-14	46	4.5	1-24	40	2.4	1-10	
<i>Pseudocapillaria tomentosa</i>	A	G	10	1.3	1-2	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Anisakis simplex</i>	L	G	-	-	-	-	-	-	-	-	-	3.3	3	3	-	-	-	
<i>Raphidascaris</i> cf. <i>acus</i>	PA	G	-	-	-	3.3	2	2	-	-	-	-	-	-	-	-	-	
<i>Paraquimperia tenerrima</i>	A	S	-	-	-	-	-	-	-	-	-	23	6	1-22	-	-	-	
<i>Paraquarria adunca</i>	L	G	-	-	-	-	-	-	-	-	-	-	-	-	3.3	9	9	
Acanthocephala																		
<i>Paratenuisentis ambigua</i>	A	-	-	-	-	20	5.3	1-26	-	-	-	-	-	-	-	-	-	
<i>Paratenuisentis</i> cf. <i>ambigua</i>	A	-	-	-	-	-	-	-	-	-	6.6	1	1	-	-	-	-	
<i>Acanthocephala</i> indet.	A	-	-	-	-	-	-	-	-	-	-	-	-	-	3.3	1	1	
Crustacea																		
<i>Ergasilus gibbus</i>	A	S	3.3	1	1	30	2.3	1-5	-	-	-	-	-	-	3.3	1	1	
<i>Lernaeocera branchialis</i>	A	G	-	-	-	-	-	-	13.3	1.8	1-3	-	-	-	-	-	-	
<i>Argulus foliaceus</i>	A	G	-	-	-	3.3	1	1	-	-	-	-	-	-	-	-	-	

Table I-3 Component community structure of helminth parasites and their diversity characteristics in eels from the fresh-water (F) Lake Plön and River Eider, the brackish (B) water Friedrichsort, Maasholm, and Fehmarn Belt, and the marine (M) locality Helgoland.

Locality	Lake Plön (F)	River Eider (F)	Friedrichsort (B)	Maasholm (B)	Fehmarn Belt (B)	Helgoland (M)
Number of eels examined	30	30	30	30	30	20
Number of helminth species, <i>s</i>	12	9	8	11	15	7
Shannon's diversity index, <i>H'</i>	1.42	0.55	1.21	1.83	1.67	0.56
Shannon's evenness, <i>E</i>	0.57	0.25	0.58	0.76	0.62	0.29
Berger–Parker dominance index, <i>d</i>	0.59	0.88	0.59	0.27	0.47	0.80
Dominant species	P.sp.	P.spp.	P.spp.	P.a.	D.i.	L.r.

P.sp., *Plagioporus* sp.; P.spp., *Pseudodactylogyrus* spp.; P.a., *Podocotyle atomon*; D.i., *Deropristis inflata*; L.r., *Lecithochirium rufoviride*.

Table I-4 Mean total length ($L_T \pm$ s.d.) and percentage of eels in each of five stages of maturation for eels collected from two freshwater (F), three brackish (B), and one marine (M) locality. Undifferentiated stage Mean total length (\pm S.D.) and percentage of eels in each of five stages of maturation for eels collected from two freshwater (F), three brackish (B), and one marine (M) locality. Undifferentiated stage I and female stage II (FII), growth phase; female stage III (FIII), pre-migrant stage; female stages IV and V (FIV, FV), migrant stages.

Locality	<i>n</i>	Mean L_T (cm) \pm s.d.	Maturation stage (%)				
			Growth phase		Pre-migrant	Migrant	
			I	FII	FIII	FIV	FV
Lake Plön (F)	30	91.7 \pm 6.7	0	0	6.6	93.3	0
River Eider (F)	30	49.7 \pm 11.9	40	46.6	6.6	6.6	0
Friedrichsort (B)	30	63.9 \pm 9.6	3.3	73	20	0	3.3
Maasholm (B)	30	71.5 \pm 7.4	0	50	40	10	0
Fehmarn Belt (B)	30	84.6 \pm 5.0	0	0	10	90	0
Helgoland (M)	20	59.4 \pm 8.5	10	70	20	0	0

Undifferentiated stage I and female stage II (FII), growth phase; female stage III (FIII), pre-migrant stage; female stages IV and V (FIV and FV), migrant stages.

Discussion

Size- and age-dependence of parasite infestation

The intensity of infection of metazoan parasites in fish populations increases with age or size of the host, because parasite accumulation is a time-driven process (Dogiel et al., 1958). The high species richness and diversity of the Fehmarn Belt eels ($s = 15$, $H' = 1.67$) can therefore be explained largely by their considerably larger size (mean $L_T = 84.6$ cm) and later developmental stage (90% stage IV). These migrating silver eels were most probably an assemblage of eels of different origin, because the Fehmarn Belt forms a bottleneck for eels migrating from east of Fehmarn to the North Sea and on to the Sargasso Sea. Possible origins east of Fehmarn include the Baltic Sea proper and the adjacent river systems. Different migration paths are also supported by the high species richness and component community structure. Low species richness and diversity of the parasite fauna of the River Eider ($s = 9$, $H' = 0.55$) most likely reflect the overall smaller body length (mean $L_T = 49.7$ cm) and therefore earlier maturation stages (40% stage I, 46.6% stage II) of their hosts.

Dominance

Direct competition of parasites within a host can result in strong dominance (Poulin, 1999), reflected by low Shannon's diversity and higher Berger–Parker dominance indices. Values for the Berger–Parker dominance index were relatively high for all localities except for the western Baltic Sea site near Maasholm. The highest values were calculated for Helgoland and the River Eider. These results support the hypothesis of Kennedy et al. (1997) that

parasite communities of the European eel are characterized by low species diversity and high dominance of a single parasite species, although the dominant species can vary. From our study, though, we did not confirm the general dominance of acanthocephalans as eel parasite communities in fresh water, suggested by Kennedy et al. (1998). The greatest prevalence (20%) of an acanthocephalan, *Paratenuisentis ambiguus*, was detected in eels from the River Eider, whereas the prevalence of infection of the Maasholm (6.6%; *Paratenuisentis* cf. *ambiguus*) and Fehmarn Belt samples (3.3%; *Acanthocephala* indet.) was rather low.

Salinity-dependence of parasite community structure

Parasite communities of the European eel clearly reflect the habitat preferences of their hosts. Despite overall similarities in parasite species composition, salinity-dependent specificities are well supported and reflect the life history of individual eels. The strictly host-specific, introduced parasites *A. crassus* and *Pseudodactylogyrus* spp. could not be found in the marine environment of the North Sea. Their restriction to fresh and brackish waters, where they occur with high prevalence, might affect the locality-specific survival of eels, and therefore contribute to recruitment success. However, salinity-dependence is also evident for autochthonous parasite species such as the cestode *Proteocephalus macrocephalus* and the digeneans *Podocotyle atomon* and *Deropristis infalta*, which can be regarded as purely fresh-water- and seawater-specific, respectively. Although parasite species richness and diversity are considerably reduced in the marine environment of the North Sea around Helgoland, we cannot confirm the hypothesis of Kennedy et al. (1997) that these declines follow a clear salinity gradient. On the contrary, the intermediate salinity conditions of the brackish Baltic Sea seem to favour parasites in eels by integrating both marine and fresh-water species.

Implications for the management of eels

Owing to the relatively low intensities of infestation with autochthonous parasites, a negative effect on the health of their eel hosts that would impair their reproductive success can be excluded. Nonetheless, the recently introduced and highly pathogenic parasites *A. crassus* and *Pseudodactylogyrus* spp. were found at all investigated fresh- and brackish water sampling sites at high prevalence. Although infestation intensities and observed pathological alterations of the swimbladders of eels infected with *A. crassus* were mostly moderate to low, a negative effect on the fitness of eels cannot be excluded. The unique spawning migration, a distance of almost 5000 km to the Sargasso Sea, requires maximum fitness and health. *Anguillicoloides crassus* was equally regarded as a serious threat in *A. rostrata* following its first occurrence (Fries et al., 1996) in American brackish and fresh-water habitats, where infestation rates can now be up to 90% (COSEWIC, 2006). Eels that stay in a purely marine environment are obviously not at risk of infection by these neozoans and may therefore be favoured to reach their spawning grounds in good condition. The common practice of catching glass eels in river estuaries for unselective restocking of fresh-water systems all over Europe might therefore worsen the problem of declining eel stocks by further diluting the number of eels that would stay in marine coastal habitats. Moreover, uncontrolled restocking further intensifies the risk of transferring diseases and parasites to pristine areas. This outcome has been demonstrated in a longterm study of eels in Swedish lakes and brackish waters in the spread of *A. crassus*; it was already well established in all localities investigated just 9 years after its first record in 1987 (Wickström et al., 1998). For

A. rostrata in Canadian waters, where *A. crassus* has not yet been detected, its arrival is seen as just a matter of time (COSEWIC, 2006).

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CHAPTER II

A checklist of the protozoan and metazoan parasites of European eel (*Anguilla anguilla*)

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Summary

A comprehensive literature review on prevalence and distribution of parasites of the European eel (*Anguilla anguilla*) in European waters was conducted to set a baseline for future trend analyses and biodiversity considerations. The resulting checklist, compiled from peer reviewed journals as well as grey literature including scientific reports, conference contributions, PhD theses and own survey data includes all protozoan and metazoan parasites of the European eel from freshwater, brackish and marine habitats. Parasites are arranged according to phylum and family. Species within families are listed alphabetically. Infected host organs, recorded habitats, localities, countries and literature citations are provided for each species. A total of 161 parasite species/taxa are listed from 30 countries. With the trypanorhynch cestode *Tentacularia coryphaenae* a new host record could be documented. Furthermore, three new locality records of parasitic nematodes could be added based on own survey data: *Anisakis simplex* from an eel caught in the Baltic Sea, *Eustrongylides mergorum* for German freshwaters and *Goezia anguillae* from the Tagus estuary in Portugal. Special consideration was given to the distribution of the swimbladder nematode *Anguillicoloides (Anguillicola) crassus*. We provide a map and table of first reported records of this neozoan parasite species for 25 countries as well as a survey map indicating all published localities documented in the checklist.

Introduction

To date, a comprehensive checklist of the protozoan and metazoan parasites of the European eel hasn't been published yet. The latest but incomplete list of parasite species recorded for the genus *Anguilla* was composed by Reimer (1999) with a total of 78 records for *Anguilla anguilla*. Published synopses on eel parasites are mostly geographically confined to countries or regions (e.g. Bykhovskaya-Pavlovskaya et al., 1964; Holland and Kennedy, 1997; Kennedy, 1974). The aim of the present literature review was to summarize all published data on the parasite fauna of the European eel to an updated and comprehensive checklist. In the light of rising interest in the European eel and the causes of its decline, this checklist was compiled to provide a detailed overview about the recorded parasite fauna

known to date, the reported localities and if available about prevalences, intensities and abundances of parasite specific infections. Therefore, this review should serve as a baseline for future trend analyses and biodiversity considerations.

Methods

The checklist (Table II-1) was compiled from peer reviewed journals as well as grey literature including scientific reports, conference contributions and PhD theses. In addition, parasite data from own surveys comprising 150 eels from 5 different sampling sites collected in 2006 and 2007 were included (Table II-2).

The parasites are arranged by phylum and if appropriate class and family. Species within families are listed in alphabetical order. Each species is listed together with infected host organ(s), recorded habitats (if available including salinity values), localities, countries and according literature citations. The recorded countries are listed alphabetically. If available the number of examined eels, prevalences (P in %), mean intensities (mI), intensities (I) and mean abundances (mA) of infection are cited from the respective source or calculated from the given data. Protozoan taxonomy follows Lom & Dyková (1992), for Trematoda Gibson et al. (2002) and Jones et al. (2005), for Nematoda Moravec (2001), for Cestoda Khalil et al. (1994), for trypanorhynch Cestodes Palm (2004), and for Monogenea, Acanthocephala, Arthropoda, Annelida and Mollusca the database "Fauna Europaea" (www.faunaeur.org) by Karsholt & Nieuwerkerken (2004). The swimbladder parasite *Anguillicola crassus* was recently transferred to the genus *Anguillicoloides* (Moravec, 2006). However in the majority of literature used for this review the parasite is recorded with its former genus name *Anguillicola*. Therefore this species is referred to as *Anguillicola crassus* in the checklist (Table I-1) Parasites are reported from natural localities including lakes, rivers, coastal lagoons, fjords and marine localities but also from freshwater reservoirs and fish ponds.

Table II-2 Sampling localities of European eel studied in 2006 and 2007 by the first author. n = total number of eels examined, TL = Total length, SD = Standard deviation.

Locality	Country	n	TL ± SD (in cm)
River Elbe estuary	Germany	30	78 ± 5.6
River Elbe/Gorleben	Germany	30	80 ± 7.3
Kattegat/Skagerrak	Denmark	30	55 ± 4
Kotka/Gulf of Finland	Finland	30	84 ± 7
Hortas/Tagus estuary	Portugal	30	27 ± 3.7

Results

A total of 161 parasite species/taxa were recorded for European eel from 30 European/ North African countries. The protozoan parasites species consisted of the classes Mastigophora (3 species), Apicomplexa (3 species), Myxozoa (13 species) and Ciliophora (8 species) and one species of yet uncertain taxonomic position (*Dermocystidium anguillae* Spangenberg, 1975). The metazoan parasite species consisted of the platyhelminth classes Trematoda (Digenea) (39 species), Monogenea (8 species) and Cestoda (20 species), the phyla Nematoda (38 species), Acanthocephala (15 species), Arthropoda (9 species), Annelida (2 species) and Mollusca (1 genus). Trematodes and nematodes were the most abundant taxonomic groups and the eel specific cestode species *Bothriocephalus claviceps* and *Proteocephalus macrocephalus* were recorded from 19 and 18 countries, respectively. The

Table II-3. Countries and dates and of first reported records of *Anguillicola crassus* from European eels (*Anguilla anguilla*).

Country	First record	Reference
Austria	1990	Konecny & Wais, 1993
Belgium	1985	Belpaire et al., 1989
Czech Republic	1991	Moravec, 1992
Denmark	1986	Kølle, 1988a
England	1987	Kennedy & Fitch, 1990
Estonia	1990	Didžiulis, 2006
Finland	2007	own survey
France	1985	Dupont & Petter, 1988
Corsica (France)	2002	Ternengo et al., 2005
Germany	1982	Neumann, 1985
Hungary	1990	Székely et al., 1991
Ireland	1999	Evans & Matthews, 1999
Italy	1987	Canestri-Trotti, 1987
Sardinia (Italy)	1988	Moravec, 1992
Latvia	1998	Didžiulis, 2006
Lithuania (Coast)	1998	Pilecka-Rapacz & Kesminas, 2006
Lithuania (Inland)	2004	Pilecka-Rapacz & Kesminas, 2006
Macedonia	1995	Cakic et al., 2002
Marocco	1996	El Hilali, 1996
Netherlands	1985	Van Banning et al., 1985
Norway	1993	Mo & Steien, 1994
Poland	1988	Koops & Hartmann, 1989
Portugal	1992	Cruz et al., 1992
Russia	2006	Rodjuk & Shelenkova, 2006
Scotland	2004	Lyndon & Pieters, 2005
Spain	1995	Maillo et al., 2005
Sweden	1988	Höglund & Andresen, 1993
Tunesia	1994	Maamouri et al., 1999

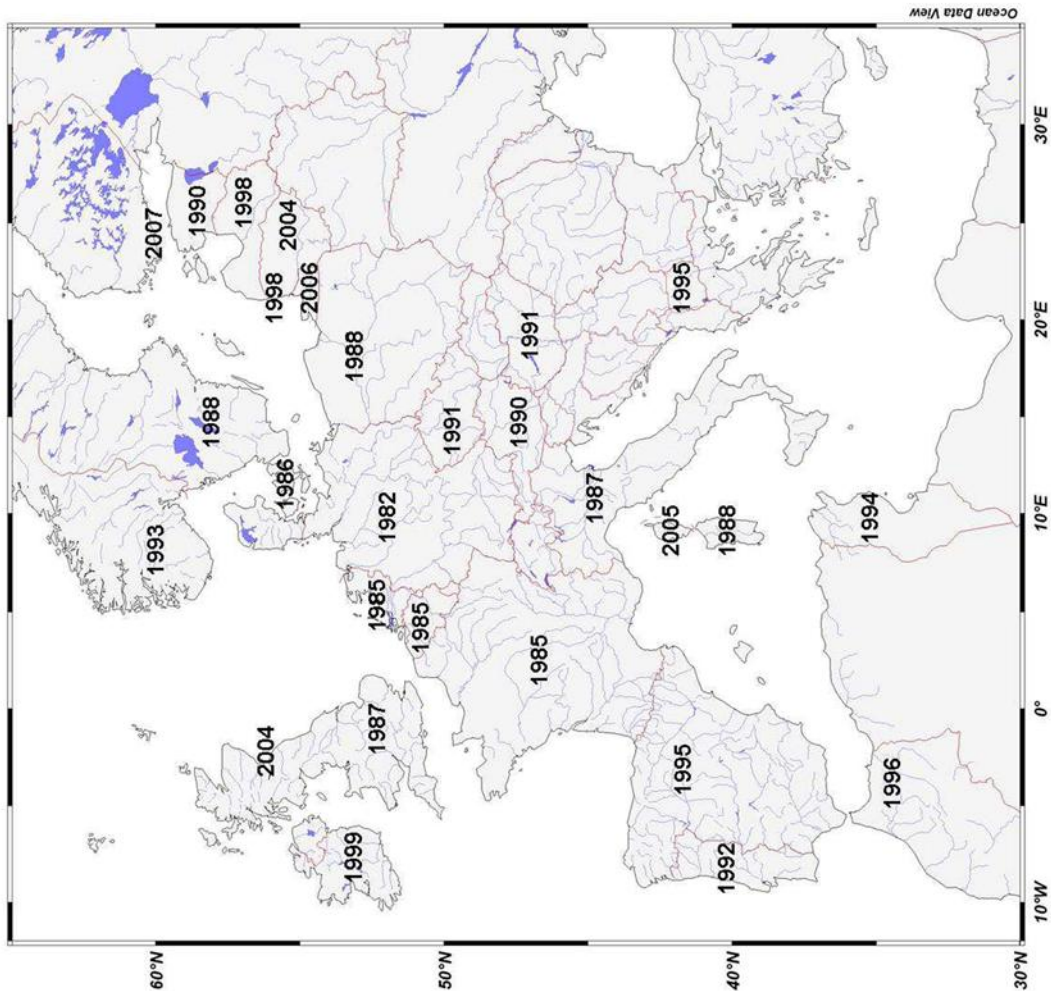


Figure II-1 Dates of first reported records of *Anguillicola crassus* from the European eel (*Anguilla anguilla*).

introduced nematode *Anguillicoloides crassus* and the monogenean *Pseudodactylogyrus* spp. were recorded from 25 and 16 countries, respectively but the invasive acanthocephalan *Paratenuisentis ambiguus* only from Germany, Netherlands and Russia. *Anguillicoloides crassus* successfully spread over Europe (Figure II-1, Table II-3) and reached even North Africa since its introduction and first record in German waters in 1982 (Neumann, 1985) and is present in eels from freshwater as well as from saline habitats (Figure II-2).

With the trypanorhynch cestode *Tentacularia coryphaenae* a new host record could be documented. A single specimen was isolated from an eel caught in the Tagus estuary in Portugal examined in our own survey. Furthermore, three new locality records of parasitic nematodes could be documented based on own survey data: *Anisakis simplex* from an eel caught in the Baltic Sea, *Eustrongylides mergorum* for German freshwaters and *Goezia anguillae* from the Tagus estuary in Portugal.

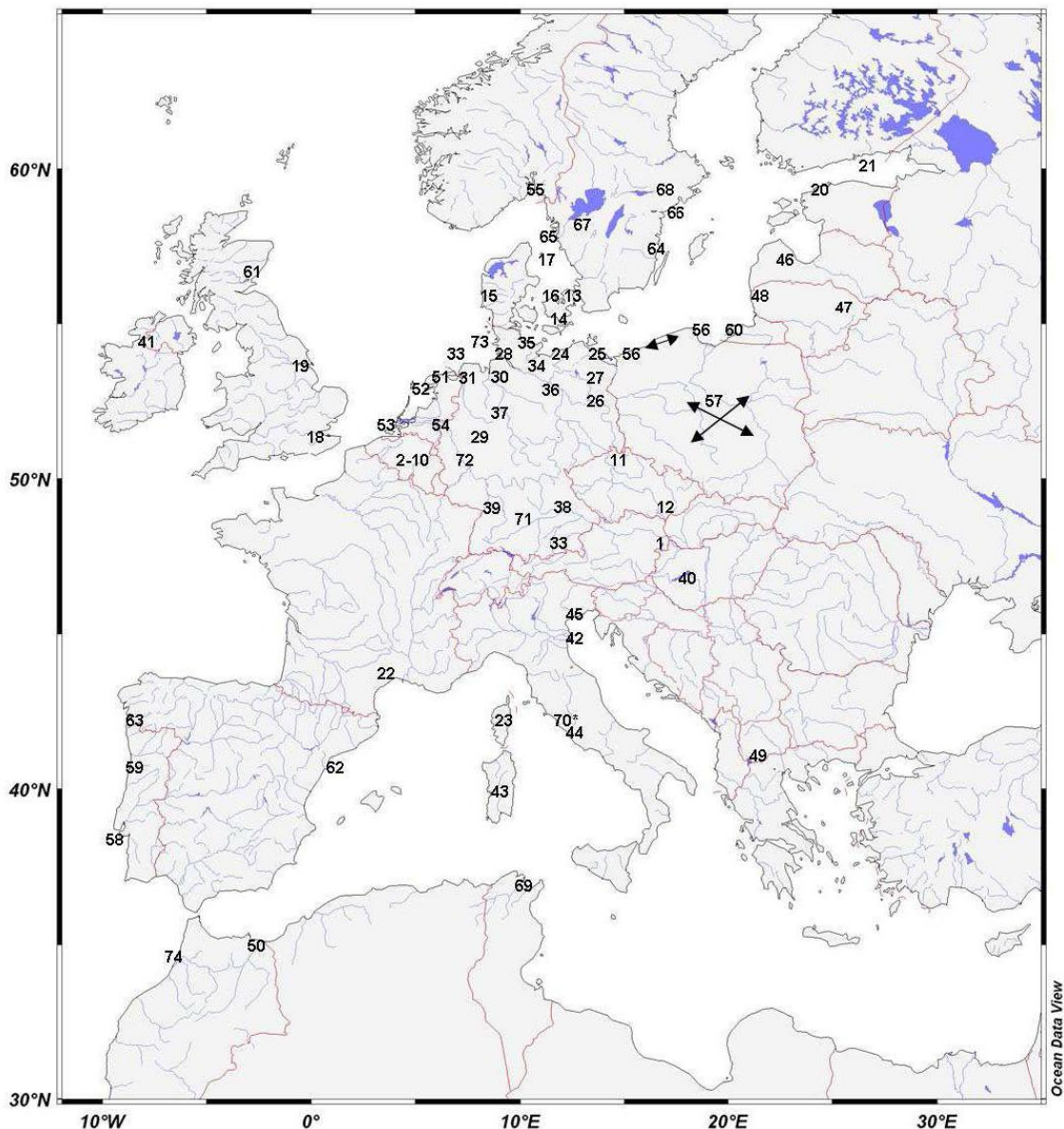


Figure II-2 Overview of studied localities with records for *Anguillicoloides crassus* (*Anguillicoloides* sp.) in European eel listed in Table 1. * = *A. novaezelandia*. Map source: Ocean Data View; Schlitzer, 2007.

Discussion

During the last 10 years the number of known European eel parasites has significantly grown considering the 78 species records listed by Reimer (1999) compared to the 161 species listed in the present checklist. The overall scientific interest in eel increased significantly since it became obvious that recruitment of glass eels are declining and that the European eel stock is severely depleted (ICES, 2008). The search for the causes of this decline also resulted in an increasing number of parasitological studies. Especially the invasive and highly eel pathogenic swimbladder nematode *Anguillicoloides crassus* (Kennedy, 2007) which was introduced from south-eastern Asia into western European water bodies as a result of uncontrolled intercontinental transfer of live eels for consumption (Køie, 1991) has been identified as a possible threat to the European eel stock (Kennedy, 2007). *Anguillicoloides crassus* which is originally endemic to East Asia in its native host *Anguilla japonica* (Japanese Eel) (Nagasawa et al., 1994) has by now already been recorded for 25 European countries and can be found in fresh- and brackish waters with moderate to very high infection rates (Jakob et al., 2009). The high success of this invasive species can be explained not only by its high tolerance towards ecological factors like temperature and habitat conditions (Taraschewski, 2006) but also by the ability to infest a wide range of copepod and ostracods as intermediate (Kirk, 2003; Moravec et al., 2005) as well as prey fishes, aquatic snails, insect larvae and amphibians as paratenic hosts (Moravec and Škorikova, 1998). The two monogenean species *Pseudodactylogyrus anguilla* and *P. bini* also originated from the Japanese eel and were introduced at the same time as *A. crassus* to central Europe via eel trade (Køie, 1991). They are presently recorded for 16 countries. Both species co-occur in European eels even on the same individual host (Buchmann et al., 1987) and can cause heavy losses in intensively cultured eel stocks (Buchmann et al., 1987). As a consequence of the direct lifecycle of *Pseudodactylogyrus* spp., high host densities favour their spread. However, eel mortality caused by these parasites has not yet been reported in the wild (Kennedy, 2007). In contrast to *A. crassus* and *Pseudodactylogyrus* spp. the third introduced parasite species *Paratenuisentis ambiguus* (Acanthocephala) has so far only been recorded from 3 countries. This acanthocephalan, indigenous to northern America and originating from *Anguilla rostrata*, is highly host specific for its intermediate as well as for its final host (Taraschewski, 2006). The exclusive intermediate host for *P. ambiguus*, the American euryhaline amphipod *Gammarus tigrinus*, was naturalized into the German River Weser in 1957 and with *Anguilla anguilla* a susceptible final host was present to fulfil the lifecycle (Taraschewski, 2006). As a consequence of its high host specificity, *P. ambiguus* is a far less successful invader than *A. crassus*.

The widespread distribution of *A. crassus* shows the potential of parasitic invasive species to spread rapidly under favourable conditions, including the availability of adequate intermediate hosts and a lack of an acquired protective immune response of the final host.

Acknowledgements

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Table II-1: Checklist of the protozoan and metazoan parasites of the European eel (*Anguilla anguilla*). Parasite species are arranged by phylum and family. Species within the families are listed in alphabetical order. Each species is listed with its site of infection in/on the eel, habitat (salinity), locality, country (alphabetical order) and author of record. If available the number of examined eels (n), prevalence (in %) (P), mean intensity (mi), mean intensity (mi), intensity (I) and mean abundance (mA) of infection and the respective standard deviation (SD) is given. ND = not determined; bl = blood, e = eye, f = fin, g = gill, gb = gall bladder, i = intestine, io = internal organs, iw = intestinal wall, k = kidney, li = liver, mc = mouth cavity, mu = musculature, sb = swim bladder, sbw = swim bladder wall, sc = scale, sk = skin, sp = spleen, st = stomach, stw = stomach wall, subt = subcutaneous tissue; * = unknown authority. [No. in Figure II-2] = Location numbers in Figure II-2.

Phylum/Family	Infection site	Habitat (Salinity)	Locality	Country	n	P (%)	mi/I	mA/SD	Author of record
uncertain taxonomic position									
<i>Dermocystidium anguillae</i>									
Spangenberg, 1975	g	ND	Europe	Europe	ND	ND	ND	ND	Lom & Dyková, 1992
PHYLUM									
SARCOMASTIGOPHORA									
Family Trypanosomatidae									
Doflein, 1911									
<i>Trypanosoma granulosum</i>	bl	Lake	Lake Esrum	Denmark	120	100	ND	ND	Køie, 1988a
Laveran & Mesnil, 1909		Lake	Lake Arresø	Denmark	30	100	ND	ND	Køie, 1988b
		Lake	Slapton Ley	England/UK	ND	ND	ND	ND	Canning et al., 1973
		River	River Rhine (Leimersheimer Altheim)	Germany	61	77.0	ND	ND	Sures et al., 1999
		River	River Rhine (harbour of Germersheim)	Germany	60	78.3	ND	ND	Sures et al., 1999
		Lake	Lake Constance/Langenargen	Germany	24	83.3	ND	ND	Thielen, 2005
		River	River Rhine/Laufenburg	Germany	64	79.7	ND	ND	Thielen, 2005
		Stream	Sulzbach/Laufenburg	Germany	36	22.2	ND	ND	Thielen, 2005
		Stream	Elterbach/Laufenburg	Germany	10	33.3	ND	ND	Thielen, 2005
		River	River Main/Gemünden	Germany	22	76.5	ND	ND	Thielen, 2005
		River	River Rhine/St. Goar	Germany	29	27.6	ND	ND	Thielen, 2005
		River	River Ruhr/Mühlheim	Germany	12	66.7	ND	ND	Thielen, 2005
		River	River Lippe/Hünxe	Germany	31	3.2	ND	ND	Thielen, 2005
		Lake	Müggelsee/Berlin	Germany	36	16.7	ND	ND	Thielen, 2005
		Lakes, Baltic Sea	Lakes Rāzmas, Ūsmas; Gulf of Riga	Latvia	ND	ND	ND	ND	Kirjušina & Vismānis, 2007
		Lake	Ijsselmeer	Netherlands	30	89	ND	ND	Boon et al., 1990
		River	River Rhine/Leenwen	Netherlands	43	18.6	ND	ND	Thielen, 2005
		Lake	Ijsselmeer/Makkum	Netherlands	30	50.0	ND	ND	Thielen, 2005
		River	River Este	Portugal	129	83.7	ND	ND	Saraiva & Chubb, 1989
		Estuary/Atlantic (30)	Ferrol	Spain	479	0.4	1	4.2 x10 ⁻³ /0.06	Outeiral et al., 2002
		River	River Ulla	Spain	323	73.9	ND	ND	Aguilar et al., 2005
		River	River Tea	Spain	200	89.0	ND	ND	Aguilar et al., 2005
Family Bodonidae Bitschli, 1887									
<i>Cryptobia markewitchi</i> *		Freshwater	former U.S.S.R.	former U.S.S.R.	ND	ND	ND	ND	Bykhovskaya-Pavlovskaya et al., 1964
Family Hexamitidae Kent, 1980									
<i>Spiroucleus anguillae</i> Einszporn-Orecka, 1979	bl, k, l, mu, sp	ND	Poland	Poland	ND	ND	ND	ND	Einszporn-Orecka, 1979
PHYLUM APICOMPLEXA									

Phylum/Family	Infection site	Habitat (Salinity)	Locality	Country	n	P (%)	m/l	mASD	Author of record
Family Cryptosporidiidae									
Léger, 1911									
<i>Epicimeria anguillae</i> (Léger & Hollande, 1922)	i	ND	Europe	Europe	ND	ND	ND	ND	Lom & Dyková, 1992
	i, iw	Lagoon /Baltic Sea	Vistula Lagoon	Russia	142	25.2	ND	ND	Rodjuk & Shelenkova, 2006
Family Eimeriidae Minchin, 1903									
<i>Eimeria anguillae</i> Léger & Hollande, 1922	i	River	River Olfusa	Iceland	15	6.6	ND	ND	Kristmundsson & Helgason, 2007
		Creek/Atlantic (30-33)	Grafarvogur	Iceland	20	5.0	ND	ND	Kristmundsson & Helgason, 2007
		Estuary/Atlantic (30)	Arousa	Spain	477	73.8	1/1-2	0.74/0.5	Outeiral et al., 2002
		Estuary/Atlantic (30) Lagoon/Mediterranean Sea (3-30)	Ferrol	Spain	479	73.9	1	0.69/0.4	Outeiral et al., 2002
		Lagoon/Mediterranean Sea (8-36)	Encanyissada, Ebro Delta	Spain	ND	9.1	ND	ND	Mafllo et al., 2005
		River	Tancada Ebro, Delta	Spain	ND	7.7	ND	ND	Mafllo et al., 2005
		River	River Ulla	Spain	323	3.7	ND	ND	Aguilar et al., 2005
		River	River Tea	Spain	200	2.5	ND	ND	Aguilar et al., 2005
<i>Eimeria</i> sp.	g	Freshwater	former U.S.S.R.	former U.S.S.R.	ND	ND	ND	ND	Bykhovskaya-Pavlovskaya et al., 1964
PHYLUM MYXOZOA									
Family Myxidiidae Thélohan, 1892									
<i>Myxidium giardi</i> Cépède, 1906	g, io, sk	Lake	Lake Esrum	Denmark	120	65.8	ND	ND	Kjøte, 1988a
		Lake	Lake Arresø	Denmark	30	30	ND	ND	Kjøte, 1988b
		Lake	Lake Sjøelsø	Denmark	20	70	ND	ND	Kjøte, 1988b
		Baltic Sea (4-8)	Ulf Sund	Denmark	60	30	ND	ND	Kjøte, 1988b
		Fjord/North Sea (10) Fjord/Baltic Sea (15-20)	Ringkøbing Fjord	Denmark	24	62.5	ND	ND	Kjøte, 1988b
		Kattegat (30-34)	Isefjord	Denmark	80	35	ND	ND	Kjøte, 1988b
		ND	Kattegat	Denmark	36	61.1	ND	ND	Kjøte, 1988b
		Baltic Sea	Europe	Europe	ND	ND	ND	ND	Lom & Dyková, 1992
		Lagoon/Baltic Sea	Kiel	Germany	ND	ND	ND	ND	Möller, 1975
		Baltic Sea	Lassan /Peenestrom	Germany	205	ND	ND	ND	Reimer, 1987
		Baltic Sea	Greifswalder Bodden	Germany	28	ND	ND	ND	Reimer, 1987
		Baltic Sea	Bight of Wismar	Germany	104	ND	ND	ND	Reimer, 1987
		River	River Rhine (Leimersheimer Altrhein)	Germany	61	19.7	ND	ND	Sures et al., 1999
		River	River Rhine (harbour of Germersheim)	Germany	60	20.0	ND	ND	Sures et al., 1999
		River	River Weser (Schlisselburg)	Germany	291	86.3	ND	ND	Reimer, 2004

Phylum/Family	Infection site	Habitat (Salinity)	Locality	Country	n	P (%)	m/I	mA/SD	Author of record
	Lake		Lake Constance/Langenargen	Germany	24	4.2	ND	ND	Thielen, 2005
	River		River Rhine/Laufenburg	Germany	64	50.0	ND	ND	Thielen, 2005
	Stream		Eitzebach/Laufenburg	Germany	10	33.3	ND	ND	Thielen, 2005
	Stream		Sulzbach/Laufenburg	Germany	36	22.2	ND	ND	Thielen, 2005
	River		River Main/Gemünden	Germany	22	52.9	ND	ND	Thielen, 2005
	River		River Rhine/St. Goar	Germany	29	75.9	ND	ND	Thielen, 2005
	River		River Ruhr/Mühlheim	Germany	12	33.3	ND	ND	Thielen, 2005
	River		River Lippe/Hünxe	Germany	31	51.6	ND	ND	Thielen, 2005
	Lake		Muggelsee/Berlin	Germany	36	ND	ND	ND	Thielen, 2005
	Lake		Lake Balaton	Hungary	81	3.7	ND	ND	Molnár & Székely, 1995
	River		River Olfusa	Iceland	15	93.3	ND	ND	Kristmundsson & Helgason, 2007
	Lake		Lake Steinsmyrarfljot	Iceland	30	33.3	ND	ND	Kristmundsson & Helgason, 2007
	Lake		Lake Vifilsstadvatn	Iceland	30	30.0	ND	ND	Kristmundsson & Helgason, 2007
	Creek/Atlantic (30-33)		Grafarvogur	Iceland	20	70.0	ND	ND	Kristmundsson & Helgason, 2007
	Lakes, Baltic Sea		Lakes Lepajas, Rāznas, Ūsmas; Kegums Water Reservoir; Gulf of Riga	Latvia	ND	ND	ND	ND	Kirjušina & Vismānis, 2007
	River		River Rhine/Leeuwen	Netherlands	43	55.8	ND	ND	Thielen, 2005
	Lake		Ijsselmeer/Makkum	Netherlands	30	66.7	ND	ND	Thielen, 2005
	River		Ria de Aveiro	Portugal	142	53	42.1/16.34/	ND	Cruz et al., 1992
	Estuary/Atlantic		Ria de Aveiro	Portugal	134	38.8	1-552	60.84	Hermida et al., 2008
	River		River Este	Portugal	129	96.1	ND	ND	Saraiva & Chubb, 1989
	Lagoon/Baltic Sea		Vistula Lagoon	Russia	142	30.1	ND	ND	Rodjnk & Shelenkova, 2006
	Estuary/Baltic Sea		Neva Bight	Russia	ND	ND	ND	ND	Reimer, 1987
	Estuary/Atlantic (30)		Arousa	Spain	477	75.3	1.1/1-3	0.8/0.5	Outeiral et al., 2002
	Estuary/Atlantic (30)		Ferrol	Spain	479	68.5	1/1-3	0.69/0.5	Outeiral et al., 2002
	Lagoon/Mediterranean Sea (3-30)		Encanyissada, Ebro Delta	Spain	ND	44.4	ND	ND	Mafllo et al., 2005
	Lagoon/Mediterranean Sea (8-36)		Tancada, Ebro Delta	Spain	ND	20.5	ND	ND	Mafllo et al., 2005
	Lagoon/Mediterranean Sea (8-30)		Canal Vell, Ebro Delta	Spain	ND	25.0	ND	ND	Mafllo et al., 2005
	River		River Ulla	Spain	323	95.1	ND	ND	Aguilar et al., 2005
	River		River Tea	Spain	200	95.0	ND	ND	Aguilar et al., 2005
	Freshwater		former U.S.S.R.	former U.S.S.R.	ND	ND	ND	ND	Bykhovskaya-Pavlovskaya et al., 1964
<i>Myxidium rhodei</i> Léger, 1905	Lagoon/Baltic Sea		Vistula Lagoon	Russia	142	16.1	ND	ND	Rodjnk & Shelenkova, 2006

Phylum/Family	Infection site	Habitat (Salinity)	Locality	Country	n	P (%)	ml/l	mASD	Author of record
<i>Myxidium truttae</i> Léger, 1930	g, gbl, i	Pond	Munich	Germany	ND	ND	ND	ND	Reimer, 1999
<i>Myxidium</i> sp.		River	River Almond	Scotland/UK	ND	ND	ND	ND	Kennedy, 1974
<i>Zschokkella stettinensis</i> Wierzbicka, 1987	ubl, ut	River	River Este	Portugal	129	ND	ND	ND	Saraiva & Monlár, 1990
<i>Zschokkella</i> sp.1	f	Lagoon /Baltic Sea	Vistula Lagoon	Russia	142	4.9	ND	ND	Rodjuk & Shelenkova, 2006
		River	River Ölfusa	Iceland	15	6.6	ND	ND	Kristmundsson & Helgason, 2007
<i>Zschokkella</i> sp.2	stw	Lake	Lake Steinsmyrarfljot	Iceland	30	6.6	ND	ND	Kristmundsson & Helgason, 2007
		Lake	Lake Vifilsstadavatn	Iceland	30	6.6	ND	ND	Kristmundsson & Helgason, 2007
		Creek/Atlantic (30-33)	Grafarvogur	Iceland	20	5.0	ND	ND	Kristmundsson & Helgason, 2007
Family Ceratomyxidae Doflein, 1899									
<i>Ceratomyxa anguillae</i> Tuzet & Ormières, 1957		Lagoons/brackish	Brackish lagoons/France	France	ND	ND	ND	ND	Lom & Dyková, 1992
Family Sphaerosoridae Davis, 1917									
<i>Sphaerospora anguillae</i> Wierzbicka, 1986	ubl	ND	Poland	Poland	ND	ND	ND	ND	Wierzbicka, 1986
<i>Hoferellus gilsoni</i> (Debaistoux, 1925)	ubl	Lagoon /Baltic Sea	Vistula Lagoon	Russia	142	3.5	ND	ND	Rodjuk & Shelenkova, 2006
		ND	Europe	Europe	ND	ND	ND	ND	Lom & Dyková, 1992
		River	River Este	Portugal	129	ND	ND	ND	Saraiva & Molnár, 1990
Family Myxobolidae Thélohan, 1892									
<i>Myxobolus koiyai</i> Molnár, Lom & Malik, 1986	f, subt	ND	Europe	Europe	ND	ND	ND	ND	Lom & Dyková, 1992
		Lake	Lake Constance/Langenargen	Germany	24	66.6	ND	ND	Thielen, 2005
		River	River Rhine/Laufenburg	Germany	64	29.7	ND	ND	Thielen, 2005
		Stream	Sulzbach/Laufenburg	Germany	36	5.6	ND	ND	Thielen, 2005
		Stream	Etzerbach/Laufenburg	Germany	10	10.0	ND	ND	Thielen, 2005
		River	River Main/Gemünden	Germany	22	64.7	ND	ND	Thielen, 2005
		River	River Rhine/St. Goar	Germany	29	62.1	ND	ND	Thielen, 2005
		River	River Ruhr/Mühlheim	Germany	12	33.3	ND	ND	Thielen, 2005
		River	River Lippe/Hünxe	Germany	31	48.4	ND	ND	Thielen, 2005
		Lake	Muggelsee/Berlin	Germany	36	16.7	ND	ND	Thielen, 2005
		River	River Ölfusa	Iceland	15	6.6	ND	ND	Thielen, 2005
		Lake	Lake Steinsmyrarfljot	Iceland	30	3.3	ND	ND	Kristmundsson & Helgason, 2007

Phylum/Family	Infection site	Habitat (Salinity)	Locality	Country	n	P (%)	m/I	mA/SD	Author of record
<i>Myxobolus portucalensis</i> Saraiva & Molnár, 1990	f	Creek/Atlantic (30-33)	Grafarvogur	Iceland	20	5.0	ND	ND	Kristmundsson & Helgason, 2007
		River	River Rhine/Leeuwen	Netherlands	43	27.9	ND	ND	Thielen, 2005
		Lake	Ijsselmeer/Makkum	Netherlands	30	26.7	ND	ND	Thielen, 2005
		Lake	Lake Balaton	Hungary	81	27.2	ND	ND	Molnár & Székely, 1995
		River	River Este	Portugal	129	53.5	ND	ND	Saraiva & Molnár, 1990
		River	River Ulla	Spain	323	26.6	ND	ND	Aguilar et al., 2005
		River	River Tea	Spain	200	34.5	ND	ND	Aguilar et al., 2005
		Lake	Lake Esrum	Denmark	120	ND	ND	ND	Køte, 1988a
		Lake	Lake Arresø	Denmark	30	ND	ND	ND	Køte, 1988b
		Lake	Lake Sjølsø	Denmark	20	ND	ND	ND	Køte, 1988b
<i>Myxobolus</i> sp.	f, io, iw, k, mes, ut	Baltic Sea (4-8)	Ulf Sund	Denmark	60	ND	ND	ND	Køte, 1988b
		Fjord/North Sea (10)	Ringkøbing Fjord	Denmark	24	ND	ND	ND	Køte, 1988b
		Fjord/Baltic Sea (15-20)	Isefjord	Denmark	80	ND	ND	ND	Køte, 1988b
		Kattegat (30-34)	Kattegat	Denmark	36	ND	ND	ND	Køte, 1988b
		River	River Rhine (Leimersheimer Altrhein)	Germany	61	49.2	ND	ND	Sures et al., 1999
		River	River Rhine (harbour of Germersheim)	Germany	60	68.3	ND	ND	Sures et al., 1999
		River	River Este	Portugal	129	53.5	ND	ND	Saraiva & Chubb, 1989
		Lagoon /Baltic Sea	Vistula Lagoon	Russia	142	1.4	ND	ND	Rodjuk & Shelenkova, 2006
		Estuary/Atlantic (30)	Arousa	Spain	477	0.2	1	2.1x10.3/ 4.6x10-2	Outeral et al., 2002
		Estuary/Atlantic (30) Lagoon/Mediterranean Sea (3-30)	Ferrol	Spain	479	0.4	1	4.2x10-3/0.06	Outeral et al., 2002
PHYLUM CILIOPHORA Family Chilodonella Strand, 1926 <i>Chilodonella hexasticha</i> (Kiernik, 1909) Family Ichthyophthiriidae Kent, 1881	g, sk	Lagoon/Mediterranean Sea (8-36)	Encanyissada, Ebro Delta	Spain	ND	14.7	ND	ND	Mafllo et al., 2005
		River	Tancada, Ebro Delta	Spain	ND	7.7	ND	ND	Mafllo et al., 2005
		River	River Olfusa	Iceland	15	ND	ND	ND	Kristmundsson & Helgason, 2007
		Lake	Lake Esrum	Denmark	120	30.8	ND	ND	Køte, 1988a
		Lake	Lake Sjølsø	Denmark	20	ND	ND	ND	Køte, 1988b
		Tanks	Latvia	Latvia	ND	ND	ND	ND	Kirjušina & Vismans, 2007
		Lake	Lake Esrum	Denmark	120	30.8	ND	ND	Køte, 1988a
		Lake	Lake Sjølsø	Denmark	20	ND	ND	ND	Køte, 1988b
		Tanks	Latvia	Latvia	ND	ND	ND	ND	Kirjušina & Vismans, 2007
		Lake	Lake Esrum	Denmark	120	30.8	ND	ND	Køte, 1988a

Phylum/Family	Infection site	Habitat (Salinity)	Locality	Country	n	P (%)	m/l	mASD	Author of record
Family Trichodinidae Raabe, 1959		River	River Este	Portugal	129	3.1	ND	ND	Saraiva & Chubb, 1989
		River	River Ulla	Spain	323	23.5	ND	ND	Aguilar et al., 2005
		River	River Tea	Spain	200	30.5	ND	ND	Aguilar et al., 2005
<i>Trichodina anguillae*</i>	g	Baltic Sea	Neva Bight	Russia	ND	ND	ND	ND	Reimer, 1987 Bykhovskaya-Pavlovskaya et al., 1964
<i>Trichodina fulvoni</i> Davis, 1947	g, sk	Freshwater	former U.S.S.R.	former U.S.S.R.	ND	ND	ND	ND	Kristmundsson & Helgason, 2007
<i>Trichodina jadrantica</i> Raabe, 1958	g, sk	River	River Olfusa	Iceland	15	ND	ND	ND	Kristmundsson & Helgason, 2007
		Lake	Lake Steinsmyrarfljot	Iceland	30	ND	ND	ND	Kristmundsson & Helgason, 2007
		River	River Olfusa	Iceland	15	ND	ND	ND	Kristmundsson & Helgason, 2007
		Lake	Lake Vifilsstadvatn	Iceland	30	ND	ND	ND	Kristmundsson & Helgason, 2007
		River	River Este	Portugal	129	17.8	ND	ND	Saraiva & Chubb, 1989
		Lagoon /Baltic Sea	Vistula Lagoon	Russia	142	24.3	ND	ND	Rodjink & Shelenkova, 2006
		River	River Ulla	Spain	323	9.91	ND	ND	Aguilar et al., 2005
		River	River Tea	Spain	200	1.5	ND	ND	Aguilar et al., 2005
<i>Trichodina pediculus</i> (O.F.Müller, 1786)	g	Lagoon/Mediterranean Sea (3-30)	Encanyissada Ebro Delta	Spain	ND	0.02	ND	ND	Mafllo et al., 2005
<i>Trichodina</i> sp.	g	Lake	Lake Esrum	Denmark	120	2.5	ND	ND	Køite, 1988a
		Lake	Lake Sjølsø	Denmark	20	ND	ND	ND	Køite, 1988b
		Baltic Sea (4-8) Fjord/Baltic Sea (15-20)	Ulf Sund	Denmark	60	ND	ND	ND	Køite, 1988b
<i>Trichodinella epitzoatica</i> (Raabe, 1950)	g, sk	River	Isefjord River Rhine (Leimersheimer Althein)	Denmark Germany	80 61	ND 8.2	ND ND	ND ND	Køite, 1988b Sures et al., 1999
		Lagoon /Baltic Sea	Vistula Lagoon	Russia	142	9.5	ND	ND	Rodjink & Shelenkova, 2006
		Baltic Sea	Neva Bight	Russia	ND	ND	ND	ND	Reimer, 1987
		Freshwater	former U.S.S.R.	former U.S.S.R.	ND	ND	ND	ND	Bykhovskaya-Pavlovskaya et al., 1964
PHYLUM PLATHYHELMINTHES CLASS TREMATODA Family Azygidae Lühe, 1909	st	Lake Baltic Sea (0-4) Lagoon/Baltic Sea	Lake Mácha Kotka/Gulf of Finland Stepnica (Szezezin Lagoon)	Czech Republic Finland Poland	132 30 30	3.8 3.3 3.3	1-3 1/1 1	ND 0.03 0.03	Moravec, 1985 this paper Orecka-Grabda & Wierzbicka, 1994

Phylum/Family	Infection site	Habitat (Salinity)	Locality	Country	n	P (%)	m/I	mA/SD	Author of record
Family Bucephalidae Poche, 1907									
<i>Bucephalus polymorphus</i> Baer, 1827	i, st	Lagoon/Thyrrhenian Sea (10-40)	Lake Burano	Italy	187	6.4	ND	0.68/4.36	Kennedy et al., 1997
		Lagoon/Thyrrhenian Sea (28-48)	Lake Fogliano	Italy	20	40.0	ND	3.65/7.28	Kennedy et al., 1997
		Lagoon/Thyrrhenian Sea (17-39)	Lake Monaci	Italy	44	27.3	ND	4.16/12.97	Kennedy et al., 1997
		Lagoon/Thyrrhenian Sea (32-44)	Lake Caprolace	Italy	38	5.3	ND	0.42/1.94	Kennedy et al., 1997
		Lagoon/Adriatic Sea (15-35)	Valle Figheri/Adriatic Coast	Italy	33	45.4	ND	22.2/69.3	Di Cave et al., 2001
		Lagoon/Adriatic Sea (23-37)	Comacchio /Adriatic Coast	Italy	42	2.4	ND	0.1	Di Cave et al., 2001
		Lagoon/Adriatic Sea (30-42)	Acquatina/ Adriatic Coast	Italy	21	47.6	ND	9.6/37	Di Cave et al., 2001
		Estuary/Atlantic (30)	Arousa	Spain	477	5.0	1-103	0.5/5.0	Outeiral et al., 2001
		Estuary/Atlantic (30)	Ferrol	Spain	479	4.8	4-0/1-31	0.2/1.6	Outeiral et al., 2001
Family Diplostomidae Poirier, 1886									
<i>Diplostomum chromaophorum</i> Brown, 1931	e	Lake	Upper Lough Erne	Ireland	ND	ND	ND	ND	McCloughlin & Irwin, 1991
<i>Diplostomum gasterostei</i> Williams, 1966	e	River/Lake	Corrib catchment area	Ireland	15	ND	ND	ND	Conneely & McCarthy, 1984
		River	River Drimneen	Ireland	49	2	6	0.12	Conneely & McCarthy, 1986
		Lake	Lake Corrib	Ireland	39	3	27	0.81	Conneely & McCarthy, 1986
		River	Dunkellin River	Ireland	117	6.8	2.38	0.16	Callaghan & McCarthy, 1996
		River	Rafford River	Ireland	125	2.4	2.33	0.21	Callaghan & McCarthy, 1996
		Lake	Assaroe Lake, Co Donegal/River Erne catchment	Ireland	30	3.3	1/1	0.03	Copley & McCarthy, 2005
<i>Diplostomum paracaudum</i> (Iles, 1959)	e	Lagoon/Baltic Sea	Vistula Lagoon	Russia	142	3.5	1	0.035	Rodjuk & Shelenkova, 2006
<i>Diplostomum parviventosum</i> (Dubois, 1970)	e	Lake	Upper Lough Erne	Ireland	ND	ND	ND	ND	McCloughlin & Irwin, 1991
<i>Diplostomum pseudobaeri</i> (Razmaskin & Andryuk, 1978)	e	Lake	Upper Lough Erne	Ireland	ND	ND	ND	ND	McCloughlin & Irwin, 1991
<i>Diplostomum spathaceum</i> (Rudolphi, 1819)	e	Lake	Slapton Ley	England/UK	ND	ND	ND	ND	Canning et al., 1973
		Lake	Shobrooke Lake	England/UK	131	78.6	7.4/1-32	5.8	Kennedy et al., 1992
		Reservoir/freshwater	Hanningford Reservoir/Essex	England/UK	4	100	29.5	29.5	Wootten, 1973
		Baltic Sea (0-4)	Kotka/Gulf of Finland	Finland	30	53	2.7/1-8	1.4	this paper
		Baltic Sea	Hiddensee	Germany	ND	ND	ND	ND	Reimer, 1987

Phylum/Family	Infection site	Habitat (Salinity)	Locality	Country	n	P (%)	m/l	mASD	Author of record
<i>Diplostomum</i> sp.	River		River Weser (Schlüsselburg)	Germany	291	14.1	ND	ND	Reimer, 2004
	Lake		Lake Constance/Langenargen	Germany	24	25.0	ND	ND	Thielen, 2005
	Lake		Lake Plön	Germany	30	100	5.2/1-15	5.20	Jakob et al., 2009
	River		River Eider	Germany	30	10	1.3/1-2	0.13	Jakob et al., 2009
	Baltic Sea (10-20)		Maasholm	Germany	30	3.3	4/4	0.13	Jakob et al., 2009
	Baltic Sea (15-20)		Fehmarn Belt	Germany	30	20	3.5/1-8	0.70	Jakob et al., 2009
	Estuary/Noth Sea		River Elbe Estuary	Germany	30	3	2/2	0.06	this paper
	Freshwater		Freshwaters in Ireland	Ireland	ND	ND	ND	ND	Kennedy, 1974
	River		Dunkellin River	Ireland	117	44.4	2.71	1.21	Callaghan & McCarthy, 1996
	Lake		Lough Rea	Ireland	32	90.6	16.93	15.34	Callaghan & McCarthy, 1996
	River		Rafford River	Ireland	125	25.6	2.38	2.61	Callaghan & McCarthy, 1996
	Lake		Lough Derg	Ireland	ND	ND	ND	ND	Holland & Kennedy, 1997
	Lake		Upper Lough Erne	Ireland	ND	ND	ND	ND	McCloughlin & Irwin, 1991
	River/Lake		Corrib catchment area	Ireland	15	ND	ND	ND	Conneely & McCarthy, 1984
	River		River Abbert	Ireland	33	67	4.4	2.9	Conneely & McCarthy, 1986
	River		River Drimneen	Ireland	49	49	2.8	1.4	Conneely & McCarthy, 1986
	Lake		Lake Corrib	Ireland	39	92	13.5	12.4	Conneely & McCarthy, 1986
	Lake		Assaroe Lake, Co Donegal/River Erne catchment	Ireland	45	88.8	ND	ND	Copley & McCarthy, 2005
	Lake		Lough Ardara, Co Cavan/River Erne catchment	Ireland	18	66.7	2	1.33	Copley & McCarthy, 2005
	Lake, Baltic Sea		Rāznas, Kegums Water Reservoir, Gulf of Riga	Latvia	ND	ND	ND	ND	Kirjušina & Vismannis, 2007
	River		West Odra River/Stoleczyn	Poland	83	ND	ND	ND	Seyda, 1973
	Lagoon/Baltic Sea		Szezećin Firth	Poland	83	ND	ND	ND	Seyda, 1973
	Lake		Lake Dąbie	Poland	83	ND	ND	ND	Seyda, 1973
	Freshwater		Freshwaters in Britain	UK	ND	ND	ND	ND	Kennedy, 1974
	Lake	e	Lake Esrum	Denmark	120	61.7	3.2/1-10	1.97	Kjøte, 1988a
	Lake		Lake Arresø	Denmark	30	40	2.0/1-3	0.8	Kjøte, 1988b
Lake		Lake Sjølsø	Denmark	20	20	1.5/1-3	0.3	Kjøte, 1988b	
Baltic Sea (4-8)		Ulf Sund	Denmark	60	48.3	1.7/1-5	0.82	Kjøte, 1988b	
Fjord (10)		Ringkøbing Fjord	Denmark	24	16.6	1.8/1-3	0.29	Kjøte, 1988b	
Lake		Windermere catchment area	England/UK	ND	ND	ND	ND	Frost, 1946	
Freshwater		Freshwaters in Ireland	Ireland	ND	ND	ND	ND	Kennedy, 1974	
River/Lake		Corrib catchment area	Ireland	15	ND	ND	ND	Conneely & McCarthy, 1984	

Phylum/Family	Infection site	Habitat (Salinity)	Locality	Country	n	P (%)	m/I	mA/SD	Author of record
<i>Tylodelephys clavata</i> von Nordmann, 1832		River	River Olfusa	Iceland	15	20.0	3.6/1-6	0.72	Kristmundsson & Helgason, 2007
		Lake	Lake Steinsmyrarfljot	Iceland	30	66.6	3.4/1-13	2.2	Kristmundsson & Helgason, 2007
		Lake	Lake Vifilisstadavatn	Iceland	30	20.0	6.0/2-14	1.2	Kristmundsson & Helgason, 2007
		Lake	Lake Usmas	Latvia	ND	ND	ND	ND	Kirjusina & Vismanis, 2007
		River	River Ulla	Spain	323	18.3	1.63/1-6	0.3/0.76	Aguilar et al., 2005
		River	River Tea	Spain	200	2.5	3.2/1-8	0.08/0.65	Aguilar et al., 2005
		Freshwater	Freshwaters in Britain	UK	ND	ND	ND	ND	Kennedy, 1974
		Lagoon/Baltic Sea	Szczecin Firth	Poland	83	ND	ND	ND	Seyda, 1973
		Lake	Lake Dąbie	Poland	83	ND	ND	ND	Seyda, 1973
		Lagoon/Baltic Sea	Trzebiez (Szczecin Lagoon)	Poland	71	1.4	3	0.04	Orecka-Grabda & Wierzbicka, 1994
Family Strigidae Railliet, 1919									
<i>Ichthyocopylanus platycephalus</i> (Creplin 1825)	st	Baltic Sea (4-8)	Ulf Sund	Denmark	60	8.3	3.2/1-7	ND	Køie, 1988b
Family Hemiuridae Looss, 1899									
<i>Brachyphallus crenatus</i> (Rudolphi, 1802)	st	Fjord/North Sea (10)	Ringkøbing Fjord	Denmark	24	16.6	1.5/1-3	ND	Køie, 1988b
		Fjord/Baltic Sea (15-20)	Isefjord	Denmark	80	17.5	3.6/1-15	ND	Køie, 1988b
		Kattegat (30-34)	Kattegat	Denmark	36	22.2	2.4/1-6	ND	Køie, 1988b
		Baltic Sea	Hiddensee	Germany	ND	ND	ND	ND	Reimer, 1987
		Baltic Sea	Bight of Wismar	Germany	ND	ND	ND	ND	Palm et al., 1999
		Baltic Sea	Bight of Mecklenburg, Salzhaff	Germany	ND	ND	ND	ND	Palm et al., 1999
		Baltic Sea	Fehmarn Belt	Germany	30	6.66	11-14	0.83	Jakob et al., 2009
<i>Hemiurus communis</i> Odhner, 1905	st	Baltic Sea	Gdansk Bay	Poland	17	0.06	1/1	ND	Rokicki, 1975
		Fjord/Baltic Sea (15-20)	Isefjord	Denmark	80	26.3	6.5/1-30	1.71	Køie, 1988b
<i>Lecithochirium furcolabiatum</i> (Jones 1933)	st	Baltic Sea	Hiddensee	Germany	ND	ND	ND	ND	Reimer, 1970
		Estuary/Atlantic (30)	Arousa	Spain	477	9.0	3.5/1-18	0.3/1.5	Outeiral et al., 2001
<i>Lecithochirium musculus</i> (Looss, 1907)	i, st	Estuary/Atlantic (30)	Ferrol	Spain	479	0.8	3.5	0.03/0.4	Outeiral et al., 2001
		Pond (30)	Urbino pond/Corsica	France (Corsica)	31	20	4	0.39	Temengo et al., 2005
		Lagoon/Thyrrhenian Sea (28-48)	Lake Fogliano	Italy	20	45.0	ND	3.00/7.95	Kennedy et al., 1997
		Lagoon/Thyrrhenian Sea (17-39)	Lake Monaci	Italy	44	34.1	ND	1.41/3.79	Kennedy et al., 1997
		Lagoon/Thyrrhenian Sea (32-44)	Lake Caprolace	Italy	38	18.4	ND	0.45/1.03	Kennedy et al., 1997

Phylum/Family	Infection site	Habitat (Salinity)	Locality	Country	n	P (%)	m/l	m/ASD	Author of record
		Lagoon/Adriatic Sea							
		(15-35)	Valle Figheri/Adriatic Coast	Italy	33	36.4	ND	2.2/9.9	Di Cave et al., 2001
		Lagoon/Adriatic Sea							
		(23-37)	Comacchio /Adriatic Coast	Italy	42	69.0	ND	2.3/6.6	Di Cave et al., 2001
		Lagoon/Adriatic Sea							
		(30-42)	Acquatina/ Adriatic Coast	Italy	21	4.8	ND	0.1	Di Cave et al., 2001
		Estuary/Atlantic (30)	Arousa	Spain	477	40.0	1-282	6.4/19.3	Outeiral et al., 2001
		Estuary/Atlantic (30)	Ferrol	Spain	479	6.3	1.7/1-6	0.1/0.5	Outeiral et al., 2001
		Kattegat/Skagerrak							
	st	(30-34)	Denmark	Denmark	30	46.6	1-126	6.53	this paper
		Kattegat (30-34)	Kattegat	Denmark	36	36.1	2.2/1-9	0.79	Køie, 1988b
		Atlantic	outer Kaldbak Fjord	Faroe Islands	1	100	1/1	1	Køie, 2000
		North Sea (32-35)	Helgoland	Germany	20	90	7-193	41.22	Jakob et al., 2009
		Estuary/Atlantic	Ria de Aveiro	Portugal	134	7.5	4.6/1-23	0.34/2.12	Hermida et al., 2008
		Estuary/Atlantic (30)	Arousa	Spain	477	2.7	1.9/1-7	0.05/0.4	Outeiral et al., 2001
		Estuary/Atlantic (30)	Ferrol	Spain	479	0.2	1	0.002/0.045	Outeiral et al., 2001
		Estuary/Atlantic	Ria de Aveiro	Portugal	134	0.8	8.0	0.06	Hermida et al., 2008
<i>Lecithochirium</i> sp.									
Family Derogenidae Nicoll, 1910									
<i>Derogenes varicus</i> (Müller, 1784)	st	Kattegat (30-34)	Kattegat	Denmark	36	2.8	1/1	0.03	Køie, 1988b
		Creek/Atlantic							Kristmundsson & Helgason, 2007
		(30-33)	Grafarvogur	Iceland	20	45.0	1.7/1-6	0.7	
		Estuary/Atlantic (30)	Arousa	Spain	477	0.2	1	0.002/0.002	Outeiral et al., 2001
		Estuary/Atlantic (30)	Ferrol	Spain	479	0.6	1	0.01/0.10	Outeiral et al., 2001
Family Lecithasteridae Odhner, 1905									
<i>Lecithaster gibbosus</i> (Rudolphi, 1802)	st	Kattegat (30-34)	Kattegat	Denmark	36	2.8	1/1	0.03	Køie, 1988b
		Estuary/Atlantic (30)	Ferrol	Spain	479	0.4	5.0/1-9	0.02/0.41	Outeiral et al., 2001
Family Allocreadiidae Looss, 1902									
<i>Bunodera luciopercae</i> (Müller, 1776)		Lake	Lake Esrum	Denmark	120	0.8	4/4	0.03	Køie, 1988a
<i>Crepidostomum farionis</i> (Müller, 1784)	st	River	River Teify	England/UK	155	0.65	ND	ND	Thomas, 1958
		River	River Clyst	England/UK	206	0.5	1/1	0.05	Kennedy et al., 1992
		River	River Otter	England/UK	233	0.4	1/1	0.04	Kennedy et al., 1992
		Lake	Assaroe Lake, Co Donegal/River Erne catchment	Ireland	30	3.3	29/29	0.96	Copley & McCarthy, 2005
<i>Crepidostomum metoecus</i> (Braun, 1900)	st	Lake	Lough Derg	Ireland	ND	ND	ND	ND	Holland & Kennedy, 1997
Family Opcoelidae Ozaki, 1925									

Phylum/Family	Infection site	Habitat (Salinity)	Locality	Country	n	P (%)	m/I	mA/SD	Author of record
<i>Helicoverma fasciata</i> (Rudolphi, 1819)	i	North Sea (32-35) Lagoon/Adriatic Sea (23-37)	Helgoland	Germany	20	80	12.5/1-37	10.0	Jakob et al., 2009
			Comacchio /Adriatic Coast	Italy	42	73.8	ND	13.8/21.7	Di Cave et al., 2001
			Ria de Aveiro	Portugal	134	3.7	10.0/17.7/	0.37/3.79	Hermida et al., 2008
			Arousa	Spain	477	32.1	1-23.6	5.7/18.3	Outeiral et al., 2001
<i>Nicollia gallica</i> (Dollfus, 1941)	i	Lake	Ferrol	Spain	479	5.2	4.4/1-19	0.2/1.7	Outeiral et al., 2001
			Lake Esrum	Denmark	120	3.3	2.3/1-3	0.08	Køte, 1988a
			River Thames	England/UK	ND	ND	ND	ND	Norton et al., 2004
			River Test	England/UK	ND	ND	ND	ND	Norton et al., 2004
<i>Plagioporus angulatus</i> Dujardin, 1845	i	River	River Tiber	Italy	101	1.0	3.93/1-31	ND	Kennedy et al., 1998
			River Tea	Spain	200	14.0	1-31	0.55/2.72	Aguilar et al., 2005
			Baltic Sea (0-4)	Finland	30	3.3	27/27	0.9	this paper
			Baltic Sea	Germany	ND	ND	ND	ND	Reimer, 1987
<i>Plagioporus</i> sp.	i	Baltic Sea	Bight of Wismar	Germany	ND	ND	ND	Reimer, 1987	
			Hiddensee	Germany	ND	ND	ND	Reimer, 1987	
			River Weser (Schlisselburg)	Germany	291	1.3	ND	ND	Reimer, 2004
			Creek/Atlantic (30-33)	Germany	ND	ND	ND	ND	Kristmundsson & Helgason, 2007
<i>Podocoryle atomon</i> (Rudolphi, 1802)	i	Lake	Grafarvogur	Iceland	20	15.0	3.7/1-6	0.55	Reimer, 1987
			Baltic Sea	Poland	ND	ND	ND	ND	Reimer, 1987
			Lagoon/Baltic Sea	Russia	142	1.4	1	0.014	Rodjuk & Shelenkova, 2006
			Freshwater	former U.S.S.R.	ND	ND	ND	ND	Bykhovskaya-Pavlovskaya et al., 1964
<i>Podocoryle atomon</i> (Rudolphi, 1802)	i	Baltic Sea	Bight of Wismar	Germany	104	ND	ND	ND	Reimer, 1987
			Lake Plön	Germany	30	63.3	109.7/1-1630	69.44	Jakob et al., 2009
			Bight of Wismar	Germany	ND	ND	ND	ND	Palm et al., 1999
			Bight of Mecklenburg, Salzhaff	Germany	ND	ND	ND	ND	Palm et al., 1999
<i>Podocoryle atomon</i> (Rudolphi, 1802)	i	Estuary/Atlantic (30)	Arousa	Spain	477	27.0	8.4/1-77	2.26	Outeiral et al., 2001
			Ferrol	Spain	479	50.9	11.6/1-65	5.9	Outeiral et al., 2001
			Kattegat/Skagerrak (30-34)	Denmark	30	3.3	2/2	0.06	this paper
			Baltic Sea (4-8)	Denmark	60	36.7	8.1/1-50	2.97	Køte, 1988b
<i>Podocoryle atomon</i> (Rudolphi, 1802)	i	Fjord/Baltic Sea (15-20)	Ulfr Sund	Denmark	80	27.5	7.1/1-20	1.91	Køte, 1988b
			Isefjord	Denmark	36	13.9	5.2/1-21	0.72	Køte, 1988b
			Kattegat (30-34)	Denmark	233	0.9	1/1	0.009	Kennedy et al., 1992
			River Orter	England/UK	233	0.9	1/1	0.009	Kennedy et al., 1992

Phylum/Family	Infection site	Habitat (Salinity)	Locality	Country	n	P (%)	m/l	mASD	Author of record
		Baltic Sea	Kiel	Germany	ND	ND	ND	ND	Möller, 1975
		Baltic Sea	Bight of Wismar	Germany	104	ND	ND	ND	Reimer, 1987
		Baltic Sea	Hiddensee	Germany	ND	ND	ND	ND	Reimer, 1987
		Baltic Sea	Greifswalder Bodden	Germany	28	ND	ND	ND	Reimer, 1987
		Lagoon/Baltic Sea	Lassan /Peenestrom	Germany	205	ND	ND	ND	Reimer, 1987
		Baltic Sea	Arkona Bassin, Rügen Island	Germany	ND	ND	ND	ND	Palm et al., 1999
		Baltic Sea	German waters	Germany	ND	ND	ND	ND	Palm et al., 1999
		Baltic Sea	Poel Island	Germany	ND	ND	ND	ND	Palm et al., 1999
		Baltic Sea	Bight of Mecklenburg, Salzhaff	Germany	ND	ND	ND	ND	Palm et al., 1999
		Baltic Sea (12-18)	Kiel Fjord	Germany	30	33.3	4.3/1-11 10.8/	1.43	Jakob et al., 2009
		Baltic Sea (10-20)	Maasholm	Germany	30	43	1-56	4.66	Jakob et al., 2009
		North Sea (32-35)	Helgoland	Germany	20	5	1/1	0.05	Jakob et al., 2009
		Baltic Sea (15-20)	Fehmarn Belt	Germany	30	20	4.3/2-8	0.86	Jakob et al., 2009
		Creek/Atlantic (30-33)	Grafarvogur	Iceland	20	20.0	1.7/1-3	0.34	Kristmundsson & Helgason, 2007
		Estuary/Atlantic	Hortas/Tagus estuary	Portugal	30	3.3	2/2	0.06	this paper
		Freshwater	former U.S.S.R.	former U.S.S.R.	ND	ND	ND	ND	Bykhovskaya-Pavlovskaya et al., 1964
<i>Podocotyle</i> sp.	i	Estuary/Atlantic	Ria de Aveiro	Portugal	134	9.7	1-106	1.90/10.21	Hermida et al., 2008
<i>Sphaerosstoma bramae</i> (Müller, 1776)	i	Estuary/North Sea	Exminster Marshes	England/UK	64	18.8	8.8/1-15	1.65	Kennedy et al., 1992
		River	River Otter (River Exe system)	England/UK	30	3.3	ND	0.07/0.4	Kennedy, 2001
		River	River Clyst (River Exe system)	England/UK	19	5.2	ND	0.02/0.2	Kennedy, 2001
		Baltic Sea	Rügen Island	Germany	ND	ND	ND	ND	Palm et al., 1999
		River/Lake	Corrib catchment area	Ireland	15	6.6	1	0.06	Conneely & McCarthy, 1984
		Lake	Lake Corrib	Ireland	39	49	104	50.9	Conneely & McCarthy, 1986
		River	Dunkellin River	Ireland	117	18.8	4.00	0.75	Callaghan & McCarthy, 1996
		River	Rafford River	Ireland	125	16.0	4.65	13.00	Callaghan & McCarthy, 1996
		Lake	Lough Rea	Ireland	32	64.6	135	89.09	Callaghan & McCarthy, 1996
		Lake	Lough Derg	Ireland	ND	ND	ND	ND	Holland & Kennedy, 1997
		Lake	Assaroe Lake, Co Donegal/River Erne catchment	Ireland	30	3.3	3/3	0.09	Copley & McCarthy, 2005
		Lakes, Baltic Sea	Lakes Liepājas, Usmas, Gulf of Riga	Latvia	ND	ND	ND	ND	Kirjušina & Vismānis, 2007
		Freshwater	former U.S.S.R.	former U.S.S.R.	ND	ND	ND	ND	Bykhovskaya-Pavlovskaya et al., 1964

Phylum/Family	Infection site	Habitat (Salinity)	Locality	Country	n	P (%)	m/I	mA/SD	Author of record
<i>Sphaerosoma</i> sp.		Lake	Lake Esrum	Denmark	120	11.7	1.9/1-5	ND	Køte, 1988a
Family Deropristidae Cable & Hunninen, 1942									
<i>Deropristis infidata</i> (Molin, 1859)	i, s	Pond (30) Kattegat/Skagerrak (30-34)	Urbino pond Denmark	France (Corsica) Denmark	31 30	70 90	13.95 1.46/ 1-81 15.8/ 1-100	9.45 13.17	Temengo et al., 2005 this paper Køte, 1988b
		Baltic Sea (4-8) Fjord/Baltic Sea (15-20)	Ulff Sund Isefjord	Denmark Denmark	60 80	60 50	1-100 22.3/ 1-200	9.48 11.2	Køte, 1988b Køte, 1988b
		Kattegat (30-34)	Kattegat	Denmark	36	50	6.1/1-22	3.05	Køte, 1988b
		River	River Thames	England/UK	ND	ND	ND	ND	Norton et al., 2004
		Brackish-water reservoir (1.3-14.3)	Cavendish Dock, Barrow-in-Furness	England/UK	12	25	1-26	ND	Markowski, 1966
		River	River Ötter	England/UK	233	0.4	2/2 11.8/ 1-54	0.008	Kennedy et al., 1992
		River	River Clyst	England/UK	59	10.2	1-54	ND	Kennedy et al., 1992
		Baltic Sea	Kiel	Germany	ND	ND	ND	ND	Möller, 1975
		Baltic Sea	Hiddensee	Germany	ND	ND	ND	ND	Reimer, 1970
		Baltic Sea	Bight of Wismar	Germany	104	ND	ND	ND	Reimer, 1987
		Baltic Sea	Greifswalder Bodden	Germany	28	ND	ND	ND	Reimer, 1987
		Lagoon/Baltic Sea	Lassan /Peenestrom	Germany	205	ND	ND	ND	Reimer, 1987
		Baltic Sea	Rügen Island	Germany	ND	ND	ND	ND	Palm et al., 1999
		Baltic Sea	Bight of Mecklenburg, Salzhaff	Germany	ND	ND	ND	ND	Palm et al., 1999
		Baltic Sea (12-18)	Kiel Fjord	Germany	30	40	10.8/ 1-64	4.32	Jakob et al., 2009
		Baltic Sea (10-20)	Maasholm	Germany	30	46	9.7/1-56	4.48	Jakob et al., 2009
		North Sea (32-35)	Helgoland	Germany	20	20	1.3/1-2 34.6/ 1-180	0.26	Jakob et al., 2009
		Baltic Sea (15-20) Creek/Atlantic	Fehmarn Belt	Germany	30	36.6	104.6/ 2-379	12.66	Jakob et al., 2009 Kristmundsson & Helgason, 2007
		Lagoon/Thyrrhenian Sea (10-40)	Grafarvogur Lake Burano	Iceland Italy	20 187	85.0 32.1	ND	88.9	Kennedy et al., 1997
		Lagoon/Thyrrhenian Sea (28-48)	Lake Fogliano	Italy	20	40.0	ND	1.80/2.93	Kennedy et al., 1997
		Lagoon/Thyrrhenian Sea (17-39)	Lake Monaci	Italy	44	36.4	ND	4.34/14.13	Kennedy et al., 1997
		Lagoon/Thyrrhenian Sea (32-44)	Lake Caprolace	Italy	38	44.7	ND	1.79/2.69	Kennedy et al., 1997
		Lagoon/Adriatic Sea (15-35)	Valle Figheri/Adriatic Coast	Italy	33	93.9	ND	38.6/60.9	Di Cave et al., 2001

Phylum/Family	Infection site	Habitat (Salinity)	Locality	Country	n	P (%)	m/l	mASD	Author of record
		Lagoon/Adriatic Sea	Comacchio /Adriatic Coast	Italy	42	73.8	ND	29.7/67	Di Cave et al., 2001
		Lagoon/Adriatic Sea	Acquatina/ Adriatic Coast	Italy	21	19.0	ND	0.3/0.9	Di Cave et al., 2001
		Lake	Lake Dąbie	Poland	83	ND	ND	ND	Seyda, 1973 Orecka-Grabda & Wierzbicka, 1994
		Lagoon/Baltic Sea	Piastowski Canal (Szczecin Lagoon)	Poland	20	10.0	1-15	0.30	Orecka-Grabda & Wierzbicka, 1994
		Lagoon/Baltic Sea	Trzebiez (Szczecin Lagoon)	Poland	71	5.6	2-63	1.22	Wierzbicka, 1994
		Baltic Sea	Gdansk Bay	Poland	17	17.6	13/2-30	ND	Wierzbicka, 1994 Rokicki, 1975
		Estuary/Atlantic	Ria de Aveiro	Portugal	134	47.0	1-732	15.49/67.17	Hermida et al., 2008
		Estuary/Atlantic	Hortas/Tagus estuary	Portugal	30	13	1/1 22.1/	0.13	this paper
		Estuary/Atlantic (30)	Arousa	Spain	477	57.0	1-419 33.6/	12.6/5.0	Outeiral et al., 2001
		Estuary/Atlantic (30)	Ferrol	Spain	479	53.2	1-396	17.9/46.1	Outeiral et al., 2001
		Lagoon/Mediterranean Sea (3-30)	Encanyissada, Ebro Delta	Spain	ND	14.9	ND	0.57/4.56	Mafllo et al., 2005
		Lagoon/Mediterranean Sea (8-36)	Tancada, Ebro Delta	Spain	ND	41.0	ND	2.31/10.77	Mafllo et al., 2005
Family Heterophyidae Odhner, 1914		Lagoon/Mediterranean Sea (8-30)	Canal Vell, Ebro Delta	Spain	ND	23.1	ND	1.13/4.72	Mafllo et al., 2005
<i>Cryptocotyle lingua</i> (Creplin, 1825)	i	River	River Danube	Czech Republic	ND	ND	ND	ND	Moravec, 2001
<i>Metagonimus yokogawai</i> Katsurada, 1912	f, sc	River	River Danube	Czech Republic	ND	ND	ND	ND	Moravec, 2001
Family Gorgoderidae		River	River Clyst	England/UK	206	16.5	3.8/1-15	0.63	Kennedy et al., 1992
<i>Phylodistomum folium</i> (Olfers, 1816)	ubl	River	River Teifi, Cardiganshire	Wales/UK	ND	ND	ND	ND	Chappell & Owen, 1969
<i>Phylodistomum simile</i> Nybelin, 1926	ubl	River	Dunkellin River	Ireland	117	1.7	1.0	0.02	Callaghan & McCarthy, 1996
<i>Phylodistomum</i> sp.		River	Dunkellin River	Ireland	117	1.7	1.0	0.02	Callaghan & McCarthy, 1996
Family Zoogonidae		Lagoon/Thyrrhenian Sea (10-40)	Lake Burano	Italy	187	0.5	ND	0.05/0.1	Kennedy et al., 1997
<i>Limnodreterema</i> sp.	i	Lagoon/Thyrrhenian Sea (10-40)	Lake Burano	Italy	187	0.5	ND	0.05/0.1	Kennedy et al., 1997
Family unknown		Lake	Lake Balaton	Hungary	14	ND	ND	ND	Murai, 1971
<i>Crowcoecaecum skrjabinii</i> (Iwanitzky, 1928)		Lake	Lake Balaton	Hungary	14	ND	ND	ND	Murai, 1971
CLASS MONOGENEA									
Family Ancrycocephalidae									
Bychowsky, 1937									
<i>Pseudodactylogyrus anguillae</i> (Yin & Sproston, 1948)	g	Lake	Lake Neusiedler	Austria	141	66.6	7/1-57	4.62	Gelnar et al., 1996

Phylum/Family	Infection site	Habitat (Salinity)	Locality	Country	n	P (%)	ml/l	mA/SD	Author of record
	River		Danube River Basin	Czech Republic	312	40.0	3-65	ND	Škoriková et al., 1996
	River		Sázava River	Czech Republic	312	54.0	1-12	ND	Škoriková et al., 1996
	Water Reservoir		Želivka water reservoir	Czech Republic	312	30.0	1-6	ND	Škoriková et al., 1996
	River		Metuje River	Czech Republic	312	80.0	1-9	ND	Škoriková et al., 1996
	River		Úhlavaka River	Czech Republic	312	71.0	ND	ND	Škoriková et al., 1996
	River		Ohře River	Czech Republic	312	23.0	1-2	ND	Škoriková et al., 1996
	River		Lužnice River	Czech Republic	312	20.0	ND	ND	Škoriková et al., 1996
	Water Reservoir		Orlík water reservoir	Czech Republic	312	75.0	ND	ND	Škoriková et al., 1996
	Lake/Pond		Břehyně Brook/Lake Mácha fish pond system	Czech Republic	312	42.0	ND	ND	Škoriková et al., 1996
	Lake		Lake Esrum	Denmark	120	66.7	10/1-50	6.67	Køie, 1988a
	Lake		Lake Arresø	Denmark	30	50	6.8/2-22	3.4	Køie, 1988b
	Lake		Lake Sjørelø	Denmark	20	20	6.0/2-15 23.6/	1.2	Køie, 1988b
	Baltic Sea (4-8)		Ulf Sund	Denmark	60	60	1-100	14.1	Køie, 1988b
	Fjord/North Sea (10)		Ringkøbing Fjord	Denmark	24	54.2	3.1/1-6 19.0/	1.67	Køie, 1988b
	Fjord/Baltic Sea (15-20)		Isefjord	Denmark	80	37.5	1-100	7.12	Køie, 1988b
	River		River Clyst	England/UK	206	81.1	20.1	16.3	Kennedy et al., 1992
	River		River Otter	England/UK	233	40.3	4.9	1.97	Kennedy et al., 1992
	Estuary/North Sea		Exminster Marshes	England/UK	64	90.6	25.8	23.4	Kennedy et al., 1992
	River		Rivers southeastern France	France	ND	ND	ND	ND	Buchmann et al. 1987
	Baltic Sea		Bight of Wismar	Germany	104	ND	ND	ND	Reimer, 1987
	Lake		Lake Balaton	Hungary	81	7.4	ND	ND	Molnár & Székely, 1995
	River		Dunkellin River	Ireland	ND	ND	ND	ND	Holland & Kennedy, 1997
	Lake		Lough Derg	Ireland	ND	ND	ND	ND	Holland & Kennedy, 1997
	River		River Corrib	Ireland	ND	ND	ND	ND	McCarthy & Rita, 1991
	Lake		Lough Rea	Ireland	32	56.3	16.2	9.09	Callaghan & McCarthy, 1996
	Lake		Assaroe Lake, Co Donegal/River Erne catchment	Ireland	45	64.4	15.6/ 1-76 26.7/	10.0	Copley & McCarthy, 2001
	Lake		Lough Ardara, Co Cavan/River Erne catchment	Ireland	18	100	2-137	26.7	Copley & McCarthy, 2001
	River		River Tiber	Italy	101	55.4	ND	ND	Kennedy et al., 1998
	Lagoon/Thyrrhenian Sea (10-40)		Lake Burano	Italy	187	33.7	ND	1.44/2.54	Kennedy et al., 1997
	Lagoon/Adriatic Sea (15-35)		Valle Figheri/Adriatic Coast	Italy	33	54.5	ND	10.3/21.4	Di Cave et al., 2001
	Lagoon/Adriatic Sea (30-42)		Acquatina/ Adriatic Coast	Italy	21	4.8	ND	0.2	Di Cave et al., 2001

Phylum/Family	Infection site	Habitat (Salinity)	Locality	Country	n	P (%)	m/l	m/SD	Author of record
<i>Pseudodactylogyrus bini</i> (Kikuchi, 1929)	Lake/River/Baltic Sea	Lake Usmas, Venta River, Gulf of Riga	Latvia	ND	ND	ND	ND	ND	Kirjušina & Vismānis, 2007 Sobecka & Pilecka-Rapacz, 2003
	River	Rivers Radaw, Rega, Wieprza	Poland	201	ND	ND	ND	ND	Hermida et al., 2008
	Estuary/Atlantic River	Ria de Aveiro	Portugal	134	31.3	6.1/1-45	1.90/5.05	ND	Saraiva & Chubb, 1989
	Lagoon/Baltic Sea	River Este	Portugal	129	36.4	ND	ND	ND	Rodjuk & Shelenkova, 2006
	Estuary/Atlantic (30)	Vistula Lagoon	Russia	142	1.4	1-2	0.014	0.03/0.47	Rodjuk & Shelenkova, 2006
	Estuary/Atlantic (30)	Arousa	Spain	477	0.6	4.3/1-10	0.03/0.47	0.04/0.96	Outeiral et al., 2002
	Lagoon/Mediterranean Sea (3-30)	Ferrol	Spain	479	0.2	21/21	0.04/0.96	0.04/0.96	Outeiral et al., 2002
	Lagoon/Mediterranean Sea (8-36)	Encanyissada Ebro Delta	Spain	ND	75.9	ND	21.25/29.93	ND	Mañflo et al., 2005
	Lagoon/Mediterranean Sea (8-30)	Tancada Ebro Delta	Spain	ND	84.6	ND	14.08/19.69	ND	Mañflo et al., 2005
	Lake	Canal Vell Ebro Delta	Spain	ND	35.9	ND	1.26/3.55	ND	Mañflo et al., 2005
	Lake	Lake Neusiedler	Austria	141	58.8	6/1-52 125/	3.48	ND	Gelnar et al., 1996
	Lake	Ischler Ache	Austria	9	77.7	3-363	97.2	ND	Gelnar et al., 1996
	River	Ploučnice River	Czech Republic	312	90.0	85-1451	ND	ND	Škoriková et al., 1996
	River	Úhlavaka River	Czech Republic	312	71.0	ND	ND	ND	Škoriková et al., 1996
	River	Ohře River	Czech Republic	312	29.0	2-10	ND	ND	Škoriková et al., 1996
	River	Lužnice River	Czech Republic	312	10.0	ND	ND	ND	Škoriková et al., 1996
	Water Reservoir	Orlík water reservoir	Czech Republic	312	78.0	ND	ND	ND	Škoriková et al., 1996
	Lake/Pond	Břehyně Brook/Lake Mácha fish pond system	Czech Republic	312	87.0	ND	ND	ND	Škoriková et al., 1996
	Lake	Lake Esrum	Denmark	120	3.3	1.5/1-2	0.05	0.05	Køie, 1988a
	Lake	Lake Balaton	Hungary	81	4.9	ND	ND	ND	Molnár & Székely, 1995
	Lake	Assaroe Lake, Co Donegal/River Erne catchment	Ireland	45	84.4	1-344	30.6	30.6	Copley & McCarthy, 2001
	River	River Tiber	Italy	101	28.7	ND	ND	ND	Kennedy et al., 1998
	Lagoon/Adriatic Sea (15-35)	Valle Figheri/Adriatic Coast	Italy	33	3.0	ND	0.1	0.1	Di Cave et al., 2001
Lake/River/Baltic Sea	Lake Usmas, Venta River, Gulf of Riga	Latvia	ND	ND	ND	ND	ND	Kirjušina & Vismānis, 2007 Sobecka & Pilecka-Rapacz, 2003	
River	Rivers Radaw, Rega, Wieprza	Poland	201	ND	ND	ND	ND	this paper	
Baltic Sea (0-4)	Kotka/Gulf of Finland	Finland	30	16	1-183	6.72	6.72	Sures et al., 1999	
River	River Rhine (Leimersheim er Altrhein)	Germany	61	45.9	ND	ND	ND	Sures et al., 1999	
River	River Rhine (harbour of Germersheim)	Germany	60	45.0	ND	ND	ND	Sures et al., 1999	
River	River Rhine (Worms)	Germany	35	94.3	ND	ND	ND	Sures & Streit, 2001	
River	River Rhine (Karlsruhe)	Germany	19	89.5	ND	ND	ND	Sures & Streit, 2001	

Phylum/Family	Infection site	Habitat (Salinity)	Locality	Country	n	P (%)	ml/l	mA/SD	Author of record
	River		River Weser (Schlüsselburg)	Germany	291	57.7	ND	ND	Reimer, 2004
	Lake		Lake Constance/Langenangen	Germany	24	95.8	ND	ND	Thielen, 2005
	River		River Rhine/Laufenburg	Germany	64	62.5	ND	ND	Thielen, 2005
	Stream		Sulzbach/Laufenburg	Germany	36	19.4	ND	ND	Thielen, 2005
	Stream		Eizerbach/Laufenburg	Germany	10	33.3	ND	ND	Thielen, 2005
	River		River Main/Gemünden	Germany	22	100	ND	ND	Thielen, 2005
	River		River Rhine/St. Goar	Germany	29	89.7	ND	ND	Thielen, 2005
	River		River Ruhr/Mühlheim	Germany	12	100	ND	ND	Thielen, 2005
	River		River Lippe/Hünxe	Germany	31	87.1	ND	ND	Thielen, 2005
	Lake		Muggelsee/Berlin	Germany	36	ND	11.2/ 11.2/	ND	Thielen, 2005
	Lake		Lake Plön	Germany	30	76	1-62 64.3/	8.56	Jakob et al., 2009
	River		River Eider	Germany	30	100	3-236 26.2/	64.3	Jakob et al., 2009
	Baltic Sea (12-18)		Kiel Fjord	Germany	30	43.3	1-202 4.78/	11.43	Jakob et al., 2009
	Baltic Sea (10-20)		Maasholm	Germany	30	46	1-36 11.26/	2.20	Jakob et al., 2009
	Baltic Sea (15-20)		Fehmarn Belt	Germany	30	76	1-62 20.5/	8.56	Jakob et al., 2009
	River		River Elbe Estuary	Germany	30	80	1-147 15.1/1-	16.4	this paper
	River		River Elbe (Gorleben)	Germany	30	53.3	11.5	8.07	this paper
	River		River Tiber	Italy	101	16.8	ND	ND	Kennedy et al., 1998
	River		River Rhine/Leeuwen	Netherlands	43	20.9	ND	ND	Thielen, 2005
	Lake		IJsselmeer/Makkum	Netherlands	30	33.3	ND	ND	Thielen, 2005
	Estuary/Atlantic		Hortas/Tagus estuary	Portugal	30	46.6	7.8/1-31 40.58/	3.58	this paper
	River		River Ulla	Spain	323	56.0	1-644 30.24/	22.74/66.64	Aguilar et al., 2005
	River		River Tea	Spain	200	61.5	1-602	18.6/61.87	Aguilar et al., 2005
Family Tetraonchidae Bychowsky, 1937									
<i>Tetraonchus</i> sp.			Lake Liepājas	Latvia	ND	ND	ND	ND	Kirjušina & Vismannis, 2007
Family Gyrodactylidae Van Beneden & Hesse, 1863									
<i>Gyrodactylus anguillicae</i> Ergens, 1960			River Weser (Schlüsselburg)	Germany	291	7.6	ND	ND	Reimer, 2004
			River Tiber	Italy	230	12.6	ND	ND	Kennedy et al., 1998
			Valle Figheri/Adriatic Coast (15-35)	Italy	33	3.0	ND	0.1	Di Cave et al., 2001

Phylum/Family	Infection site	Habitat (Salinity)	Locality	Country	n	P (%)	ml/l	mASD	Author of record
<i>Gyrodactylus lucii</i> Kulakovskaja, 1951	f, sk	Baltic Sea	Neva Bight	Russia	ND	ND	ND	ND	Reimer, 1987 Bykhovskaya-Pavlovskaya et al., 1964
<i>Gyrodactylus</i> spp.	g	Freshwater	former U.S.S.R.	former U.S.S.R.	ND	ND	ND	ND	Moravec, 2001
Family Diplozoidae Palombi, 1949		River	River Danube	Czech Republic	ND	ND	ND	ND	Køte, 1988b
<i>Diplozoon paradoxum</i> Nordmann, 1832	g	Fjord/Baltic Sea (15-20)	Isefjord	Denmark	80	ND	ND	ND	Kirjušina & Vismamis, 2007
CLASS CESTODA		Lake	Lake Liepājas	Latvia	ND	ND	ND	ND	
Family Acrobothriidae Olsson, 1872		Lake	Llyn Padarn, Caernavornshire	Wales/UK	ND	ND	ND	ND	Chubb, 1970
<i>Cyathocephalus truncatus</i> (Pallas, 1781)	i	Lake							
Family Lytocestidae Hunter, 1927		River	River Este	Portugal	47	2.1	1.0	0.02/0.15	Saraiva et al., 2005
<i>Khawia baltica</i> Szidat, 1942	i	River	River Tiber	Italy	230	0.4	ND	ND	Kennedy et al., 1998
Family Caryophyllaeidae Leuckart, 1878		River							
Caryophyllaeidae gen. sp.									
Family Tentaculidae Poche, 1926		Estuary/Atlantic	Hortas/Tagus estuary	Portugal	30	3.3	1/1	0.03	this paper
<i>Tentacularia coryphaenae</i> (Bosc, 1797)	i	Black Sea	Black Sea	ND	ND	ND	ND	ND	Reimer, 1999
<i>Tentaculartasp.</i>									
Family Grilloiidae Dollfus, 1969		River	River Rhine	Germany	ND	ND	ND	ND	Reimer, 1999
<i>Grilloia erinaceus</i> (van Beneden, 1858)		Estuary/Atlantic (30)	Arousa	Spain	477	1.9	1.7/1-6	0.03/0.31	Outeiral et al., 2002
<i>Grilloia</i> sp.		Estuary/Atlantic (30)	Ferrol	Spain	479	1.5	2.7/1-6	0.04/0.41	Outeiral et al., 2002
Family Phyllobothriidae Braun, 1900		North Sea (32-35)	Helgoland	Germany	20	5	1/1	0.05	Jakob et al., 2009
Tetraphyllidea gen. sp.		Fjord/North Sea (10)	Ringkøbing Fjord	Denmark	24	16.6	2.5/1-4	0.04	Køte, 1988b
(<i>Scolex pleuronectis</i> Müller, 1788)	i	Lagoon/Adriatic Sea (30-42)	Acquatina/ Adriatic Coast	Italy	21	4.8	ND	0.1	Di Cave et al., 2001
		Estuary/Atlantic (30)	Arousa	Spain	477	0.8	2.3/1-5	0.02/0.24	Outeiral et al., 2002
		Estuary/Atlantic (30)	Ferrol	Spain	479	3.1	3.5/1-5	0.11/0.87	Outeiral et al., 2002
Order Pseudophyllidea Carus, 1863									

Phylum/Family	Infection site	Habitat (Salinity)	Locality	Country	n	P (%)	m/I	m/SD	Author of record
Pseudophyllidea gen. sp. Family Bothriocephalidae Blanchard, 1849 <i>Bothriocephalus claviceps</i> (Goeze, 1782)	i, iw	Creek/Atlantic (30-33)	Grafarvogur	Iceland	20	10.0	2.0/2	0.2	Kristmundsson & Helgason, 2007
	i	Lake	Lake Neusiedler	Austria	720	0.6-26.8	1.0-15.0	0.0-3.0	Schabuss et al., 2005
		River	River Leie, River Scheld	Belgium	107	0.93	2/2	0.02	Schabuss et al., 1997
		Lake	Lake Máchá	Czech Republic	132	42	8/1-112	3.3	Moravec, 1985
		River	Rivers Elbe, Lužnice, Matka, Sázava and Vltava	Czech Republic	ND	ND	ND	ND	Moravec, 2001
		Water	Orlická, Řimovská, Mrázov; Máchovo jezero	Czech Republic	ND	ND	ND	ND	Moravec, 2001
		Reservoir/Pond	pond system; South Bohemian ponds	Czech Republic	ND	ND	ND	ND	Moravec, 2001
		Lake	Lake Esrum	Denmark	120	24.2	1.8/1-7	0.43	Køte, 1988a
		Lake	Lake Arresø	Denmark	30	3.3	1/1	0.03	Køte, 1988b
		Lake	Lake Sjøelsø	Denmark	20	15	1.3/1-2	0.19	Køte, 1988b
		Baltic Sea (4-8)	Ulf Sund	Denmark	60	31.7	2.3/1-6	0.73	Køte, 1988b
		Fjord/North Sea (10)	Ringkøbing Fjord	Denmark	24	4.2	1/1	0.04	Køte, 1988b
		Fjord/Baltic Sea (15-20)	Isefjord	Denmark	80	2.5	1/1	0.02	Køte, 1988b
		River	River Thames	England/UK	ND	ND	ND	ND	Norton et al., 2004
		River	River Test	England/UK	ND	ND	ND	ND	Norton et al., 2004
		Lake	Shobrooke Lake	England/UK	131	42.8	3.9/1-31	1.64	Kennedy et al., 1992
		Estuary/North Sea	Exminster Marshes	England/UK	64	7.8	1/1	0.08	Kennedy et al., 1992
		River	River Clyst (River Exe system)	England/UK	206	19.9	1.6/1-9	0.32	Kennedy et al., 1992
		River	River Clyst (River Exe system)	England/UK	19	21.0	ND	0.3/0.7	Kennedy, 2001
		River	River Otter (River Exe system)	England/UK	30	16.7	ND	0.3/0.7	Kennedy, 2001
		River	Stoodly Bridge (River Exe system)	England/UK	10	30.0	ND	0.7/1.1	Kennedy, 2001
		River	Bickleigh (River Exe system)	England/UK	10	20.0	ND	0.2/0.4	Kennedy, 2001
		River	River Culm (River Exe system)	England/UK	74	10.1	ND	0.2/0.6	Kennedy, 2001
		River	River Creedy (River Exe system)	England/UK	26	20.7	ND	0.3/0.8	Kennedy, 2001
		River	Alphin Brook (River Exe system)	England/UK	23	4.3	ND	0.04/0.2	Kennedy, 2001
		Freshwater	Worcestershire	England/UK	ND	ND	ND	ND	Baylis, 1928
		Lake	Windermere catchment area	England/UK	ND	ND	ND	ND	Frost, 1946
		Reservoir/freshwater	Hanningford Reservoir/Essex	England/UK	4	50	6.5	3.3	Wooten, 1973
		Baltic Sea (0-4)	Kotka/Gulf of Finland	Finland	30	30	2,4/1-4	0.7	this paper
		Baltic Sea	Kiel	Germany	ND	ND	ND	ND	Möller, 1975
		Baltic Sea	Greifswalder Bodden	Germany	ND	1.5	ND	ND	Engelbrecht, 1958
		Baltic Sea	Hiddensee	Germany	ND	ND	ND	ND	Reimer, 1970
		Baltic Sea	Greifswalder Bodden	Germany	ND	ND	ND	ND	Reimer, 1970
		Baltic Sea	Bight of Wismar	Germany	104	ND	ND	ND	Reimer, 1987

Phylum/Family	Infection site	Habitat (Salinity)	Locality	Country	n	P (%)	m/l	m/ASD	Author of record
	Lagoon/Baltic Sea	Lassan /Peenestrom	Germany	205	ND	ND	ND	ND	Reimer, 1987
	Baltic Sea	Rügen Island	Germany	ND	ND	ND	ND	ND	Palm et al., 1999
	Lake	Lake Constance/Langenargen	Germany	24	37.5	2.3/1-7	0.87	0.87	Thielen, 2005
	River	River Rhine/Laufenburg	Germany	64	23.4	2.4/1-7	0.55	0.55	Thielen, 2005
	Stream	Eizerbach/Laufenburg	Germany	10	40.0	1/1	0.4	0.4	Thielen, 2005
	River	River Ruhr/Mühlheim	Germany	12	16.7	1.0	0.2	0.2	Thielen, 2005
	Lake	Muggelsee/Berlin	Germany	36	25.0	1.4	0.4	0.4	Thielen, 2005
	Lake	Lake Plön	Germany	30	60	2.3/1-5	1.38	1.38	Jakob et al., 2009
	River	River Eider	Germany	30	46	3/1-9	1.38	1.38	Jakob et al., 2009
	Baltic Sea	Fehmarn Belt	Germany	30	13	1/1	0.13	0.13	Jakob et al., 2009
	River	River Elbe Estuary	Germany	30	33.3	6.1/1-23	2.01	2.01	this paper
	River	River Elbe (Gorleben)	Germany	30	50	3/1-14	1.8	1.8	this paper
	River	River Rhine (Leimersheimer Altrhein)	Germany	61	4.9	3.7	0.2/0.8	0.2/0.8	Sures et al., 1999
	River	River Rhine (harbour of Germersheim)	Germany	60	21.7	4.7	1.0/2.5	1.0/2.5	Sures et al., 1999
	River	River Rhine (Worms)	Germany	35	5.7	5.0	0.3/1.5	0.3/1.5	Sures & Streit, 2001
	River	River Rhine (Karlsruhe)	Germany	19	15.8	1.7	0.3/0.7	0.3/0.7	Sures & Streit, 2001
	River	River Weser (Schlüsselburg)	Germany	291	2.4	ND	ND	ND	Reimer, 2004
	Lake	Lake Balaton	Hungary	81	1.2	ND	ND	ND	Molnár & Székely, 1995
	Lake	Lake Balaton	Hungary	14	35.7	1-50	ND	ND	Murai, 1971
	Lake	Lough Arrow/River Boyne	Ireland	6	16.6	ND	ND	ND	Kane, 1966
	River	River Boyne	Ireland	ND	ND	ND	ND	ND	Kennedy, 1966
	River	River Abbert	Ireland	33	6	1	0.06	0.06	Conneely & McCarthy, 1986
	River	River Drumneen	Ireland	49	4	1	0.04	0.04	Conneely & McCarthy, 1986
	Lake	Lake Corrib	Ireland	39	23	1.7	0.39	0.39	Conneely & McCarthy, 1986
	River	Dunkellin River	Ireland	117	4.8	1.0	0.04	0.04	Callaghan & McCarthy, 1996
	River	Rafford River	Ireland	125	1.6	2.5	0.04	0.04	Callaghan & McCarthy, 1996
	Lake	Lough Rea	Ireland	32	40.6	3.6	1.47	1.47	Callaghan & McCarthy, 1996
	Lake	Lough Derg	Ireland	ND	ND	ND	ND	ND	Holland & Kennedy, 1997
	Lake	Assaroe Lake, Co Donegal/River Erne catchment	Ireland	45	26.6	ND	ND	ND	Copley & McCarthy, 2005
	Lake	Lough Ardan, Co Cavan/River Erne catchment	Ireland	18	22.2	2	0.44	0.44	Copley & McCarthy, 2005
	Lake	Lake Vífilsstaðavatn	Iceland	30	26.6	5.7/1-25	1.5	1.5	Kristmundsson & Helgason, 2007
	River	River Tiber	Italy	101	2.2 / 1.0	ND	ND	ND	Kennedy et al., 1998

Phylum/Family	Infection site	Habitat (Salinity)	Locality	Country	n	P (%)	m/l	mA/SD	Author of record
		Lakes/Baltic Sea	Lakes Rāznas, Rušons, Usmas, Kegums Water Reservoir, Venta River, Gulf of Riga	Latvia	ND	ND	ND	ND	Kirjušina & Vismānis, 2007
		Lake	Ijsselmeer/Makkum	Netherlands	30	10.0	4.0	0.4	Thielen, 2005
		River	West Odra River/Stolezyn	Poland	83	ND	ND	ND	Seyda, 1973
		Lagoon/Baltic Sea	Szczecin Firth	Poland	83	ND	ND	ND	Seyda, 1973
		Lake	Lake Dąbie	Poland	83	ND	ND	ND	Seyda, 1973
		Lagoon/Baltic Sea	Piastowski Canal (Szczecin Lagoon)	Poland	20	15.0	1	0.15	Orecka-Grabda & Wierzbicka, 1994
		Lagoon/Baltic Sea	Lubin (Szczecin Lagoon)	Poland	25	52.0	1-3	0.84	Orecka-Grabda & Wierzbicka, 1994
		Lagoon/Baltic Sea	Trzebiez (Szczecin Lagoon)	Poland	71	33.8	1-5	0.75	Orecka-Grabda & Wierzbicka, 1994
		Lagoon/Baltic Sea	Stepnica (Szczecin Lagoon)	Poland	30	26.7	1-2	0.37	Orecka-Grabda & Wierzbicka, 1994
		Lagoon/Baltic Sea	Nowe Warpno (Szczecin Lagoon)	Poland	13	61.5	1	0.61	Orecka-Grabda & Wierzbicka, 1994
		Estuary/Baltic Sea	River Odra Mouth	Poland	24	29.2	1-3	0.42	Orecka-Grabda & Wierzbicka, 1994
		Baltic Sea	Gdansk Bay	Poland	ND	ND	ND	ND	Reimer, 1987
		Estuary/Atlantic	Ria de Aveiro	Portugal	134	2.2	1.7/1-3	0.04/4.97	Hermida et al., 2008
		River	River Trovela	Portugal	55	7.3	2.0/1-4	0.15/0.62	Saraiva et al., 2005
		River	River Covo	Portugal	79	1.3	1.0	0.01/0.11	Saraiva et al., 2005
		River	River Sousa	Portugal	93	3.2	1.3/1-2	0.04/0.25	Saraiva et al., 2005
		River	River Este	Portugal	129	6.2	ND	ND	Saraiva & Chubb, 1989
		Lagoon/Baltic Sea	Vistula Lagoon	Russia	142	0.7	2	0.014	Rodjuk & Shelenkova, 2006
		Estuary/Baltic Sea	Neva-Bight	Russia	ND	ND	ND	ND	Reimer, 1987
		River	River Danube	Slovak Republic	ND	ND	ND	ND	Moravec, 2001
		Lagoon, Mediterranean Sea (2)	Encanyissada, Ebro Delta	Spain	ND	1.4	ND	0.04/1.41	Mañño et al., 2005
		River	River Ulja	Spain	323	0.62	5/3-7	0.03/0.42	Aguilar et al., 2005
		River	River Tea	Spain	200	1.0	1	0.01/0.10	Aguilar et al., 2005
		Lake	Llyn Tegid (Lake Bala), Merionethshire	Wales/UK	ND	ND	ND	ND	Chubb, 1970
		Lake	Llyn Padarn, Caernarvonshire	Wales/UK	ND	ND	ND	ND	Chubb, 1970
		Freshwater	former U.S.S.R.	former U.S.S.R.	ND	ND	ND	ND	Bykhovskaya-Pavlovskaya et al., 1964
		Lagoon/Baltic Sea	Lagoon/Baltic Sea	Germany	ND	ND	ND	ND	Reimer, 1999
		Estuary/Atlantic (30)	Ferrol	Spain	479	0.2	1/1	0.002/0.044	Outeiral et al., 2002
<i>Bothriocephalus scarpai</i>	i								
<i>Bothriocephalus</i> sp.	i								
Family Triaenophoridae									
Lönnberg, 1889									
<i>Eubothrium crassum</i> (Bloch, 1779)	i	Lake	Lake Neusiedler	Austria	40	65	1-23/2	8.32	Kritscher, 1988

Phylum/Family	Infection site	Habitat (Salinity)	Locality	Country	n	P (%)	ml/l	mASD	Author of record
<i>Triacanthophorus lucii</i> (Müller, 1776)	li	River	River Severn, Montgomeryshire	Wales/UK	19	5.3	3/3	0.16	Rawson, 1952
<i>Triacanthophorus nodulosus</i> (Pallas, 1781)	li	Freshwater	freshwaters of Czech and Slovak Republic	Czech Republic / Slovak Republic	ND	ND	ND	ND	Moravec, 2001
		Lake	Lakes Liepājas	Latvia	ND	ND	ND	ND	Kirjušina & Viismanis, 2007
		River	River Severn, Montgomeryshire	Wales/UK	ND	ND	ND	ND	Kennedy, 1974
<i>Triacanthophorus tricuspidatus</i> (Bloch, 1779)		Freshwater	former U.S.S.R.	former U.S.S.R.	ND	ND	ND	ND	Bykhovskaya-Pavlovskaya et al., 1964
Family Diphyllotothriidae		Baltic Sea	Greifswalder Bodden	Germany	ND	5.3	ND	ND	Engelbrecht, 1958
<i>Diphyllotothrium latum</i> (Linnaeus, 1758)	li, mu	Freshwater	former U.S.S.R.	former U.S.S.R.	ND	ND	ND	ND	Bykhovskaya-Pavlovskaya et al., 1964
Family Proteocephalidae La Rue, 1911									
<i>Proteocephalus macrocephalus</i> (Creplin, 1825)	i	Lake	Lake Neusiedler	Austria	720	1.3-24.2	1.5-6.5 5.44/	0.0-0.7	Schabuss et al., 2005
		Lake	Lake Neusiedler	Austria	40	45	1-51	2.45	Kritscher, 1988
		River	River Leie, River Scheld	Belgium	107	42.1	6.69	2.81	Schabuss et al., 1997
		River	Rivers Lužnice, Ohře and Vltava	Czech Republic	ND	ND	ND	ND	Moravec, 2001
		Water	Mrázov, Otlická and Želivská; South Bohemian ponds						
		Reservoir/Ponds							
		River	River Lužnice	Czech Republic	ND	ND	ND	ND	Moravec, 2001
		Lake	Lake Esrum	Czech Republic	2	100	16.5	16.5	Scholz & Kepr, 1988
		Lake	Lake Arresø	Denmark	120	7.5	2.0/1-6	0.15	Køite, 1988a
		Lake	Lake Sjølsø	Denmark	30	13.3	1/1	0.13	Køite, 1988b
		Lake	Ulf Sund	Denmark	20	25	1.2/1-2	0.3	Køite, 1988b
		Baltic Sea (4-8)	Ulf Sund	Denmark	60	25	3.2/1-11	0.8	Køite, 1988b
		Fjord/North Sea (10)	Ringkøbing Fjord	Denmark	24	41.7	2.5/1-7	1.04	Køite, 1988b
		Fjord/Baltic Sea (15-20)	Isefjord	Denmark	80	2.5	1/1	0.03	Køite, 1988b
		River	River Thames	England/UK	ND	ND	ND	ND	Norton et al., 2004
		River	River Test	England/UK	ND	ND	ND	ND	Norton et al., 2004
		River	River Otter	England/UK	ND	ND	ND	ND	Kennedy, 1974
		Brackish water							
		reservoir (1.3-14.3)	Cavendish Dock, Barrow-in-Furness	England/UK	12	16	1	0.16	Markowski, 1966
		Reservoir/freshwater	Hanningford Reservoir/Essex	England/UK	4	50	2.5	1.25	Wooten, 1973
		River	River Clyst (River Exe system)	England/UK	206	7.3	2.3/1-8	0.17	Kennedy et al., 1992
		River	River Otter (River Exe system)	England/UK	233	7.3	1.8/1-5	0.13	Kennedy et al., 1992
		River	River Otter (River Exe system)	England/UK	ND	ND	ND	ND	Kennedy 1997
		River	Alphin Brook (River Exe system)	England/UK	23	8.6	ND	0.09/0.03	Kennedy, 2001

Phylum/Family	Infection site	Habitat (Salinity)	Locality	Country	n	P (%)	ml/l	mA/SD	Author of record
		Baltic Sea (0-4)	Kotka/Gulf of Finland	Finland	30	16	5.8/1-14	0.92	this paper
		Baltic Sea	Kiel/Germany	Germany	ND	ND	ND	ND	Möller, 1975
		Baltic Sea	Bight of Wismar	Germany	104	ND	ND	ND	Reimer, 1987
		Baltic Sea	Hiddensee	Germany	ND	ND	ND	ND	Reimer, 1987
		Baltic Sea	Greifswalder Bodden	Germany	28	ND	ND	ND	Reimer, 1987
		Lagoon/Baltic Sea	Lassan, Peenestrom	Germany	205	ND	ND	ND	Reimer, 1987
		Baltic Sea	Greifswalder Bodden	Germany	ND	2.2	ND	ND	Engelbrecht, 1958
		Baltic Sea	Rügen Island	Germany	ND	ND	ND	ND	Palm et al., 1999
		Lake	Lake Plön	Germany	30	86.6	5.7/1-19	9.53	Jakob et al., 2009
		River	River Eider	Germany	30	50	3.1/1-8	1.55	Jakob et al., 2009
		Baltic Sea (12-18)	Kiel Fjord	Germany	30	16.6	5.2/1-18	0.86	Jakob et al., 2009
		Baltic Sea (10-20)	Maasholm	Germany	30	13.3	2.75/1-5	0.37	Jakob et al., 2009
		Baltic Sea (15-20)	Fehmarn Belt	Germany	30	3	5.8/1-12	0.17	Jakob et al., 2009
		River	River Elbe Estuary	Germany	30	50	4.9/1-8	2.45	this paper
		River	River Elbe (Gortleben)	Germany	30	53.3	5.9/1-31	3.13	this paper
		River	River Rhine (Karlsruhe)	Germany	19	15.8	4.7	0.7/1.9	Sures & Streit, 2001
		River	River Weser (Schlüsselburg)	Germany	291	4.8	ND	ND	Reimer, 2004
		Lake	Lake Constance/Langenargen	Germany	24	20.8	2/1-5 3.42/	0.42	Thielen, 2005
		River	River Rhine/Laufenburg	Germany	64	10.9	1-10	0.37	Thielen, 2005
		River	River Rhine/St. Goar	Germany	29	3.4	4.0	0.1	Thielen, 2005
		River	River Ruhr/Mühlheim	Germany	12	25.0	1.3	0.3	Thielen, 2005
		River	River Lippe/Hünxe	Germany	31	6.5	3.0	0.2	Thielen, 2005
		Lake	Muggelsee/Berlin	Germany	36	44.4	2.4	1.1	Thielen, 2005
		Lake	Lake Balaton	Hungary	81	1.2	ND	ND	Molnár & Székely, 1995
		Lake	Lake Balaton	Hungary	14	14.3	30-80	ND	Murai, 1971
		Lake	Lake Corrib	Ireland	39	8	1	0.08	Conneely & McCarthy, 1986
		Lake	Assaroe Lake, Co Donegal/River Erne catchment	Ireland	30	16.7	6.6	1.10	Copley & McCarthy, 2005
		Lake	Lough Ardara, Co Cavan/River Erne catchment	Ireland	18	16.7	3	0.50	Copley & McCarthy, 2005
		Lake	Lough Derg	Ireland	ND	ND	ND	ND	Holland & Kennedy, 1997
		Lake	Lake Steinsmyrarfljot	Iceland	30 230 /	16.6	1.3/1-2	0.2	Kristmundsson & Helgason, 2007
		River	River Tiber	Italy	101	0.8 / 1.0	ND	ND	Kennedy et al., 1998
		Lagoon/Thyrrhenian Sea (10-40)	Lake Burano	Italy	187	8.5	ND	0.35/0.48	Kennedy et al., 1997
		Lagoon/Adriatic Sea (15-35)	Valle Figherri/Adriatic Coast	Italy	33	9.1	ND	0.3/2.5	Di Cave et al., 2001

Phylum/Family	Infection site	Habitat (Salinity)	Locality	Country	n	P (%)	m/l	mASD	Author of record
<i>Proteocephalus percae</i> (Müller, 1780) <i>Proteocephalus</i> sp.	Lakes/Baltic Sea	Lakes Liepājas, Usmas, Gulf of Riga	Latvia	ND	ND	ND	ND	ND	Kirjušina & Vismānis, 2007
	Lake	Ijsselmeer/Makkum	Netherlands	30	26.7	2.0	0.5	0.5	Thielen, 2005
	River	West Odra River/Stoleczyn	Poland	83	ND	ND	ND	ND	Seyda, 1973
	Lagoon/Baltic Sea	Szczecin Firth	Poland	83	ND	ND	ND	ND	Seyda, 1973
	Lake	Lake Dąbie	Poland	83	ND	ND	ND	ND	Seyda, 1973
	Lagoon/Baltic Sea	Piastowski Canal (Szczecin Lagoon)	Poland	20	70.0	1-4	1.25	1.25	Orecka-Grabda & Wierzbicka, 1994
	Lagoon/Baltic Sea	Lubin (Szczecin Lagoon)	Poland	25	24.0	1-2	0.32	0.32	Orecka-Grabda & Wierzbicka, 1994
	Lagoon/Baltic Sea	Trzebiez (Szczecin Lagoon)	Poland	71	50.7	1-33	2.32	2.32	Orecka-Grabda & Wierzbicka, 1994
	Lagoon/Baltic Sea	Stepnica (Szczecin Lagoon)	Poland	30	6.7	1	0.07	0.07	Orecka-Grabda & Wierzbicka, 1994
	Lagoon/Baltic Sea	Nowe Warpno (Szczecin Lagoon)	Poland	13	30.8	1-3	0.46	0.46	Orecka-Grabda & Wierzbicka, 1994
	Estuary/Baltic Sea	River Odra Mouth	Poland	24	16.7	1-2	0.25	0.25	Orecka-Grabda & Wierzbicka, 1994
	Baltic Sea	Gdansk Bay	Poland	17	41.2	1-19	ND	ND	Orecka-Grabda & Wierzbicka, 1994
	Estuary/Atlantic	Hortas/Tagus estuary	Portugal	30	3.3	1/1	0.03	0.03	Orecka-Grabda & Wierzbicka, 1994
	Lagoon/Baltic Sea	Vistula Lagoon	Russia	142	22.5	1-14	0.979	0.979	Rokicki, 1975
	Bight/Baltic Sea	Newa Bight	Russia	ND	ND	ND	ND	ND	this paper
	Estuary/Atlantic (30)	Arousa	Russia	477	2.3	2.9/1-15	0.07/0.74	0.07/0.74	Rodjuk & Shelenkova, 2006
	Estuary/Mediterranean Sea (3-30)	Ferrol	Spain	479	2.1	1.9/1-5	0.04/0.33	0.04/0.33	Reimer, 1987
	Lagoon/Mediterranean Sea (8-30)	Encanyissada, Ebro Delta	Spain	ND	2.1	ND	0.03/0.58	0.03/0.58	Outeiral et al., 2002
	Lake	Canal Vell, Ebro Delta	Spain	ND	5.1	ND	0.23/0.71	0.23/0.71	Outeiral et al., 2002
	Lake	Llyn Teigrd (Lake Bala), Merionethshire	Wales/UK	ND	ND	ND	ND	ND	Mafllo et al., 2005
Lake	Llyn Padarn, Caernavornshire	Wales/UK	ND	ND	ND	ND	ND	Chubb, 1970	
Freshwater	former U.S.S.R.	former U.S.S.R.	ND	ND	ND	ND	ND	Chubb, 1970	
Mediterranean Sea	Valencia	Spain	ND	ND	ND	ND	ND	Bykhovskaya-Pavlovskaya et al., 1964	
Canal	Shropshire Union Canal/ Backford, Cheshire	England/UK	4	25	1	0.25	0.25	Reimer, 1999	
Lake	Lake Pilon	Germany	30	43.4	6.6/1-19	2.86	2.86	Mishra & Chubb 1969	
Estuary/Atlantic	Ria de Aveiro	Portugal	134	5.2	1.4/1-2	0.07/0.34	0.07/0.34	Jakob et al., 2009	
Lakes	Llyn Teigrd (Lake Bala), Merionethshire	Wales/UK	ND	ND	ND	ND	ND	Hermida et al., 2008	
Lake	Llyn Padarn, Caernavornshire	Wales/UK	ND	ND	ND	ND	ND	Chubb, 1970	

PHYLUM NEMATODA
Family Capillariidae Railliet, 1915

Phylum/Family	Infection site	Habitat (Salinity)	Locality	Country	n	P (%)	m/l	mA/SD	Author of record	
<i>Capillaria</i> sp.	River		River Clyst	England/UK	206	3.5	1.1/1-2	0.04	Kennedy et al., 1992	
	River		River Otter	England/UK	233	3.4	1.3/1-3	0.04	Kennedy et al., 1992	
	Baltic Sea (12-18)		Kiel Fjord	Germany	ND	ND	ND	ND	Möller, 1975 Callaghan & McCarthy, 1996	
	River		Dunkellin River	Ireland	117	7.7	1.44	0.11		
<i>Pseudocapillaria tomentosa</i> (Dujardin, 1843)	River		Rafford River	Ireland	125	3.2	1.0	0.03	Callaghan & McCarthy, 1996	
	Lake		Lough Rea	Ireland	32	3.1	1.0	0.03	Callaghan & McCarthy, 1996	
	Lake		Lough Derg	Ireland	ND	ND	ND	ND	Holland & Kennedy, 1997	
	Lake		Lake Esrum	Denmark	120	8.3	1.2/1-2	0.09	Kjøte, 1988a	
	River		River Weser (Schlüsselburg)	Germany	291	6.5	ND	ND	Reimer, 2004	
	Lake		Lake Constance/Langenargen	Germany	24	29.2	1.14/1-2	0.33	Thielen, 2005	
	River		River Main/Gemünden	Germany	22	26.9	2.6	0.8	Thielen, 2005	
	River		River Rhine/St. Goar	Germany	29	3.4	1.0	0.03	Thielen, 2005	
	Lake		Lake Plön	Germany	30	10	1.3/1-2	0.13	Jakob et al., 2009	
	River		River Tiber	Italy	101	1.0	ND	ND	Kennedy et al., 1998	
<i>Pseudocapillaria</i> sp.	River		River Ulla	Spain	323	4.0	1.46/1-4	0.06/0.33	Aguilar et al., 2005	
	River		River Tea	Spain	200	4.5	1.89/1-5	0.09/0.49	Aguilar et al., 2005	
	River		River Otter (River Exe system)	England/UK	30	23.3	ND	0.4/1.0	Kennedy, 2001	
	River		River Clyst (River Exe system)	England/UK	19	15.8	ND	0.2/0.4	Kennedy, 2001	
	River		River Culm (River Exe system)	England/UK	74	6.7	ND	0.08/0.3	Kennedy, 2001	
	Estuary/Atlantic (30)		Arousa	Spain	477	0.2	5/5	0.01/0.22	Outeiral et al., 2002	
	<i>Capillariidae</i> gen. sp. Family Dioctophymatidae Raillet, 1915 <i>Eustrongylides excisus</i> Jägerskiöld, 1909	bc, stw	Lagoon/Baltic Sea	Szezezin Firth	Poland	83	ND	ND	ND	Seyda, 1973 Orecka-Grabda & Wierzbicka, 1994
			Lagoon/Baltic Sea	Trzebiez (Szezezin Lagoon)	Poland	71	2.8	1-2	0.04	Orecka-Grabda & Wierzbicka, 1994
			Lagoon/Baltic Sea	Nowe Warpno (Szezezin Lagoon)	Poland	13	15.4	3	0.46	
		stw	Lake	Lake Mácha	Czech Republic	132	0.7	2	0.015	Moravec, 1985
<i>Eustrongylides mergorum</i> (Rudolphi, 1809)	Lake		Lake Esrum	Denmark	120	0.8	1/1	0.008	Kjøte, 1988a	
	Lake		Lake Plön	Germany	30	53.3	2.1/1-4	1.12	Jakob et al., 2009	
	Baltic Sea		Fehmarn Belt	Germany	30	10	4.3/1-8	0.43	Jakob et al., 2009	
	River		River Elbe Estuary	Germany	30	3.3	2/2	0.06	this paper Kristmundsson & Helgason, 2007	
<i>Eustrongylides</i> sp.	stw	Lake	Lake Vifilistadavatn	Iceland	30	13.3	1.5/1-2	0.02		

Phylum/Family	Infection site	Habitat (Salinity)	Locality	Country	n	P (%)	m/l	m/ASD	Author of record
Family Anisakidae Railliet & Henry, 1915									
<i>Anisakis simplex</i> (Rudolphi, 1809)	mes	Freshwater	Kegums Water Reservoir	Latvia	ND	ND	ND	ND	Kirjušina & Vismanis, 2007
<i>Contracaecum rudolphi</i> Hartwich, 1964	mes, iw	Baltic Sea (10-20) Creek/Atlantic (30-33) River	Maasholm Grafarvogur River Ulla	Germany Iceland Spain	30 20 323	3.3 5.0 0.3	3/3 1/1 85	0.10 0.05 0.26/4.73	Jakob et al., 2009 Kristmundsson & Helgason, 2007 Aguilar et al., 2005
<i>Contracaecum squatii</i> Linstow, 1908	iw, mes	Baltic Sea (4-8) Fjord/Baltic Sea (15-20)	Ulif Sund Isefjord	Denmark Denmark	60 80	ND ND	ND ND	ND ND	Kjøte, 1988b Kjøte, 1988b
<i>Contracaecum</i> sp.	bc, iw, mes	Freshwater Lake Kattegat/Skagerrak (30-34) Lake Baltic Sea (12-18)	former U.S.S.R. Lake Esrum Denmark Lake Plön Kiel Fjord	former U.S.S.R. Denmark	ND 120	ND 0.8	ND 1/1	ND 0.008	Bykhovskaya-Pavlovskaya et al., 1964 Kjøte, 1988a
		Baltic Sea (10-20) Baltic Sea (15-20) Lagoon/Thyrrhenian Sea (28-48) Lagoon/Thyrrhenian Sea (17-39) Lagoon/Adriatic Sea (15-35) Lagoon/Adriatic Sea (23-37) Lagoon/Adriatic Sea (30-42)	Maasholm Fehmarn Belt Lake Fogliano Lake Monaci Valle Figheri/Adriatic Coast Comacchio /Adriatic Coast Acquatina/ Adriatic Coast	Italy Italy Italy Italy	20 44 33 42	10.0 4.5 69.7 9.5	ND ND ND ND	2.15/8.93 0.11/0.54 28.0/75.2 0.2/1.5	Kennedy et al., 1997 Kennedy et al., 1997 Di Cave et al., 2001 Di Cave et al., 2001
<i>Goezia anguillae</i> Lèbre & Petter, 1983	i	Estuary/Atlantic Estuary/Atlantic Estuary/Atlantic (30) Estuary/Atlantic (30) Lagoon/Thyrrhenian Sea (10-40) Estuary/Atlantic	Ria de Aveiro Hortas/Tagus estuary Arousa Ferrol Lake Burano Hortas/Tagus estuary	Portugal Portugal Spain Spain Italy Portugal	21 134 30 477 479 187 30	61.9 13.4 23 7.5 5.8 2.7 26	ND 1-311 2/1-6 5.1/1-37 3.4/1-17 ND 1.4/1-3	23.9/71.4 3.11/27.20 0.46 0.38/2.46 0.2/1.2 0.08/0.82 0.36	Di Cave et al., 2001 Hermida et al., 2008 this paper Outeiral et al., 2002 Outeiral et al., 2002 Kennedy et al., 1997 this paper
<i>Goezia</i> sp.	bc, i, mu, sbw, st, stw	Estuary/North Sea Estuary/North Sea Pond (30)	lower Elbe River River Elbe estuary Urbino pond/Corsica	Germany Germany France (Corsica)	ND 101 31	ND 11 6.45	ND ND 1	ND ND 0.06	Denecke, 1935 Lick, 1991 Temengo et al., 2005
<i>Hysterothylacium aduncum</i> (Rudolphi, 1802)	i, iw								

Phylum/Family	Infection site	Habitat (Salinity)	Locality	Country	n	P (%)	m/I	m/SD	Author of record
		Baltic Sea (4-8) Fjord/Baltic Sea (15-20)	Ulf Sund	Denmark	60	6.7	1/1	0.07	Køie , 1988b
		Baltic Sea	Isefjord	Denmark	80	11.3	3.1/1-7	0.34	Køie , 1988b
		Baltic Sea	Rügen Island	Germany	ND	ND	ND	ND	Palm et al., 1999
		Baltic Sea	Greifswalder Bodden	Germany	ND	0.7	ND	ND	Engelbrecht, 1958
		Baltic Sea	Kiel Fjord	Germany	ND	ND	ND	ND	Møller, 1975
		Baltic Sea	Fehmarn Belt	Germany	20	10	1/1	0.10	Jakob et al., 2009
		North Sea (32-35)	Helgoland	Germany	30	3	4/4	0.12	Jakob et al., 2009
		Baltic Sea	Gulf of Riga	Latvia	ND	ND	ND	ND	Kirjušina & Vismamis, 2007
<i>Hysterothylacium</i> sp.	bc, i, mes, mu	Baltic Sea	Kiel Fjord	Germany	ND	ND	ND	ND	Reimer, 1987
		Baltic Sea	Bight of Wismar	Germany	104	ND	ND	ND	Reimer, 1987
		Baltic Sea	Greifswalder Bodden	Germany	28	ND	ND	ND	Reimer, 1987
		Lagoon/Baltic Sea	Lassan /Peenestrom	Germany	205	ND	ND	ND	Reimer, 1987
		Estuary/North Sea	River Elbe estuary	Germany	101	5	ND	ND	Lick, 1991
<i>Pseudoterranova decipiens</i> (Krabbe, 1878)	bc, mes, mu, st	Estuary/North Sea	River Elbe estuary	Germany	101	9	ND	ND	Lick, 1991
		Estuary/North Sea	River Elbe estuary	Germany	1778	3.7	2.7	0.09	Møller et al., 1991
		Estuary/North Sea	River Elbe estuary	Germany	17	11.8	2.5	0.29	Kerstan, 1992
		Estuary/North Sea	River Weser estuary	Germany	23	8.7	1.5	0.13	Kerstan, 1992
<i>Raphidascaris acus</i> (Bloch, 1779)	i, iw	Lake	Lake Neusiedler	Austria	720	0.6-8.8	1.0-15.0	0.0-0.3	Schabuss et al., 2005
		Lake	Lake Máchá	Czech Republic	132	3	1-2	ND	Moravec, 1985
		Lake	Lake Esrum	Denmark	120	11.7	5.1/1-22	0.56	Køie , 1988a
		Baltic Sea (4-8) Fjord/Baltic Sea (15-20)	Ulf Sund	Denmark	60	13.3	2.8/1-11	0.37	Køie , 1988b
		River	Isefjord	Denmark	80	1.3	1/1	0.001	Køie , 1988b
		River	River Thames	England/UK	ND	ND	ND	ND	Norton et al., 2004
		River	River Test	England/UK	ND	ND	ND	ND	Norton et al., 2004
		River	River Otter (River Exe system)	England/UK	30	6.7	ND	0.1/0.2	Kennedy, 2001
		River	River Clyst (River Exe system)	England/UK	206	0.5	1/1	0.005	Kennedy et al., 1992
		River	River Clyst (River Exe system)	England/UK	19	10.5	ND	0.1/0.3	Kennedy, 2001
		River	River Culm (River Exe system)	England/UK	74	2.6	ND	0.02/0.2	Kennedy, 2001
		River	Stoodly Bridge (River Exe system)	England/UK	10	10.0	ND	0.1/0.3	Kennedy, 2001
		Estuary/North Sea	Exminster Marshes	England/UK	64	1.6	3/3	0.05	Kennedy et al., 1992
		Baltic Sea (0-4)	Kotka/Gulf of Finland	Finland	30	10	2.3/1-5	0.2	this paper
		Baltic Sea	Finnish Gulf	Finland	ND	ND	ND	ND	Reimer, 1999
		Baltic Sea	Bight of Wismar	Germany	104	ND	ND	ND	Reimer, 1987
		Baltic Sea	Greifswalder Bodden	Germany	28	ND	ND	ND	Reimer, 1987
		Lagoon/Baltic Sea	Lassan /Peenestrom	Germany	205	ND	ND	ND	Reimer, 1987

Phylum/Family	Infection site	Habitat (Salinity)	Locality	Country	n	P (%)	m/l	mASD	Author of record
	Baltic Sea		Rügen Island	Germany	ND	ND	ND	ND	Palm et al., 1999
	Baltic Sea		Kleines Haff	Germany	ND	12.3	ND	ND	Engelbrecht, 1958
	Baltic Sea		Greifswalder Bodden	Germany	ND	5.3	ND	ND	Engelbrecht, 1958
	River		River Rhine (Leimersheimer Altrhein)	Germany	61	6.6	3.3	0.2/0.9	Sures et al., 1999
	River		River Rhine (harbour of Germersheim)	Germany	60	6.7	2.0	0.1/0.5	Sures et al., 1999
	River		River Rhine (Worms)	Germany	35	2.9	5.0	0.1/0.9	Sures & Streit, 2001
	River		River Rhine (Karlsruhe)	Germany	19	26.3	4.8	1.3/3.1	Sures & Streit, 2001
	Lake		Lake Constance/Langenargen	Germany	24	4.2	2/2	0.08	Thielen, 2005
	Stream		Sulzbach/Laufenburg	Germany	36	2.8	1/1	0.03	Thielen, 2005
	Stream		Eizerbach/Laufenburg	Germany	10	50.0	4.4/2.8	2.2	Thielen, 2005
	River		River Main/Gemünden	Germany	22	4.5	3.0	0.1	Thielen, 2005
	River		River Rhine/St. Goar	Germany	29	10.3	1.3	0.1	Thielen, 2005
	River		River Ruhr/Mühlheim	Germany	12	8.3	1.0	0.1	Thielen, 2005
	River		River Lippe/Hünxe	Germany	31	45.2	3.8	1.7	Thielen, 2005
	River		River Weser (Schlüsselburg)	Germany	291	12.4	ND	ND	Reimer, 2004
	River		River Eider	Germany	30	3.3	2/2	0.07	Jakob et al., 2009
	River		River Elbe (Gontleben)	Germany	30	13.3	3/1-7 246.4/	0.33	this paper
	River		River Elbe Estuary	Germany	30	23.3	1-600	56.67	this paper Conneely & McCarthy, 1986
	River		River Abbert	Ireland	33	21	5	1.05	Conneely & McCarthy, 1986
	River		River Drinneen	Ireland	49	4	1	0.04	Conneely & McCarthy, 1986
	Lake		Lake Corrib	Ireland	39	21	2.1	0.44	Conneely & McCarthy, 1986
	Lake		Lough Derg	Ireland	ND	ND	ND	ND	Holland & Kennedy, 1997
	Lake		Lake Steinsmyrafljot	Iceland	30	43.3	4.0/1-18	1.7	Kristmundsson & Helgason, 2007
	River		River Tiber	Italy	230	3.0	ND	ND	Kennedy et al., 1998
	Lakes/Baltic Sea		Lakes Lepājas, Usmas, Gulf of Riga	Latvia	ND	ND	ND	ND	Kirjušina & Vismans, 2007
	River		River Rhine/Leeuwen	Netherlands	43	41.9	1.6	0.7	Thielen, 2005
	Lake		IJsselmeer/Makkum	Netherlands	30	3.3	2.0	0.1	Thielen, 2005
	Baltic Sea		West Odra River/Stoleczyn	Poland	83	ND	ND	ND	Seyda, 1973
	Lagoon/Baltic Sea		Szczecin Firth	Poland	83	ND	ND	ND	Seyda, 1973
	Lake		Lake Dąbie	Poland	83	ND	ND	ND	Seyda, 1973
	Lagoon/Baltic Sea		Piastowski Canal (Szczecin Lagoon)	Poland	20	5.0	6	0.30	Orecka-Grabda & Wierzbicka, 1994
	Lagoon/Baltic Sea		Lubin (Szczecin Lagoon)	Poland	25	4.0	1	0.04	Orecka-Grabda & Wierzbicka, 1994

Phylum/Family	Infection site	Habitat (Salinity)	Locality	Country	n	P (%)	ml/l	mA/SD	Author of record
		Lagoon/Baltic Sea	Trzebiez (Szczecin Lagoon)	Poland	71	2.8	4.5	0.13	Orecka-Grabda & Wierzbicka, 1994
		Estuary/Baltic Sea	River Odra Mouth	Poland	24	4.2	2	0.08	Orecka-Grabda & Wierzbicka, 1994
		Lagoon/Baltic Sea	Vistula Lagoon	Russia	142	52.1	1-53	5.063	Rodjuk & Shelenkova, 2006
		Freshwater	former U.S.S.R.	former U.S.S.R.	ND	ND	ND	ND	Bykhovskaya-Pavlovskaya et al., 1964
<i>Raphidascaris cristata</i> (Linstow, 1872)	li, mes	Freshwater	Worcestershire	England/UK	ND	ND	ND	ND	Baylis, 1928
		Lake	Windermere catchment area	England/UK	ND	ND	ND	ND	Frost, 1946
		Lake	Llyn Tegid (Lake Bala), Merionethshire	Wales/UK	ND	ND	ND	ND	Chubb, 1970
		Lake	Llyn Padarn, Caernarvonshire	Wales/UK	ND	ND	ND	ND	Chubb, 1970
		River	River Teifi, Cardiganshire	Wales/UK	ND	ND	ND	ND	Kennedy, 1974
Family Quimperiidae Gendre, 1928									
<i>Ichthyobronema gnedini</i> Sudarikov & Ryzhikov, 1952	i	Freshwater	former U.S.S.R.	former U.S.S.R.	ND	ND	ND	ND	Bykhovskaya-Pavlovskaya et al., 1964
<i>Paraquimperia tenerrima</i> (Linstow, 1878)	i, st	Pond (30)	Urbino pond	France (Corsica)	31	6.45	2	0.3	Temengo et al., 2005
		River	Rivers Elbe, Teplá, Želivka and Rokytná	Czech Republic	ND	ND	ND	ND	Moravec, 2001
		Lake	Lake Esrum	Denmark	120	6.7	2.01-3	0.13	Køte, 1988a
		Lake	Lake Arresø	Denmark	30	10	1/1	0.1	Køte, 1988b
		River	River Thames	England/UK	ND	ND	ND	ND	Norton et al., 2004
		River	River Test	England/UK	ND	ND	ND	ND	Norton et al., 2004
		River	River Otter	England/UK	233	46.4	2.4/1-12	1.10	Kennedy et al., 1992
		River	River Clyst	England/UK	206	54.4	4.3/1-29	2.32	Kennedy et al., 1992
		Estuary/North Sea	Exminster Marshes	England/UK	64	50.0	3.0/1-10	1.5	Kennedy et al., 1992
		Lake	Shobrooke Lake	England/UK	131	4.6	2.2/1-6	0.10	Kennedy et al., 1992
		River	Bampton (River Exe system)	England/UK	7	42.8	ND	0.6/0.8	Kennedy, 2001
		River	Stoodly Bridge (River Exe system)	England/UK	10	10.0	ND	0.1/0.3	Kennedy, 2001
		River	Bickleigh (River Exe system)	England/UK	10	30.0	ND	0.3/0.7	Kennedy, 2001
		River	Little Dart (River Exe system)	England/UK	10	30.0	ND	0.7/1.2	Kennedy, 2001
		River	River Culm (River Exe system)	England/UK	74	36.5	ND	0.6/1.1	Kennedy, 2001
		River	River Creedy (River Exe system)	England/UK	26	24.1	ND	0.3/0.5	Kennedy, 2001
		River	Alphin Brook (River Exe system)	England/UK	23	30.4	ND	0.9/1.9	Kennedy, 2001
		River	River Clyst (River Exe system)	England/UK	19	76.1	ND	1.4/2.0	Kennedy, 2001
		River	River Otter (River Exe system)	England/UK	30	43.3	ND	1.6/3.0	Kennedy, 2001
		River	Ham psahre	England/UK	ND	ND	ND	ND	Kennedy, 1974
		Stream	Cunsey Beck/Westmoreland	England/UK	ND	ND	ND	ND	Rawson, 1952

Phylum/Family	Infection site	Habitat (Salinity)	Locality	Country	n	P (%)	m/l	mASD	Author of record
	River		River Weser (Schlüsselburg)	Germany	291	22.3	ND	ND	Reimer, 2004
	Lake		Lake Constance/Langenargen	Germany	24	12.5	2.33/1-4	0.29	Thielen, 2005
	River		River Rhine/Laufenburg	Germany	64	4.7	2.3/1-5 1.42/	0.10	Thielen, 2005
	Stream		Sulzbach/Laufenburg	Germany	36	97.2	1-42	13.8	Thielen, 2005
	Stream		Eizerbach/Laufenburg	Germany	10	70.0	7.1/1-15	5.0	Thielen, 2005
	River		River Main/Gemünden	Germany	22	45.5	2.9	1.3	Thielen, 2005
	River		River Rhine/St. Goar	Germany	29	65.5	3.4	2.2	Thielen, 2005
	Baltic Sea (10-20)		Maasholm	Germany	30	23	6/1-22	1.38	Jakob et al., 2009
	Lake		Lake Balaton	Hungary	ND	ND	ND	ND	Székely, 2006
	River		Dunkellin River	Ireland	117	2.6	1.0	0.03	Callaghan & McCarthy, 1996
	River		Rafford River	Ireland	125	1.6	1.0	0.02	Callaghan & McCarthy, 1996
	Lake		Lough Rea	Ireland	32	3.1	1.0	0.03	Callaghan & McCarthy, 1996
	Lake		Lough Derg	Ireland	ND	ND	ND	ND	Holland & Kennedy, 1997
	River		River Abbert	Ireland	33	27	5.5	1.48	Conneely & McCarthy, 1986
	River		River Drimneen	Ireland	49	16	1.5	0.24	Conneely & McCarthy, 1986
	Lake		Lake Corrib	Ireland	39	21	6.6	1.39	Conneely & McCarthy, 1986
	Lake		Assaroe Lake, Co Donegal/River Erne catchment	Ireland	45	20.0	ND	ND	Copley & McCarthy, 2005
	River		River Rhine/Leeuwen	Netherlands	43	4.7	1.0	0.05	Thielen, 2005
	River		River Trovela	Portugal	55	20.0	2.0/1-5	0.40/0.96	Saraiva et al., 2005
	River		River Covo	Portugal	79	13.9	2.1/1-5	0.29/0.84	Saraiva et al., 2005
	River		River Sousa	Portugal	93	10.8	2.4/1-10	0.26/1.14	Saraiva et al., 2005
	River		River Este	Portugal	47	2.1	2.0	0.04/0.29	Saraiva et al., 2005
	River		River Este	Portugal	129	29.4	ND	ND	Saraiva & Chubb, 1989
	River		River Almond	Scotland/UK	ND	ND	ND	ND	Kennedy, 1974
	River		River Ulla	Spain	323	35.9	2.67/ 1-43	0.96/2.90	Aguilar et al., 2005
	River		River Tea	Spain	200	35.5	2.41/ 1-10	0.86/1.53	Aguilar et al., 2005
	Lake		Llyn Tegid (Lake Bala), Merionethshire	Wales/UK	ND	ND	ND	ND	Chubb, 1970
	Lake		Llyn Padarn, Caernarvonshire	Wales/UK	ND	ND	ND	ND	Chubb, 1970
	River		River Teifi, Cardiganshire	Wales/UK	ND	ND	ND	ND	Kennedy, 1974

Family Cucullanidae Cobbold, 1864

Phylum/Family	Infection site	Habitat (Salinity)	Locality	Country	n	P (%)	m/I	mA/SD	Author of record
<i>Camallanus locustris</i> (Zoega, 1776)	i	River	River Leie, River Scheld	Belgium	107	0.93	1/1	0.01	Schabuss et al., 1997
		Lake	Lake Mácha	Czech Republic	132	41	9/1-235	3.69	Moravec, 1985
		Lake	Lake Esrum	Denmark	120	31.7	2.4/1-6	0.76	Køte, 1988a
		Lake	Lake Arresø	Denmark	30	13.3	1/1	0.13	Køte, 1988b
		Lake	Lake Sjøelsø	Denmark	20	5.0	1/1	0.05	Køte, 1988b
		River	River Thames	England/UK	ND	ND	ND	ND	Norton et al., 2004
		River	River Test	England/UK	ND	ND	ND	ND	Norton et al., 2004
		Reservoir/freshwater	Hanningfield Reservoir/Essex	England/UK	ND	25	3	0.75	Wooten 1973
		Lake	Shobrooke Lake	England/UK	131	31.3	2.9/1-9	0.91	Kennedy et al., 1992
		Baltic Sea (0-4)	Kotka/Gulf of Finland	Finland	30	36.6	2.3/1-7	0.8	this paper
		Baltic Sea	Bight of Wismar	Germany	104	ND	ND	ND	Reimer, 1987
		Lagoon/Baltic Sea	Lassan /Peenestrom	Germany	205	ND	ND	ND	Reimer, 1987
		Lake	Müggelsee/Berlin	Germany	36	7.7	1.0	0.1	Thielen, 2005
		Lake	Lake Plön	Germany	30	83.3	1-79	18.49	Jakob et al., 2009
		River	River Eider	Germany	30	13.3	7.5/1-21	0.97	Jakob et al., 2009
		Baltic Sea (12-18)	Kiel Fjord	Germany	30	3.3	1/1	0.03	Jakob et al., 2009
		Baltic Sea	Fehmarn Belt	Germany	30	10	1.3/1-2	0.13	Jakob et al., 2009
		River	River Elbe Estuary	Germany	30	20	1-103	3.72	this paper
		River	River Elbe (Gortleben)	Germany	30	76.6	5.1/1-18	3.90	this paper
		River/Lake	Corrib catchment area	Ireland	15	ND	ND	ND	Conneely & McCarthy, 1984
		Lake	Lake Corrib	Ireland	39	13	1.6	0.21	Conneely & McCarthy, 1986
		River	Dunkellin River	Ireland	ND	ND	ND	ND	Holland & Kennedy, 1997
		Lake	Lough Rea	Ireland	32	18.8	1.5	0.28	Callaghan & McCarthy, 1996
		Lake	Lough Derg	Ireland	ND	ND	ND	ND	Holland & Kennedy, 1997
		Lake	Assaroe Lake, Co Donegal/River Erne catchment	Ireland	45	24.4	ND	ND	Copley & McCarthy, 2005
		Lake	Lough Ardan, Co Cavan/River Erne catchment	Ireland	18	16.7	1.7	0.28	Copley & McCarthy, 2005
		Lakes/Baltic Sea	Lakes Rāznas, Usmas, Venta River, Gulf of Riga	Latvia	ND	ND	ND	ND	Kirjušina & Vismānis, 2007
	River	West Odra River/Stolecyn	Poland	83	ND	ND	ND	Seyda, 1973	
	Lake	Lake Dąbie	Poland	83	ND	ND	ND	Seyda, 1973	
	Lagoon/Baltic Sea	Lu bin (Szczecin Lagoon)	Poland	25	12.0	1-6	0.36	Orecka-Grabda & Wierzbicka, 1994	
	Lagoon/Baltic Sea	Trzebiez (Szczecin Lagoon)	Poland	71	1.4	1	0.01	Orecka-Grabda & Wierzbicka, 1994	

Phylum/Family	Infection site	Habitat (Salinity)	Locality	Country	n	P (%)	m/l	mASD	Author of record
<i>Camallanus truncatus</i> (Rudolphi, 1814)		Lagoon/Baltic Sea	Stepnica (Szczecin Lagoon)	Poland	30	3.3	7	0.22	Orecka-Grabda & Wierzbicka, 1994
		Lagoon/Baltic Sea	Vistula Lagoon	Russia	142	0.7	1	0.007	Rodjuk & Shelenkova, 2006
		Freshwater	former U.S.S.R.	former U.S.S.R.	ND	ND	ND	ND	Bykhovskaya-Pavlovskaya et al., 1964
	i	Freshwater	Freshwaters of Czech Republic	Czech Republic	ND	ND	ND	ND	Moravec, 2001
		Lake	Lake Balaton	Hungary	14	ND	ND	ND	Murai, 1971
		Lagoon/Baltic Sea	Szczecin Firth	Poland	83	ND	ND	ND	Seyda, 1973
		Freshwater	former U.S.S.R.	former U.S.S.R.	ND	ND	ND	ND	Bykhovskaya-Pavlovskaya et al., 1964
	i	Estuary/Atlantic (30) River	Arousa River Ulla	Spain	477	0.2	22/22	0.05/1.00	Outeiral et al., 2002
		River	River Tea	Spain	323	9.3	3.3/1-23 4.32/	0.31/1.65	Aguilar et al., 2005
	i	River	River Culm (River Exe system)	England/UK	200	17.0	1-30	0.74/3.16	Aguilar et al., 2005
<i>Cacullanus truttae</i> Fabricius, 1794		River	River Test	England/UK	74	1.3	ND	0.02/0.2	Kennedy, 2001
		River	Hampshire Rivers (R. Avon, R. Test, R. Itchen)	England/UK	ND	ND	ND	ND	Norton et al., 2004
		River/Lake	Corrib catchment area	Ireland	15	ND	ND	ND	Stranack 1966
		River	River Abbert	Ireland	33	9	2.3	0.21	Conneely & McCarthy, 1984
		River	River Drinneen	Ireland	49	10	3.8	0.38	Conneely & McCarthy, 1986
		River	River Trovela	Portugal	55	10.9	1.5/1-2	0.16/0.43	Saraiva et al., 2005
		River	River Covo	Portugal	79	17.7	3.4/1-17	0.61/2.23	Saraiva et al., 2005
		River	River Este	Portugal	47	27.7	2.4/1-7	0.63/1.36	Saraiva et al., 2005
		River	River Este	Portugal	129	18.4	ND	ND	Saraiva & Chubb, 1989
		Estuary/Atlantic	Hortas/Tagus estuary	Portugal	30	20	1.6/1-3	0.32	this paper
<i>Cacullanus</i> sp. Family Acanthiidae Railliet, Henry & Sisoff, 1912 <i>Cosmocephalus obvelatus</i> (Creplin, 1825)	sb	Lake	Llyn Tegid (Lake Bala), Merionethshire	Wales/UK	ND	ND	ND	ND	Chubb, 1970
		Lake	Llyn Padarn, Caernavornshire	Wales/UK	ND	ND	ND	ND	Chubb, 1970
		Lagoon/Baltic Sea	Vistula Lagoon	Russia	142	0.7	4	0.028	Rodjuk & Shelenkova, 2006
	bc, iw, mes	Baltic Sea (4-8)	Ulf Sund	Denmark	60	ND	ND	ND	Køite, 1988b
		Fjord/North Sea (10)	Ringkøbing Fjord	Denmark	24	ND	ND	ND	Køite, 1988b
		Fjord/Baltic Sea (15-20)	Isefjord	Denmark	80	ND	ND	ND	Køite, 1988b

Phylum/Family	Infection site	Habitat (Salinity)	Locality [No in Fig. 2]	Country	n	P (%)	m/I	mA/SD	Author of record
<i>Paracuarria adunca</i> (Creplin, 1846)		Lagoon/Adriatic Sea (23-37)	Comacchio /Adriatic Coast	Italy	42	4.8	ND	0.1	Di Cave et al., 2001
	mes, iw	Baltic Sea (4-8) Fjord/Baltic Sea (15-20)	Ulf Sund	Denmark	60	ND	ND	ND	Køie, 1988b
		Baltic Sea	Isefjord Fehmarn Belt	Denmark Germany	80 30	ND 3	ND 9/9	ND 0.27	Køie, 1988b Jakob et al., 2009
Family Anguillicolidae									
Yamaguti, 1935									
<i>Anguillicola crassus</i> Kuwahara, Niimi & Itagaki, 1974	sb	Lake	Lake Neustedl [1]	Austria	90	50	1-13	ND	Konecny & Wais, 1993
		River	Iepertlee [2]	Belgium	ND	35.3	ND	ND	Belpaire et al. 1989
		Channel	Plassendale Channel [3]	Belgium	ND	54.8	ND	ND	Belpaire et al. 1989
		Pond	Blaasveld Broek [4]	Belgium	ND	9.7	ND	ND	Belpaire et al. 1989
		Channel	Albert Channel [5]	Belgium	ND	3.8	ND	ND	Belpaire et al. 1989
		Pond	Roosmele Pond [6]	Belgium	ND	3.7	ND	ND	Belpaire et al. 1989
		River	River Mark (Dutch border) [7]	Belgium	ND	47.4	ND	ND	Belpaire et al. 1989
		Channel	Albert Channel (Kolenhaven, Genk) [8]	Belgium	345	90.2	17	15.3	Thomas & Ollevier, 1992
		River	River Leie, River Scheld [9]	Belgium	107	78.5	1-11/2	9.04	Sehassus et al., 1997
		River	Flanders Rivers (11 catchments) [10]	Belgium	954	88.8	5.5	4.84	Audenaert et al., 2003
		River	River Elbe (Hřensko, North Bohemia) [11]	Czech Republic	ND	80	4/1-7	3.2	Moravec, 1992
		River	River Morava (Vranov Valley Reservoir) [12]	Czech Republic	29	100	1-15	ND	Barnš, 1995
		River	Rivers Elbe, Dyje, Hloučela, Křijovka and Morava [11/12]	Czech Republic	ND	ND	ND	ND	Moravec, 2001
		Water reservoir	Water reservoirs: Orlická, Svatka, Vranovská, Mušov and Koryčany [11/12]	Czech Republic	ND	ND	ND	ND	Moravec, 2001
		Lake	Lake Esrum [13]	Denmark	120	1.7	1.5/1-2	0.03	Køie, 1988a
		Lake	Lake Arresø [13]	Denmark	30	3.3	2/2	0.06	Køie, 1988b
		Lake	Lake Sjøisø [13]	Denmark	20	85	3.9/1-10	3.3	Køie, 1988b
		Baltic Sea (4-8)	Ulf Sund [14]	Denmark	60	1.7	1/1	0.02	Køie, 1988b
		Fjord/North Sea (10)	Ringkøbing Fjord [15]	Denmark	24	4.2	1/1	0.04	Køie, 1988b
		Lake	Lake Arresø [13]	Denmark	120	85	8.9	7.56	Nielsen, 1997
		Fjord/Baltic Sea (15-20)	Isefjorden [16]	Denmark	89	30	3.2	0.96	Nielsen, 1997
		Kattegat (30-34)	Kattegat [17]	Denmark	95	25	2.9	0.73	Nielsen, 1997
		River	River Thames [18]	England/UK	ND	22.0	ND	ND	Kennedy & Fitch, 1990
		River	River Trent [19]	England/UK	ND	100	ND	ND	Kennedy & Fitch, 1990
		River	River Beam, Essex [18]	England/UK	4	25	5	1.25	Pilcher & Moore, 1993
		River (0-2)	River Lee (Tidal) [18]	England/UK	105	32	3	0.98	Pilcher & Moore, 1993

Phylum/Family	Infection site	Habitat (Salinity)	Locality [No in Fig. 2]	Country	n	P (%)	m/l	mASD	Author of record
	River (10-25)	River	West Thurrock [18]	England/UK	122	12	1.8	0.22	Pitcheur & Moore, 1993
	River	River	Beverley Brook [18]	England/UK	14	21	1	0.21	Pitcheur & Moore, 1993
	Baltic Sea	Baltic Sea	Coastal zone of Estonia [20]	Estonia	ND	ND	ND	ND	Didžiulis, 2006
	Baltic Sea (0-4)	Lagoon/Mediterranean Sea	Kotka/Gulf of Finland [21]	Finland	30	23	3.3/1-13	0.7	this paper
	River/Estuary	River/Estuary	Grand Palun /Camargue [22]	France	142	96	ND	ND	Dupont & Petter, 1988
	River/Estuary (0.9)	River/Estuary	Fumemorte Canal (River Rhône delta) [22]	France	25	32	3.70-9.66	ND	Dupont & Petter, 1988
	Pond (3.0)	Pond	Fumemorte Canal (River Rhône delta) [22]	France	549	56.73	9.66	ND	Lefebvre & Crivelli, 2004
	Baltic Sea	Baltic Sea	Urbino pond/Corsica [23]	France (Corsica)	31	13.3	1.25	0.16	Termengo et al., 2005
	Baltic Sea	Baltic Sea	Wismar Bight [24]	Germany	123	58.5	3.5	2.03	Hahlbeck, 1992
	Baltic Sea	Baltic Sea	Warnemünde (outer coast) [24]	Germany	50	44.0	4.8	2.11	Hahlbeck, 1992
	Baltic Sea	Baltic Sea	Stralsund [25]	Germany	148	84.5	5.8	4.87	Hahlbeck, 1992
	Baltic Sea	Baltic Sea	Rügen Island/Mukran [25]	Germany	58	22.4	1.1	0.24	Hahlbeck, 1992
	Baltic Sea	Baltic Sea	Greifswalder Bodden/Thiessow [25]	Germany	83	85.5	8.5	7.22	Hahlbeck, 1992
	Lagoon/Baltic Sea	Lagoon/Baltic Sea	Lassan/Peenestrom [25]	Germany	110	78.5	6.4	4.99	Hahlbeck, 1992
	Baltic Sea	Baltic Sea	Haff/Uckermark [25]	Germany	76	86.8	11.3	9.71	Hahlbeck, 1992
	Baltic Sea (11-12)	Baltic Sea	Salzhaff [25]	Germany	64	59.4	ND	ND	Reimer et al., 1994
	Lake	Lake	Müggelsee [26]	Germany	ND	85	ND	ND	Spangenberg & Reinhold, 1992
	Lake	Lake	Zenthener See [26]	Germany	ND	66	ND	ND	Spangenberg & Reinhold, 1992
	Lake	Lake	Zirker See [27]	Germany	ND	100	ND	ND	Spangenberg & Reinhold, 1992
	Lake	Lake	Galenbecker See [27]	Germany	ND	60	ND	ND	Spangenberg & Reinhold, 1992
	Estuary/North Sea	Estuary/North Sea	Elbe estuary [28]	Germany	ND	ND	ND	ND	Sprengel & Luchtenberg, 1991
	River	River	River Elbe (lower River) [28]	Germany	39	90	8.0	7.2	Hartmann, 1989
	Estuary/North Sea	Estuary/North Sea	River Elbe estuary [28]	Germany	101	73	ND	ND	Lick, 1991
	Estuary/North Sea	Estuary/North Sea	River Elbe estuary [28]	Germany	1778	57.7	7.6	4.33	Möller et al., 1991
	Estuary/North Sea	Estuary/North Sea	River Elbe estuary [28]	Germany	154	13.2	1.4/1-3	0.18	Taraschewski et al., 1987
	Lake	Lake	Ruhr lake [29]	Germany	40	97.5	1.42	13.6/13.6	Taraschewski et al., 1987
	River	River	River Weser [30]	Germany	49	51.1	8.3/1-20	4.2	Taraschewski et al., 1987
	Estuary/North Sea	Estuary/North Sea	River Elbe estuary [28]	Germany	17	35.3	6.2	2.2	Kerstan, 1992
	Estuary/North Sea	Estuary/North Sea	River Eider estuary [28]	Germany	101	23.8	6.0	1.4	Kerstan, 1992
	Estuary/North Sea	Estuary/North Sea	River Weser estuary [30]	Germany	12	43.5	2.7	1.2	Kerstan, 1992
	Estuary/North Sea	Estuary/North Sea	River Ems estuary [31]	Germany	14	41.2	5.4	2.2	Kerstan, 1992
	North -, Baltic Sea	North -, Baltic Sea	German Waters	Germany	ND	ND	ND	ND	Palm et al., 1999

Phylum/Family	Infection site	Habitat (Salinity)	Locality [No in Fig. 2]	Country	n	P (%)	m/I	mA/SD	Author of record
	North Sea		Wadden Sea [32]	Germany	ND	ND	ND	ND	Anders & Möller, 1991
	Lake		Lake Starnberg [33]	Germany	54	70	5	3.5	Leuner, 2004
	Lake		Lake Plön [34]	Germany	30	93.3	4.7/1-12 3.76/1-	4.39	Jakob et al., 2009
	River		River Eider [28]	Germany	30	83.3	13	3.13	Jakob et al., 2009
	Baltic Sea (12-18)		Kiel Fjord [35]	Germany	30	40	3/1-14	1.20	Jakob et al., 2009
	Baltic Sea (10-20)		Maasholm [35]	Germany	30	46	4.5/1-24	2.07	Jakob et al., 2009
	Baltic Sea (15-20)		Fehmarn Belt [35]	Germany	30	40	2.4/1-10	0.96	Jakob et al., 2009
	River		River Elbe Estuary [28]	Germany	30	86.6	9.5/1-47	8.17	this paper
	River		River Elbe (Gortleben) [36]	Germany	30	76.6	5.1/1-18	3.90	this paper
	River		River Weser (Schlüsselburg) [37]	Germany	ND	ND	ND	ND	Sures et al., 1994
	River		River Rhine, River Naab	Germany	120	61	5.6	3.4	Würtz et al., 1996
	River		River Naab [38]	Germany	38	39	7.7	3.0	Würtz et al., 1998
	River		River Rhine (Karlsruhe) [39]	Germany	355	80	3.6	2.9	Würtz et al., 1998
	River		River Rhine (Leimersheimer Altrhein) [39]	Germany	61	83.6	5.3	4.4/4.9	Sures et al., 1999
	River		River Rhine (harbour of Gernersheim) [39]	Germany	60	76.7	5.0	3.9/4.1	Sures et al., 1999
	River		River Rhine (Worms) [39]	Germany	35	94.3	8.6	8.1/13.2	Sures & Streit, 2001
	River		River Rhine (Karlsruhe) [39]	Germany	19	89.5	9.1	8.6/7.5	Sures & Streit, 2001
	River		River Weser (Schlüsselburg) [37]	Germany	291	67.7	ND	ND	Reimer, 2004
	Lake		Lake Balaton [40]	Hungary	20	100	3-18	ND	Székely et al., 1991
	Lake		Lake Balaton [40]	Hungary	81	66.6	ND	ND	Molnár & Székely, 1995
	River		Lough Erne (North eastern Lower) [41]	Ireland	63	3.2	2.5/1-4	0.1	Evans & Matthews, 1999
	River		Lough Erne (Southern Lower) [41]	Ireland	63	22.2	5.6/1-22	1.2	Evans & Matthews, 1999
	River		Lough Erne (Upper) [41]	Ireland	55	9.1	2.4/1-4	0.2	Evans & Matthews, 1999
	River		Lough Oughter [41]	Ireland	54	5.6	2.3/1-5	0.1	Evans & Matthews, 1999
	Lagoon (0-7)		Durnish Lake, Co Donegal [41]	Ireland	23	13.0	1.33	0.17	McCaffrey & McCarthy, 2006
	Delta		Po Delta [42]	Italy	134	64	ND	ND	Canestri-Trotti, 1987
	ND		Sardinia [43]	Italy (Sardinia)	ND	ND	ND	ND	Moravec, 1992
	River		River Tiber [44]	Italy	101	66.3	ND	ND	Kennedy et al., 1998
	Lagoon/Thyrrhenian Sea (10-40)		Lake Burano [44]	Italy	187	37.4	ND	1.1/9/1.92	Kennedy et al., 1997
	Lagoon/Adriatic Sea (15-35)		Valle Figheri/Adriatic Coast [45]	Italy	33	9.1	ND	0.4/6.3	Di Cave et al., 2001
	Lagoon/Adriatic Sea (25-37)		Comacchio /Adriatic Coast [45]	Italy	42	11.9	ND	0.1/0.4	Di Cave et al., 2001
	Lake/River		Lake Usmaas, River Venta [46]	Latvia	ND	100	ND	ND	Didžiulis, 2006
	Lakes/Baltic Sea		Lakes Puzes, Rāznas, Usmaas, River Venta, Gulf of Rīga [46]	Latvia	ND	ND	ND	ND	Kirjūšina & Višmanis, 2007

Phylum/Family	Infection site	Habitat (Salinity)	Locality [No in Fig. 2]	Country	n	P (%)	m/l	mASD	Author of record
	Lake		Lake Dringis (Aukštaitija National Park) [47]	Lithuania	28	60.7	3.9/1-14	2.37	Pilecka-Rapacz & Kesminas, 2006
	Baltic Sea		Coastal zone of Lithuania [48]	Lithuania	ND	ND	ND	ND	Pilecka-Rapacz & Kesminas, 2006
	Lake	Estuary/Mediterranean Sea	Lake Ohrid [49]	Macedonia	68	40	10.3/1-90	4.12	Cakic et al., 2002
	Lake	Estuary/Mediterranean Sea	Moulouya Estuary [50]	Marocco	114	41	1.08	0.44	Rahhou et al., 2001
	Lake		Lauwersmeer [51]	Netherlands	121	51	ND	ND	Van Banning et al., 1985
	Lake		Ijsselmeer [52]	Netherlands	135	34	ND	ND	Van Banning et al., 1985
	Estuary/North Sea		Vlaardingen Westland [53]	Netherlands	7	100	ND	ND	Van Banning et al., 1985
	Lake		Brielse Meer [53]	Netherlands	29	72	ND	ND	Van Banning et al., 1985
	River		River Waal (Beneden, Leeuwen) [54]	Netherlands	54	13	ND	ND	Van Banning et al., 1985
	Wadden Sea		Waddenzee (Harlingen) [52]	Netherlands	50	2	ND	ND	Van Banning et al., 1985
	Fresh-, brackish-, marine waters		Netherlands	Netherlands	ND	87	ND	ND	Dekker & Willigen, 1989
	Lake		Ijsselmeer [52]	Netherlands	50	80-100	ND	ND	Van Banning & Haenen, 1990
	Lake		Ijsselmeer [52]	Netherlands	30	70	3.1	2.17	Boon et al., 1990
	Lake		Ijsselmeer [52]	Netherlands	2097	40-97	ND	ND	Haenen et al., 1994
	Wadden Sea		Waddenzee (Kornwerderzand sluice) [52]	Netherlands	1676	85-90	ND	ND	Haenen et al., 1994
	Skagerrak		Coastal waters Fredrikstad/Hvaler [55]	Norway	199	2.5	3/1-9	0.08	Mo & Steien, 1994
	Baltic Sea		Vistula and Szczecin Lagoon, Gulf of Gdansk, Puck and Pomeranian Bay [56]	Poland	ND	24-100	ND	ND	Rolbiecki & Rokicki, 2005
	River		Rega, Radew, Wieprza, Dead Vistula [57]	Poland	ND	38-66	ND	ND	Rolbiecki & Rokicki, 2005
	Lake		Druzno, Lebsko, Przywłoka, Skape, Wielewickie, Miedwie, Insko, Letowskie, Niegozin, Mamry, Polnoce, Strazyn, Radumskie, Gaj [57]	Poland	ND	25-100	ND	ND	Rolbiecki & Rokicki, 2005
	Estuary/Atlantic		Hortas/Tagus estuary [58]	Portugal	30	83.3	5.6/1-38	4.66	this paper
	River		Ria de Aveiro [59]	Portugal	142	42	ND	ND	Cruz et al., 1992
	Estuary/Atlantic		Ria de Aveiro [59]	Portugal	134	32.8	5.2/1-24	1.70/4.14	Hermida et al., 2008
	Lagoon/Baltic Sea		Vistula Lagoon [60]	Russia	142	64.6	1-28	4.029	Rodjnk & Shelenkova, 2006
	River		Bridge of Earn (Perthshire) [61]	Scotland/UK	2	100	2-7	ND	Lyndon & Pieters, 2005
	Lagoon/Mediterranean Sea (3-30)		Encanyissada, Ebro Delta [62]	Spain	ND	21.3	ND	1.23/5.69	Mafllo et al., 2005
	Lagoon/Mediterranean Sea (8-36)		Tancada, Ebro Delta [62]	Spain	ND	25.6	ND	1.97/10.03	Mafllo et al., 2005
	Lagoon/Mediterranean Sea (8-30)		Canal Vell, Ebro Delta [62]	Spain	ND	30.8	ND	0.72/1.15	Mafllo et al., 2005
	River		River Tea [63]	Spain	200	55.5	5.5/1-35	3.05/5.12	Aguilar et al., 2005
	Baltic Sea (7)		Hannefjärden [64]	Sweden	235	66	48	ND	Höglund & Andersson, 1993

Phylum/Family	Infection site	Habitat (Salinity)	Locality [No in Fig. 2]	Country	n	P (%)	ml/l	mA/SD	Author of record
		Kattegat/Skagerrak Cove/Baltic Sea (4-6)	Swedish west coast [65]	Sweden	ND	ND	ND	ND	Svedäng, 1996
		Lake	Jonsbergsviken [66]	Sweden	103	44.7	3.0	ND	Wickström et al., 1998
		Lake	Lake Ymsen [67]	Sweden	58	16.9	1.8	ND	Wickström et al., 1998
		Lake	Lake Hjälmaran [68]	Sweden	108	1.9	1	ND	Wickström et al., 1998
		Lake (14-16)	Lake Ichkeul [69]	Tunisia	344	7	1.5/1-3	0.11	Maamouri et al., 1999
		River	Oued Sejmane [69]	Tunisia	5	20	1	0.2	Maamouri et al., 1999
<i>Anguillicola novaezelandiae</i> Moravec & Taraschewski, 1988	sb	Lake	Lake Bracciano [70]	Italy	ND	40	ND	ND	Paggi et al. 1982
	sb	Lake	Lake Bracciano [70]	Italy	73	20-100	ND	ND	Moravec et al. 1994
<i>Anguillicola</i> sp.	sb	River	Weser-Ems Region [30/31]	Germany	ND	ND	ND	ND	Neumann, 1985
		Baltic Sea	Bight of Wismar [24]	Germany	104	ND	ND	ND	Reimer, 1987
		Lake	Nürtingen [71]	Germany	37	54	ND	ND	Hartmann, 1987
		River	River Rhine (Bad Honnef; Kalkar) [72]	Germany	30	50	ND	ND	Lehmann & Taraschewski, 1987
		River	Ruhr (Konnader Staunsee) [29]	Germany	ND	ND	ND	ND	Lehmann & Taraschewski, 1987
		North Sea (32-35)	Helgoland [73]	Germany	83/30 77/10	4/3	2.7/9.0	ND	Koops & Hartmann, 1989
		River	Lower River Elbe [28]	Germany	8	0/19	0/2.1	ND	Koops & Hartmann, 1989
		River	River Oste [28]	Germany	50	18	1.3	ND	Koops & Hartmann, 1989
		River	Lower River Ems [31]	Germany	50/10	20/38	1.6/1.8	ND	Koops & Hartmann, 1989
		River	River Havel [27]	Germany	58	97	9.2	ND	Koops & Hartmann, 1989
		River	River Trave [24]	Germany	43	60	7.2	ND	Koops & Hartmann, 1989
		Atlantic	Atlantic Coast (Loukkos) [74]	Marocco	60	52	1.9	0.98	El Hilali et al., 1996
		Atlantic	Atlantic Coast (Sebou) [74]	Marocco	60	43	1.8	0.82	El Hilali et al., 1996
		Freshwater	Poland [57]	Poland	ND	10	5.0	ND	Koops & Hartmann, 1989
Family Daniconematidae Moravec & Kóie, 1987									
<i>Daniconema anguillae</i> Moravec & Kóie, 1987	sb	Lake	Lake Mácha	Czech Republic	ND	ND	ND	ND	Moravec & Kóie, 1987
		Lake	Lake Esrum	Denmark	120	28.3	2.7/1-23	0.75	Kóie, 1988a
		Lake	Lake Arresø	Denmark	30	6.7	3.0/1-5	0.2	Kóie, 1988b
		Baltic Sea (4-8)	Ulff Sund	Denmark	60	1.7	1/1	0.02	Kóie, 1988b
		Lake	Lake Balaton	Hungary	81	7.4	ND	ND	Molnár & Székely, 1995
Family Philometridae Baylis & Daubney, 1926									
<i>Philometra abdominalis</i> Nybelin, 1928	bc	River	River Elbe	Germany	ND	ND	ND	ND	Mann, 1962
<i>Philometra ovata</i> (Zeder, 1803)	sb	Lake	Lake Arresø	Denmark	30	10	1/1	0.1	Kóie, 1988b

Phylum/Family	Infection site	Habitat (Salinity)	Locality	Country	n	P (%)	m/l	mASD	Author of record
<i>Philomeira</i> sp.		River	River Weser (Schlüsselburg)	Germany	291	1.8	ND	ND	Reimer, 2004
Family Rhabdochoniidae									
Skrjabin, 1946									
<i>Rhabdochona anguillae</i> Spaul,	i	Freshwater	Bulgaria	Bulgaria	ND	ND	ND	ND	Reimer, 1999
1927		River	River Sousa	Portugal	93	26.9	4.8/1-65	1.29/6.78	Saraiva et al., 2005
Family Cystidicolidae Skrjabin,									
1946									
<i>Ascariochis arctica</i> Poljansky,		Fjord/Baltic Sea	Isefjord	Denmark	80	1.3	5/5	0.06	Kjøie, 1988b
1952		Lake	Lake Mácha	Czech Republic	132	3	1-12	ND	Moravec, 1985
<i>Spinitectus inermis</i> (Zeder, 1800)	i, st	River	River Thames	England/UK	ND	ND	ND	ND	Norton et al., 2004
		River	River Test	England/UK	ND	ND	ND	ND	Norton et al., 2004
		River	River Otter	England/UK	24	4.2	3.0/3	0.13	Kennedy et al., 1992
		River	River Otter (River Exe system)	England/UK	30	40.0	ND	5.6/15.0	Kennedy, 2001
		River	Bampton (River Exe system)	England/UK	7	28.6	ND	1.8/4.5	Kennedy, 2001
		River	Bickleigh (River Exe system)	England/UK	10	40.0	ND	0.4/0.5	Kennedy, 2001
		River	River Culm (River Exe system)	England/UK	74	18.9	ND	0.6/1.6	Kennedy, 2001
		River	River Creedy (River Exe system)	England/UK	26	20.7	ND	1.1/3.8	Kennedy, 2001
		River	River Rhine/Laufenburg	Germany	64	15.6	6.5/1-18	1.01	Thielen, 2005
		Stream	Sulzbach/Laufenburg	Germany	36	23.1	5.5/1-12	1.3	Thielen, 2005
		Stream	Etzerbach/Laufenburg	Germany	10	10.0	4/4	0.4	Thielen, 2005
		River	River Elbe Estuary	Germany	30	10	8/1-19	0.8	this paper
		River	River Elbe (Gorleben)	Germany	30	6.6	1/1	0.07	this paper
		River	River Sousa	Portugal	93	16.1	5.5/1-16	0.89/2.63	Saraiva et al., 2005
		River	River Almond	Scotland/UK	ND	ND	ND	ND	Kennedy, 1974
		Estuary/Atlantic (30)	Ferrol	Spain	479	0.2	1/1	0.002/0.044	Outeiral et al., 2002
		River	River Ulla	Spain	323	18.9	7.3/1-56	1.38/5.36	Aguilar et al., 2005
		River	River Tea	Spain	200	12.0	3.8/1-25	0.46/2.07	Aguilar et al., 2005
		Lake	Llyn Tegid (Lake Bala), Merionethshire	Wales/UK	ND	ND	ND	ND	Chubb, 1970
		Freshwater	former U.S.S.R.	former U.S.S.R.	ND	ND	ND	ND	Bykhovskaya-Pavlovskaya et al., 1964
<i>Cystidicolidae</i> gen. sp.		Estuary/Atlantic (30)	Arousa	Spain	477	0.4	1/1	0.004/0.063	Outeiral et al., 2002
PHYLUM									
ACANTHOCEPHALA									
Family Arhythmacanthidae									
Yamaguti, 1935									
<i>Acanthocephaloides incrassatus</i>	i	Mediterranean Sea, Black Sea	Mediterranean Sea, Black Sea		ND	ND	ND	ND	Reimer, 1999
(Molin, 1858)									

Phylum/Family	Infection site	Habitat (Salinity)	Locality	Country	n	P (%)	ml/l	mA/SD	Author of record
<i>Acanthocephaloides propinquus</i> (Dujardin, 1845)	i	Estuary/Atlantic (30)	Arousa	Spain	477	8.6	7.8/1-43	0.67/3.84	Outeiral et al., 2002
		Estuary/Atlantic (30) Mediterranean Sea, Atlantic Sea	Ferrol	Spain	479	0.8	2.9/1-4	0.02/0.02	Outeiral et al., 2002
<i>Acanthocephalus anguillae</i> (Müller, 1780)	i	Lake	Mediterranean Sea, French Atlantic coast	ND	ND	ND	ND	ND	Reimer, 1999
		Lake	Lake Neusiedler	Austria	720	3.9-30.5	1.3-25.3 10.49/	0.1-18.4	Schabuss et al., 2005
		River	River Leie, River Scheld	Belgium	107	37.4	1-119	3.9	Schabuss et al., 1997
		Freshwater	Freshwater in the Czech Republic	Czech Republic	ND	ND	ND	ND	Moravec, 2001
		Lake	Lake Esrum	Denmark	120	6.7	8.5/1-34	0.57	Kjøte, 1988a
		Lake	Lake Arresø	Denmark	30	26.7	3.9/1-9	1.0	Kjøte, 1988b
		Fjord/Baltic Sea (15-20)	Isefjord	Denmark	80	1.3	1/1	0.013	Kjøte, 1988b
		River	River Thames	England/UK	ND	ND	ND	ND	Norton et al., 2004
		Baltic Sea (0-4)	Kotka/Gulf of Finland	Finland	30	3.3	61/61	2	this paper
		Baltic Sea	Kiel Fjord	Germany	ND	ND	ND	ND	Möller, 1975
		Baltic Sea	Bight of Wismar	Germany	104	ND	ND	ND	Reimer, 1987
		Lagoon/Baltic Sea	Lassan/Peenestrom	Germany	205	ND	ND	ND	Reimer, 1987
		Baltic Sea	Kleines Haff	Germany	ND	60.0	ND	ND	Engelbrecht, 1958
		Baltic Sea	Greifswalder Bodden	Germany	ND	0.7	ND	ND	Engelbrecht, 1958
		River	River Rhine (Leimersheimer Altrhein)	Germany	61	1.6	1.0	0.0/0.6	Sures et al., 1999
		River	River Rhine/Laufenburg	Germany	64	1.5	1/1	0.02	Thielen, 2005
		River	River Main/Gemünden	Germany	22	9.1	4.0	0.4	Thielen, 2005
	River	River Rhine/St. Goar	Germany	29	10.3	1.3	0.1	Thielen, 2005	
	River	River Ruhr/Mühlheim	Germany	12	25.0	1.0	0.3	Thielen, 2005	
	River	River Rhine (Worms)	Germany	35	2.9	2.0	0.1/0.3	Sures & Streit, 2001	
	River	River Rhine (Karlsruhe)	Germany	19	15.8	4.0	0.6/1.7	Sures & Streit, 2001	
	River	River Weser (Schlisselburg)	Germany	291	14.8	ND	ND	Reimer, 2004 Callaghan & McCarthy, 1996	
	River	Dunkellin River	Ireland	125	0.9	1.0	0.01	Kennedy & Moriarty, 1987	
	Lake	Lough Derg	Ireland	ND	ND	ND	ND	Kennedy, 1992	
	Lake	Shannon lakes	Ireland	ND	ND	ND	ND	Copley & McCarthy, 2005	
	Lake	Assaroe Lake, Co Donegal/River Erne catchment	Ireland	30	3.3	4/4	0.13	Copley & McCarthy, 2005	
	Lake	Lough Ardara, Co Cavan/River Erne catchment	Ireland	18	5.6	1/1	0.05	Copley & McCarthy, 2005	
	Lakes/Baltic Sea	Lakes Liepājas, Rāznas, Usmas, Kegums Water Reservoir, Gulf of Riga	Latvia	ND	ND	ND	ND	Kirjušina & Vismānis, 2007	
	River	West Odra River/Stoleczyn	Poland	83	ND	ND	ND	Seyda, 1973	
	Lake	Lake Dąbie	Poland	83	ND	ND	ND	Seyda, 1973	

Phylum/Family	Infection site	Habitat (Salinity)	Locality	Country	n	P (%)	m/l	mASD	Author of record
<i>Acanthocephalus clavula</i> (Dujardin 1845)		Baltic Sea	Trzebiez (Szezezin Lagoon)	Poland	71	1.4	1	0.01	Orecka-Grabda & Wierzbicka, 1994
		Lagoon/Baltic Sea	Stepnica (Szezezin Lagoon)	Poland	30	6.7	1	0.07	Orecka-Grabda & Wierzbicka, 1994
		Lagoon/Baltic Sea	Nowe Warpno (Szezezin Lagoon)	Poland	13	7.7	2	0.15	Orecka-Grabda & Wierzbicka, 1994
		Baltic Sea	River Odra Mouth	Poland	24	4.2	17	0.71	Orecka-Grabda & Wierzbicka, 1994
		Baltic Sea	Neva Bight	Russia	ND	ND	ND	ND	Reimer, 1987
		Freshwater	former U.S.S.R.	former U.S.S.R.	ND	ND	ND	ND	Bykhovskaya-Pavlovskaya et al., 1964
	i	River	River Orter	England/UK	233	3.9	1.4/1-3	0.05	Kennedy et al., 1992
		River	River Clyst	England/UK	206	3.4	1/1	0.03	Kennedy et al., 1992
		Estuary/North Sea	Exminster Marshes	England/UK	64	67.7	4.0/1-57	2.7	Kennedy et al., 1992
		Lake	Shobrooke Lake	England/UK	131	1.5	4.5/3-6	0.07	Kennedy et al., 1992
		River	River Culm (River Exe system)	England/UK	74	16.2	ND	0.2/0.7	Kennedy, 2001
		River	River Clyst (River Exe system)	England/UK	19	63.1	ND	1.0/2.0	Kennedy, 2001
		Lake/River	Lough Arrow, River Boyne	Ireland	6	50.0	ND	ND	Kane, 1966
		River/Lake	Corrib catchment area	Ireland	15	ND	ND	ND	Conneely & McCarthy, 1984
		River	River Drimneen	Ireland	49	12	17.5	2.1	Conneely & McCarthy, 1986
		Lake	Lake Corrib	Ireland	39	59	3.4	2.0	Conneely & McCarthy, 1986
		River	Dunkellin River	Ireland	117	0.8	5.0	0.04	Callaghan & McCarthy, 1996
		Lake	Lough Rea	Ireland	32	12.5	1.0	0.13	Callaghan & McCarthy, 1996
		Lake	Lough Derg	Ireland	ND	ND	ND	ND	Holland & Kennedy, 1997
	River	River Tiber	Italy	101	65.3	ND	ND	Kennedy et al., 1998	
	Lakes	Lakes Liepājas Rāzinas	Latvia	ND	ND	ND	ND	Kirjušina & Vismānis, 2007	
	Estuary/Atlantic	Ria de Aveiro	Portugal	134	1.5	1.0	0.01	Hermida et al., 2008	
	River	River Trovela	Portugal	55	10.9	2.2/1-6	0.24/0.89	Saraiva et al., 2005	
	Estuary/Atlantic (30)	Arousa	Spain	477	0.4	3.5/1-6	0.01/0.28	Outeiral et al., 2002	
	River	River Ulla	Spain	323	3.7	2.5/1-5	0.09/0.55	Aguilar et al., 2005	
	River	River Tea	Spain	200	2.0	1.5/1-2	0.03/0.22	Aguilar et al., 2005	
	Lake	Llyn Tegid (Lake Bala)	Wales/UK	54	27.7	18.4	4.9	Chubb, 1964	
	Lake	Llyn Padarn, Caernarvonshire	Wales/UK	ND	ND	ND	ND	Chubb, 1970	
<i>Acanthocephalus tucii</i> (Muller, 1776)	i	Lake	Lake Neusiedler	Austria	720	67.9	1.5-12.3	0.4-8.3	Schabuss et al., 2005

Phylum/Family	Infection site	Habitat (Salinity)	Locality	Country	n	P (%)	m/I	mA/SD	Author of record
	Lake		Lake Neusiedler	Austria	56	17.85	13.5/ 1-100 19.57/	2.29	Kritischer, 1980
	River		River Leie, River Scheld	Belgium	107	26.2	1-170	5.12	Schabuss et al., 1997
	Lake		Lake Máchá	Czech Republic	132	38	4/1-18	1.5	Moravec, 1985
	Lake		Lake Esrum	Denmark	120	15	2.1/1-12	0.3	Køte, 1988a
	Lake		Lake Sjøelsø	Denmark	20	5	1/1	0.05	Køte, 1988b
	Fjord/Baltic Sea (15-20)		Isefjord	Denmark	80	1.3	1/1	0.01	Køte, 1988b
	River		River Thames	England/UK	ND	ND	ND	ND	Norton et al., 2004
	River		River Test	England/UK	ND	ND	ND	ND	Norton et al., 2004
	Lake		Slapton Ley	England/UK	ND	ND	ND	ND	Canning et al., 1973
	Freshwater		ND	England/UK	ND	ND	ND	ND	Baylis, 1928
	Canal		Shropshire Union Canal/ Backford, Cheshire	England/UK	4	75	15.6	11.7	Mishra & Chubb, 1969
	Baltic Sea		Finnish Gulf	Finland	ND	ND	ND	ND	Reimer, 1999
	River		River Rhine (Leimersheimer Althein)	Germany	61	1.6	5.0	0.1/0.6	Sures et al., 1999
	Lake		Lake Constance/Langenargen	Germany	24	16.6	1/1	0.16	Thielen, 2005
	River		River Rhine/Laufenburg	Germany	64	1.5	1/1	0.02	Thielen, 2005
	Lagoon/Baltic Sea		Lassan /Peenestrom	Germany	205	ND	ND	ND	Reimer, 1987
	Baltic Sea		Rügen Island	Germany	ND	ND	ND	ND	Palm et al., 1999
	Baltic Sea		Kleines Haiff	Germany	ND	45.5	ND	ND	Engelbrecht, 1958
	River/Lake		Corrib catchment area	Ireland	ND	ND	ND	ND	Conneely & McCarthy, 1984
	River		River Drinneen	Ireland	49	6	1.3	0.08	Conneely & McCarthy, 1986
	Lake		Lake Corrib	Ireland	39	38	3.4	1.3	Conneely & McCarthy, 1986
	Lake		Shannon lakes	Ireland	ND	ND	ND	ND	Kennedy 1992
	River		Dunkellin River	Ireland	117	6.8	1.88	0.13	Callaghan & McCarthy, 1996
	River		Rafford River	Ireland	125	7.2	5.22	0.38	Callaghan & McCarthy, 1996
	Lake		Lough Rea	Ireland	32	43.8	10.36	4.53	Callaghan & McCarthy, 1996
	Lake		Lough Derg	Ireland	ND	ND	ND	ND	Kennedy & Moriarty 1987
	Lake		Assaroe Lake, Co Donegal/River Erne catchment	Ireland	45	4.4	1/1	0.04	Copley & McCarthy, 2005
	Lake		Lough Ardara, Co Cavan/River Erne catchment	Ireland	18	16.7	1.7	0.28	Copley & McCarthy, 2005
	Lakes/Baltic Sea		Lakes Liepājas, Rāznas, Rušons, Usmas, Venta River, Gulf of Riga	Latvia	ND	ND	ND	ND	Kirjušina & Vismānis, 2007
	Baltic Sea		West Odra River/Stoleczyn	Poland	83	ND	ND	ND	Seyda, 1973
	Baltic Sea		Szececin Firth	Poland	83	ND	ND	ND	Seyda, 1973

Phylum/Family	Infection site	Habitat (Salinity)	Locality	Country	n	P (%)	ml/l	mASD	Author of record
<i>Echinorhynchus gadi</i> Zoega in Müller, 1776	Lakes/Baltic Sea	Lake Dąbie	Poland	83	ND	ND	ND	ND	Seyda, 1973 Orecka-Grabda & Wierzbicka, 1994
	Baltic Sea	Piastowski Canal (Szczecin Lagoon)	Poland	20	5.0	3	0.15		Wierzbicka, 1994
	Lagoon/Baltic Sea	Trzebiez (Szczecin Lagoon)	Poland	71	12.7	1-4	0.25		Orecka-Grabda & Wierzbicka, 1994
	Lagoon/Baltic Sea	Stepnica (Szczecin Lagoon)	Poland	30	16.7	1-7	0.53		Orecka-Grabda & Wierzbicka, 1994
	Lagoon/Baltic Sea	Nowe Warpno (Szczecin Lagoon)	Poland	13	7.7	2	0.15		Orecka-Grabda & Wierzbicka, 1994
	Estuary/Baltic Sea	River Odra Mouth	Poland	24	16.7	1-11	0.62		Orecka-Grabda & Wierzbicka, 1994
	River	River Este	Portugal	129	1.5	ND	ND		Saraiva & Chubb, 1989
	Estuary/Atlantic	Hortas/Tagus estuary	Portugal	30	3.3	1/1	0.03		this paper
	Estuary/Baltic Sea	Neva Bight	Russia	ND	ND	ND	ND		Reimer, 1987
	Freshwater	former U.S.S.R.	former U.S.S.R.	ND	ND	ND	ND		Bykhovskaya-Pavlovskaya et al., 1964
	Baltic Sea	Kiel Fjord	Germany	ND	ND	ND	ND		Möller, 1975
	Baltic Sea	Bight of Wismar	Germany	104	ND	ND	ND		Reimer, 1987
	Baltic Sea	Hiddensee	Germany	ND	ND	ND	ND		Reimer, 1987
	Lagoon/Baltic Sea	Lassan /Peenestrom	Germany	205	ND	ND	ND		Reimer, 1987
	Baltic Sea	Rügen Island	Germany	ND	ND	ND	ND		Palm et al., 1999
	Lagoon/Baltic Sea	Vistula Lagoon	Russia	142	0.7	1	0.007		Rodjuk & Shelenkova, 2006
<i>Echinorhynchus truttae</i> Schrank, 1788	River	River Culm (River Eke system)	England/UK	74	5.4	ND	ND	0.07/0.7	Kennedy, 2001
	River	River Test	England/UK	ND	ND	ND	ND	ND	Norton et al., 2004
	Lake	Windermere catchment area	England/UK	ND	ND	ND	ND	ND	Frost, 1946
	Stream	Sulzbach/Laufenburg	Germany	36	41.7	3.3/1-12	1.4		Thielen, 2005
	Stream	Eizerbach/Laufenburg	Germany	10	60.0	6.0/1-21	3.6		Thielen, 2005
	Freshwater	Freshwaters in Ireland	Ireland	ND	ND	ND	ND		Kennedy, 1974
	Freshwater	Freshwaters in Britain and Ireland	UK	ND	ND	ND	ND		Kennedy, 1974
	Freshwater	Worcestershire	England/UK	ND	ND	ND	ND		Baylis, 1928
	Baltic Sea	Gulf of Riga	Latvia	ND	ND	ND	ND		Kirjušina & Vismans, 2007
	Freshwater	former U.S.S.R.	former U.S.S.R.	ND	ND	ND	ND		Bykhovskaya-Pavlovskaya et al., 1964
<i>Echinorhynchus salmonis</i> Müller, 1776	River	Hamshire Rivers (R. Avon, R. Test, R. Itchen)	England/UK	ND	ND	ND	ND		Stranack, 1966
	Atlantic	outer Kaldbak Fjord	Faroe Islands	1	100	1/1	1		Køte, 2000
Family Illiosentidae <i>Telosenis exiguus</i> (von Linstow, 1901)	Lagoon/Thyrrhenian Sea (10-40)	Lake Burano	Italy	187	3.7	ND	ND	0.07/0.34	Kennedy et al., 1997

Phylum/Family	Infection site	Habitat (Salinity)	Locality	Country	n	P (%)	m/l	mA/SD	Author of record
<i>Pomphorhynchus laevis</i> (Müller, 1776)	i	River	River Rokytná	Czech Republic	ND	ND	ND	ND	Moravec, 2001
		Baltic Sea (4-8)	Ulf Sund	Denmark	60	10.0	1.3/1-2	0.13	Kjøie, 1988b
		Freshwater	Freshwaters in England and Wales	Wales/UK	ND	ND	ND	ND	Kennedy, 1974
		Estuary/North Sea	River Thames	England/UK	ND	ND	ND	ND	Norton et al., 2004
		River	River Test	England/UK	ND	ND	ND	ND	Norton et al., 2004
		River	River Culm (River Exe system)	England/UK	74	45.9	ND	6.8/14.0	Kennedy, 2001
		River	River Otter (River Exe system)	England/UK	30	26.7	ND	1.7/5.4	Kennedy, 2001
		River	River Otter	England/UK	45	15.6	2.1/1-5	0.33	Kennedy et al., 1992
		Baltic Sea	Kiel Fjord	Germany	ND	ND	ND	ND	Möller, 1975
		Baltic Sea	Bight of Wismar	Germany	104	ND	ND	ND	Reimer, 1987
		Baltic Sea	Hiddensee	Germany	ND	ND	ND	ND	Reimer, 1987
		Baltic Sea	Greifswalder Bodden	Germany	28	ND	ND	ND	Reimer, 1987
		Lagoon/Baltic Sea	Lassan /Peenestrom	Germany	205	ND	ND	ND	Reimer, 1987
		Baltic Sea	Greifswalder Bodden	Germany	ND	11.3	ND	ND	Engelbrecht, 1958
		Baltic Sea	Rügen Island	Germany	ND	ND	ND	ND	Palm et al., 1999
		Baltic Sea	Baltic Sea	Germany	ND	ND	ND	ND	Palm et al., 1999
		North Sea	lower River Elbe	Germany	ND	ND	ND	ND	Anders & Möller, 1991
		River	River Elbe Estuary	Germany	30	6.6	1/1	0.06	this paper
		River	River Elbe (Gorleben)	Germany	30	23.3	3.4/1-11	0.8	this paper
		River	River Rhine (Leimersheimer Altrhein)	Germany	61	6.6	14.0	0.9/4.7	Sures et al., 1999
		River	River Rhine (harbour of Germersheim)	Germany	60	8.3	4.6	0.4/1.7	Sures et al., 1999
		River	River Rhine (Karlsruhe)	Germany	19	15.8	1.0	0.2/0.4	Sures & Streit, 2001
		Lake	Lake Constance/Langenargen	Germany	24	4.2	8/8	0.33	Thielen, 2005
		River	River Rhine/Laufenburg	Germany	64	62.5	1-117	8.39	Thielen, 2005
		Stream	Sulzbach/Laufenburg	Germany	36	80.6	4.4	3.6/1-20	Thielen, 2005
		Stream	Eizerbach/Laufenburg	Germany	10	40.0	6.8/	2.7/1-20	Thielen, 2005
		River	River Rhine/St. Goar	Germany	29	34.5	3.8	1.3	Thielen, 2005
		River	River Lippe/Hünxe	Germany	31	71.0	3.4	2.4	Thielen, 2005
		River	River Weser (Schlüsselburg)	Germany	291	15.5	ND	ND	Reimer, 2004
		Freshwater	Freshwaters in Ireland	Ireland	ND	ND	ND	ND	Kennedy, 1974
		River/Lake	Corrib catchment area	Ireland	15	ND	ND	ND	Conneely & McCarthy, 1984
	River	River Abbert	Ireland	33	55	1.7	0.94	Conneely & McCarthy, 1986	
	River	River Drimneen	Ireland	49	59	4.8	2.8	Conneely & McCarthy, 1986	

Phylum/Family	Infection site	Habitat (Salinity)	Locality	Country	n	P (%)	m/l	mASD	Author of record
<i>Corynosoma</i> <i>Corynosoma sennerae</i> (Forsell, 1904)	Lake	Lake Corrib	Ireland	39	8	2.7	0.22	Conneely & McCarthy, 1986	
	River	Dunkellin River	Ireland	117	63.3	5.53	3.50	Callaghan & McCarthy, 1996	
	River	Rafford River	Ireland	125	39.2	2.0	0.78	Callaghan & McCarthy, 1996	
	Lake	Lough Rea	Ireland	32	12.5	1.0	0.13	Callaghan & McCarthy, 1996	
	River	River Boyne	Ireland	ND	ND	ND	ND	Kennedy, 1966	
	River	River Tiber	Italy	101	1.0	ND	ND	Kennedy et al., 1998	
	Lake	Lake Usnias	Latvia	ND	ND	ND	ND	Kirjušina & Vismans, 2007	
	River	River Rhine/Leenwen	Netherlands	43	34.9	2.8	1.0	Thielen, 2005	
	Lake	Lake Dąbie	Poland	83	ND	ND	ND	Seyda, 1973	
	Baltic Sea	Neva Bight	Poland	ND	ND	ND	ND	Reimer, 1987	
	Estuary/Atlantic	Ria de Aveiro	Portugal	134	0.8	1.0	0.01	Hermida et al., 2008	
	Freshwater	former U.S.S.R.	former U.S.S.R.	ND	ND	ND	ND	Bykhovskaya-Pavlovskaya et al., 1964	
	Baltic Sea	Hiddensee	Germany	ND	ND	ND	ND	Reimer, 1987	
	Freshwater	former U.S.S.R.	former U.S.S.R.	ND	ND	ND	ND	Bykhovskaya-Pavlovskaya et al., 1964	
	Baltic Sea	Gulf of Riga	Latvia	ND	ND	ND	ND	Kirjušina & Vismans, 2007	
	Lake/River	Lake Máchla, River Malše and Rokyná	Czech Republic	ND	ND	ND	ND	Moravec, 2001	
	River	River Test	England/UK	ND	ND	ND	ND	Norton et al., 2004	
River	River Otter	England/UK	ND	ND	ND	ND	Kennedy 1997		
River	River Clyst	England/UK	68	2.9	2.0/2	0.06	Kennedy et al., 1992		
Estuary/North Sea	Exminster Marshes	England/UK	15	40.0	2.7/2-5	1.1	Kennedy et al., 1992		
River	Stoodly Bridge (River Exe system)	England/UK	10	40.0	ND	0.6/0.9	Kennedy, 2001		
River	River Creedy (River Exe system)	England/UK	26	31.0	ND	0.8/2.0	Kennedy, 2001		
Baltic Sea	Finnish Gulf	Finland	ND	ND	ND	ND	Reimer, 1999		
Baltic Sea	Kleines Haiff	Germany	ND	6.2	ND	ND	Engelbrecht, 1958		
Lake/Baltic Sea	Lake Usnias, Gulf of Riga	Latvia	ND	ND	ND	ND	Kirjušina & Vismans, 2007		
Baltic Sea	Gdansk Bay	Poland	17	0.06	1/2	ND	Rokicki, 1975		
Freshwater	former U.S.S.R.	former U.S.S.R.	ND	ND	ND	ND	Bykhovskaya-Pavlovskaya et al., 1964		
Family Tenuisentidae Van Cleave, 1921	i	Estuary/North Sea	River Elbe Estuary	Germany	334	0.3	7/7	ND	Taraschewski et al. 1987
		Estuary/North Sea	River Elbe Estuary	Germany	334	0.3	7/7	ND	Taraschewski et al. 1987
<i>Paratenuisentis ambigua</i> (Van Cleave, 1921)	i	Estuary/North Sea	River Elbe Estuary	Germany	334	0.3	7/7	ND	Taraschewski et al. 1987
		Estuary/North Sea	River Elbe Estuary	Germany	334	0.3	7/7	ND	Taraschewski et al. 1987

Phylum/Family	Infection site	Habitat (Salinity)	Locality	Country	n	P (%)	m/I	mA/SD	Author of record
	River	River	River Weser	Germany	47	87.2	98.2/ 1-41.0	ND	Taraschewski et al., 1987
	River	River	River Weser (Schlüsselburg)	Germany	ND	ND	ND	ND	Sures et al., 1994
	River	River	River Rhine (Leimersheimer Altheim)	Germany	61	39.3	41.6	16.4/34.0	Sures et al., 1999
	River	River	River Rhine (harbour of Germersheim)	Germany	60	56.7	23.8	13.5/23.7	Sures et al., 1999
	River	River	River Rhine (Worms)	Germany	35	14.3	29.8	4.3/18.7	Sures & Streit, 2001
	River	River	River Rhine (Karlsruhe)	Germany	19	36.8	16.3	6.0/17.2	Sures & Streit, 2001
	River	River	River Weser (Schlüsselburg)	Germany	291	71.1	ND	ND	Reimer, 2004
	River	River	River Main/Gemünden	Germany	22	4.5	2.0	0.1	Thielen, 2005
	River	River	River Rhine/St. Goar	Germany	29	31.0	33.9	10.5	Thielen, 2005
	River	River	River Lippe/Hünxe	Germany	31	16.1	11.6	1.9	Thielen, 2005
	River	River	River Eider	Germany	30	20	5.3/1-26	1.06	Jakob et al., 2009
	Baltic Sea (10-20)		Maasholm	Germany	30	6.6	1/1 373/	0.07	Jakob et al., 2009
	River	River	River Elbe Estuary	Germany	30	6.6	3-744	22.41	this paper
	Lake	Lagoon	Ijsselmeer/Makkum	Netherlands	30	66.7	36.0	24.0	Thielen, 2005
	Lagoon/Baltic Sea		Vistula Lagoon	Russia	142	2.8	1-4	0.049	Rodjuk & Shelenkova, 2006
PHYLUM ARTHROPODA									
Family Ergasilidae Burmeister, 1835									
	Lake	Lake	Lake Bafa	Turkey	ND	ND	ND	ND	Reimer, 1999
	Freshwater		Bohemia	Czech Republic	ND	ND	ND	ND	Moravec, 2001
	Lake	Lake	Lake Esrum	Denmark	120	26.7	1.6/1-4 23.3/	0.42	Køie, 1988a
	Baltic Sea (4-8)		Ulf Sund	Denmark	60	56.7	1-13.0	13.0	Køie, 1988b
	Fjord/North Sea (10)		Ringkøbing Fjord	Denmark	24	8.3	1/1	0.83	Køie, 1988b
	Fjord/Baltic Sea (15-20)		Isefjord	Denmark	80	10	7.3/1-40	0.73	Køie, 1988b
	Lake	Estuary/North Sea	Slapton Ley	England/UK	ND	ND	ND	ND	Canning et al., 1973
	Estuary/North Sea		Exminster Marshes	England/UK	15	6.7	1.0/1	0.07	Kennedy et al., 1992
	Baltic Sea	Baltic Sea	Kiel Fjord	Germany	ND	ND	ND	ND	Möller, 1975
	Baltic Sea		Bight of Wismar	Germany	104	ND	ND	ND	Reimer, 1987
	Lagoon/Baltic Sea		Lassan /Peenestrom	Germany	205	ND	ND	ND	Reimer, 1987
	Lake	Lake	Lake Plön	Germany	30	3.3	1/1	0.03	Jakob et al., 2009
	River	River	River Eider	Germany	30	30	2.3/1-5	0.69	Jakob et al., 2009
	Baltic Sea		Fehmarn Belt	Germany	30	3.3	1/1	0.03	Jakob et al., 2009
	River		River Elbe Estuary	Germany	30	3.3	1/1	0.03	this paper

Phylum/Family	Infection site	Habitat (Salinity)	Locality	Country	n	P (%)	m/l	mASD	Author of record
<i>Ergasilus sieboldi</i> von Nordmann, 1832	River		River Elbe (Gorleben)	Germany	30	10	1/1	0.1	this paper
	Lake		Lake Balaton	Hungary	81	2.5	ND	ND	Molnár & Székely, 1995 Conneely & McCarthy, 1984
	River/Lake		Corrib catchment area	Ireland	15	ND	ND	ND	Conneely & McCarthy, 1986
	River		River Abbert	Ireland	33	6	2	0.12	Conneely & McCarthy, 1986
	River		River Drimneen	Ireland	49	4	1.5	0.06	Conneely & McCarthy, 1986
	Lake		Lake Corrib	Ireland	39	80	4.5	3.6	Conneely & McCarthy, 1986
	River		River Shannon	Ireland	ND	ND	ND	ND	Holland & Kennedy, 1997
	Lake		Assaroe Lake, Co Donegal/River Erne catchment	Ireland	45	4.4	4-5/6	13.2	Copley & McCarthy, 2001
	Lagoon/Adriatic Sea (15-35)		Valle Figheri/Adriatic Coast	Italy	33	3.0	ND	0.2	Di Cave et al., 2001
	Lake/Baltic Sea		Lakes Liepājas, Rušons, Usmas, Kegums Water Reservoir, Gulf of Riga	Latvia	ND	ND	ND	ND	Kirjušina & Vismānis, 2007
	Lake		Lakes Ohrid, Prespa and Dojran	Macedonia	5	80.0	15.25	12.2	Stojanovski et al., 2006
	Baltic Sea		Piastowski Canal (Szczecin Lagoon)	Poland	20	5.0	4	0.20	Orecka-Grabda & Wierzbicka, 1994
	Lagoon/Baltic Sea		Trzebiez (Szczecin Lagoon)	Poland	71	2.8	1-4	0.07	Orecka-Grabda & Wierzbicka, 1994
	Estuary/Atlantic		Ria de Aveiro	Portugal	134	9.7	5.9/1-25	0.57/2.63	Hermida et al., 2008
	River		River Este	Portugal	129	24.4	ND	ND	Saraiva & Chubb, 1989
	Lagoon/Baltic Sea		Vistula Lagoon	Russia	142	2.1	1	0.021	Rodjuk & Shelenkova, 2006
	Baltic Sea		Neva Bight ponds and open waters in Čunovo, southern Slovakia	Russia	ND	ND	ND	ND	Reimer, 1987
	Freshwater		former U.S.S.R.	Slovak Republic	ND	ND	ND	ND	Moravec, 2001
	Lagoon/Mediterranean Sea (8-30)		Canal Vell, Ebro Delta	Spain	ND	7.7	ND	0.59/8.33	Mafllo et al., 2005
	River		River Ulja	Spain	323	1.6	7.4/1-19	0.11/1.25	Aguilar et al., 2005
	River		River Tea	Spain	200	3.5	1.29/1-2	0.05/0.25	Aguilar et al., 2005
	Freshwater		former U.S.S.R.	former U.S.S.R.	ND	ND	ND	ND	Bykhovskaya-Pavlovskaya et al., 1964
	Lake		Lake Neustedter	Austria	56	3.57	1.5/1-2	0.05	Kritscher, 1975
	Lake/ River		Lake Mácha, River Svratka	Czech Republic	ND	ND	ND	ND	Moravec, 2001
	Lake		Lake Sjælsø	Denmark	20	25	2.4/1-6	0.6	Køte, 1988b
Lake		Lake Usmas	Latvia	ND	ND	ND	ND	Kirjušina & Vismānis, 2007	
Baltic Sea		Piastowski Canal (Szczecin Lagoon)	Poland	20	25.0	1-2	0.30	Orecka-Grabda & Wierzbicka, 1994	
Lagoon/Baltic Sea		Lu bin (Szczecin Lagoon)	Poland	25	72.0	1-11	2.32	Orecka-Grabda & Wierzbicka, 1994	

Phylum/Family	Infection site	Habitat (Salinity)	Locality	Country	n	P (%)	m/I	mA/SD	Author of record
Family Lernaeidae 1879									
<i>Lernaea cyprinacea</i> Linnaeus, 1758	g	Lagoon/Baltic Sea	Trzebiez (Szczecin Lagoon)	Poland	71	56.3	1-16	2.39	Orecka-Grabda & Wierzbicka, 1994
<i>Lernaeocera branchialis</i> (Linnaeus, 1767)	g	Lagoon/Baltic Sea	Stepnica (Szczecin Lagoon)	Poland	30	46.7	1-7	1.27	Orecka-Grabda & Wierzbicka, 1994
Family Gnathiidea Leach, 1814									
<i>Gnathia maxillaris</i> (Montagu, 1804)									
Gnathiidae gen. sp.	g	Lagoon/Baltic Sea	Nowe Warpno (Szczecin Lagoon)	Poland	13	46.1	1-6	1.00	Orecka-Grabda & Wierzbicka, 1994
		Estuary/Baltic Sea	River Odra Mouth	Poland	24	33.3	1-4	0.75	Orecka-Grabda & Wierzbicka, 1994
		Lagoon/Baltic Sea	Vistula Lagoon	Russia	142	28.9	1-21	1.366	Rodjnik & Shelenkova, 2006
		Freshwater	former U.S.S.R.	former U.S.S.R.	ND	ND	ND	ND	Bykhovskaya-Pavlovskaya et al., 1964
		Kattegat (30-34)	Kattegat	Denmark	36	13.9	1.8/1-5	0.25	Køte, 1988b
		Baltic Sea (12-18)	Kiel Fjord	Germany	30	13.3	1.8/1-3	0.24	Jakob et al., 2009
		River	River Otter	England/UK	233	1.3	1.0/1-3	0.01	Kennedy et al., 1992
Family Argulidae Müller, 1785									
<i>Argulus foliaceus</i> (Linnaeus, 1758)	g	Estuary/Atlantic	Arousa	Spain	477	2.5	1.3/1-3	0.03/0.22	Outeiral et al., 2002
		Estuary/North Sea	River Ouse	England/UK	ND	ND	ND	ND	Mugridge & Sullybrass, 1983
		Estuary/Atlantic	Ria de Aveiro	Portugal	134	3.7	1.8/1-4	0.07/0.41	Hermida et al., 2008
		Lake	Lake Esrum	Denmark	120	8.3	1.1/1-2	0.09	Køte, 1988a
		Lake	Shobrooke Lake	England/UK	131	3.1	1/1	0.03	Kennedy et al., 1992
		River	River Eider	Germany	30	3.3	1/1	0.03	Jakob et al., 2009
		Lake	Lakes Liepājas, Rāznas	Latvia	ND	ND	ND	ND	Kirjušina & Vismānis, 2007
		Lagoon/Baltic Sea	Trzebiez (Szczecin Lagoon)	Poland	71	1.4	1	0.01	Orecka-Grabda & Wierzbicka, 1994
Family Eremaeidae Willmann, 1931									
<i>Hydrozetes</i> sp.	g	Lagoon/Baltic Sea	Nowe Warpno (Szczecin Lagoon)	Poland	13	15.4	1	0.15	Orecka-Grabda & Wierzbicka, 1994
PHYLUM ANNELIDA									
Family Piscicolidae Johnston, 1865									
<i>Piscicola geometra</i> (Linnaeus, 1761)	f, g, mc, sk	Freshwater	former U.S.S.R.	former U.S.S.R.	ND	ND	ND	ND	Bykhovskaya-Pavlovskaya et al., 1964
		Lake	Lake Mácha	Czech Republic	ND	ND	ND	ND	Moravec, 2001
		Lake	Lake Mácha	Czech Republic	ND	ND	ND	ND	Moravec, 2001
		Lake	Lake Esrum	Denmark	120	ND	ND	ND	Køte, 1988a

Phylum/Family	Infection site	Habitat (Salinity)	Locality	Country	n	P (%)	m/l	mASD	Author of record
<i>Piscicola respirans</i> Troschel, 1850		Lake	Lough Rea	Ireland	32	3.1	2.0	0.06	Callaghan & McCarthy, 1996
PHYLUM MOLLUSCA Family Unionidae Rafinesque, 1820		ND	ND	Poland	ND	ND	ND	ND	Reimer, 1999
<i>Anodonta cygnea</i> (Linnaeus, 1758)	g	Lake	Assaroe Lake, Co Donegal/River Erne catchment	Ireland	45	24.4	ND	ND	Copley & McCarthy, 2001
		Lake	Lakes Usmas	Latvia	ND	ND	ND	ND	Kirjušina & Vismans, 2007
<i>Anodonta</i> sp.	g	Lake	Lake Esrum	Denmark	120	7.5	6.8/1-26	0.51	Kjøte, 1988a
		Lake	Lake Sjælø	Denmark	20	20	2.0/1-4	0.4	Kjøte, 1988b

CHAPTER III

Monitoring of *Herpesvirus anguillae* (HVA) infections in European eel, *Anguilla anguilla* (L.), in northern Germany

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Short Communication

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Freshwater eels, *Anguilla* spp., have experienced a worldwide decline over recent decades. European eel, *Anguilla anguilla* (L.), numbers have decreased remarkably since the early 1980s, with observed losses in overall recruitment of up to 99%. Similar, but slightly less dramatic declines have been reported for Japanese eels, *Anguilla japonica* Temminck and Schlegel, and American eels, *Anguilla rostrata* (Lesueur) (Dekker, 2003a). Although a coherent explanation for this phenomenon is still lacking, there are several possible causes, including: (i) contamination of aquatic habitats with xenobiotics, (ii) oceanographic/climatic changes, (iii) migration inhibitors, (iv) overfishing, (v) predating birds and (vi) infectious diseases (Dekker, 2003a, b; van Ginneken & Maes, 2005).

As a result of the steep decline in European eel numbers, the European Commission has proposed a Community Action Plan for protection and recovery of the severely depleted eel stock (Council Regulation EC, 2007). This regulation includes the preparation of management plans for each eel river basin by the member states with the objective to reduce anthropogenic mortalities so as to permit the escapement to the sea of at least 40% of the silver eel biomass relative to the best estimate of escapement that would have existed without anthropogenic influences (Council Regulation EC, 2007). One of the measures included is that 60% of eels <12 cm in length caught annually should be reserved for restocking to suitable habitats (Council Regulation EC, 2007). Besides fishing mortality, natural predation and turbine losses, recruitment to the eel spawning stock in a given water body might also be dependent on habitat quality in terms of pollution (Maes et al., 2008) as well as the occurrence of viral diseases (van Ginneken et al., 2004) and parasites (Kennedy, 2007).

While the impact of parasites, particularly, infection with the swim bladder nematode *Anguillicoloides crassus* was investigated in great detail (Kennedy, 2007), eel viruses have not received much attention (van Ginneken et al. 2004). Various viruses have been isolated from the European eel, including the rhabdoviruses eel virus America and eel virus European-X (EVEX), the birnavirus infectious pancreatic necrosis virus as well as a herpesvirus, *Herpesvirus anguillae* (HVA) (Sano et al., 1977; Jørgensen et al., 1994; Davidse

et al., 1999; van Nieuwstadt et al., 2001; van Ginneken et al. 2004; van Ginneken et al., 2005). Among these, EVEX and HVA have received most attention. Some authors (Davidse et al., 1999; Lehmann et al., 2005) consider HVA as the most significant viral threat to the European eel because of its high pathogenicity. The virus has caused severe losses in aquaculture as well as in wild eels of German rivers and lakes (Scheinert & Baath, 2004, 2006). *Herpesvirus anguillae* has been isolated from cultured eels in several countries worldwide, including Japan (Sano et al., 1990), Taiwan (Ueno et al., 1992; Chang et al., 2002) and the Netherlands (Davidse et al., 1999; van Nieuwstadt et al. 2001; Haenen et al., 2002). More recently, HVA was also detected in eels from natural habitats in rivers and lakes in the Netherlands (Haenen et al. 2002) and Germany (Scheinert & Baath, 2004, 2006; Lehmann et al., 2005), with a prevalence of up to 48% in eels from some Bavarian water bodies (Scheinert & Baath, 2006).

Clinical signs of HVA infection include dermal haemorrhagic lesions, mainly in the pectoral fin and opercular regions, as well as congestion and destruction of gill filaments (van Nieuwstadt et al., 2001). A peculiarity of herpesvirus infection is a rapid shift from a latent phase without clinical signs to an acute aetiopathology induced by immune suppression caused by endogenous or exogenous factors (Mossman & Ashkar, 2005). As the establishment of an HVA-specific polymerase chain reaction (PCR) by Rijsewijk et al. (2005), virus DNA has been detected in farmed and wild eels from many European countries, even in eels without any pathology.

The present study was undertaken to further determine the prevalence of virus infections in European eels from natural habitats. For the first time, eels from water bodies with differing salinity regimes were collected in Schleswig Holstein (northern Germany) and evaluated for the spread of viral infections in freshwater, brackish and marine habitats.

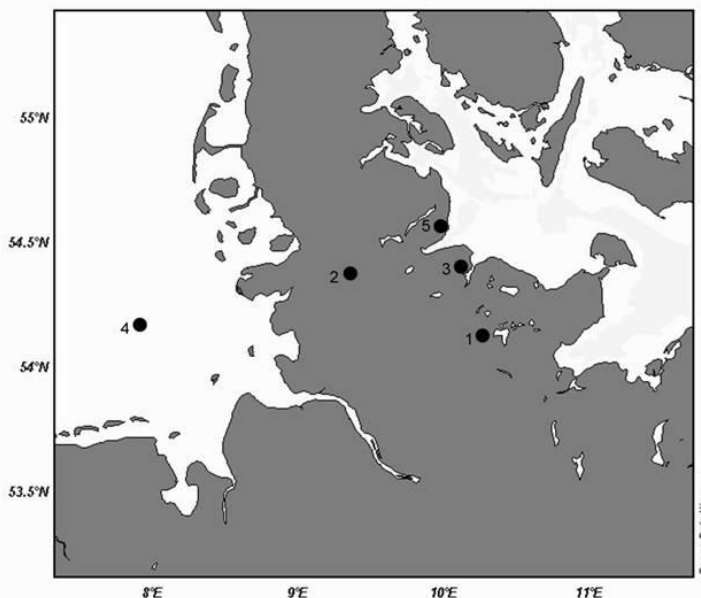


Figure III-1 Eel sampling sites in northern Germany including the freshwater localities Lake Plön and River Eider, the brackish water localities Fiedrichsort (Kiel Fjord) and Maasholm, and the marine location Helgoland. Map source: Ocean Data View, Schlitzer, 2007.

Eels (length range: 40–106 cm) were taken from commercial fyke nets at five different sample sites in northern Germany (Figure III-1) between April and October 2006. The sample sites included two freshwater locations (Lake Plön and River Eider), two brackish water locations in the western Baltic Sea (near Maasholm and in Kiel Bay near Friedrichsort) and one marine location (Helgoland coast). A total of 140 eels were examined for HVA infections. Tissue samples from liver, kidney, spleen and gills were collected from individual fish and stored at $-40\text{ }^{\circ}\text{C}$ until analysis. For virus isolation, pooled samples from liver, kidney, spleen and gills of each eel were supplemented with 5% foetal bovine serum, 200 IU mL^{-1} penicillin and $200\text{ }\mu\text{g mL}^{-1}$

streptomycin with sterile sand. The suspensions were kept at 4 °C for 1 h, centrifuged at 3000 g for 30 min and sterile filtered through a 0.20 µm pore filter (Sartorius). Additionally, non-pooled tissue samples (liver, kidney, spleen and gills) from 15 of the 30 River Eider eels were processed and examined separately. Tissue suspensions were tested on eel kidney (EK-1) cell monolayers (Chen & Kou, 1981) grown on Leibovitz L-15 medium supplemented with 10% foetal bovine serum, antibiotics and non-essential amino acids in a humidified atmosphere with 2.5% CO₂ at 25 °C. For virus isolation, tissue suspensions were inoculated into 1-day-old monolayers at 1 : 10 and 1 : 100 dilutions in culture medium, incubated at 25 °C and observed for the appearance of cytopathic effects over 7 days. Samples were examined over at least three subcultures. In case of cytopathic effect, the infected cell line was examined by PCR as described by Rijsewijk et al. (2005) for the detection of an HVA infection.

Total DNA was extracted from aliquots (25 mg) of the pooled tissue samples from all eels using DNAeasy Kits (Qiagen) following the manufacturer’s instructions. DNA was also extracted from tissue cultures showing cytopathic effect after incubation with tissue sample suspensions. All DNA samples were submitted to a PCR using HVA-specific primer pairs designed by Rijsewijk et al. (2005). The reaction was performed in a 50 µL reaction mixture. Amplification was performed in a programmable thermal cycler (Eppendorf Mastercycle) with the following parameters: initial heating at 95 °C for 2 min, followed by 36 cycles of denaturation at 94 °C for 15 s, annealing at 60 °C for 30 s and extension at 68 °C for 1 min, with a final extension at 68 °C for 10 min. The samples were then kept at 4 °C until electrophoresis. The products were separated in a 1% agarose gel, stained with ethidium bromide (Sigma) and visualized under UV illumination (Biometra).

Cell-based virus isolation did not reveal virus infections in any of the 140 eels investigated (Table III-1). Additionally, PCR tests for the detection of HVA in cell pellets and culture supernatants from EK-1 monolayers, which were incubated together with tissue suspensions from eel samples, gave negative results. Nevertheless, when the PCR was performed directly on eel tissues,

the virus was detected in eels from the North Sea around Helgoland. Two of the pooled tissue samples from 20 eels gave positive PCR results for HVA (Table III-1). In addition,

Tissue	n	Number of positive samples	
		PCR	Virus isolation
Gills	15	1	0
Kidney	15	0	0
Liver	15	0	0
Spleen	15	0	0

Figure III-2 *Herpesvirus anguillae* detection in individual tissue samples from River Eider eels.

Sampling site	Eels examined			Number of positive samples	
	n	TL ± SD (cm)	Sample date	PCR	Virus isolation
Lake Plön (F)	30	91.7 ± 6.7	4 May 2006	0	0
River Eider (F)	30	49.7 ± 11.9	9 October 2006	0	0
Friedrichsort (B)	30	63.9 ± 9.6	29 April 2006	0	0
Maasholm (B)	30	71.5 ± 7.4	30 June 2006	0	0
Helgoland (M)	20	59.4 ± 8.5	23 July 2006	2	0

n, number of eels; TL, total length; SD, standard deviation.

Figure III-1 *Herpesvirus anguillae* detection in pooled tissue samples from eels collected from the freshwater (F) localities Lake Plön and River Eider, the brackish (B) water localities Friedrichsort and Maasholm and the marine (M) location Helgoland.

samples from gills, kidney, liver and spleen of eels from the River Eider were analysed separately, one of 15 gill samples were positive by PCR (Table III-2), while pools of liver, kidney, spleen and gills from 30 eels from this location (including samples from the 15 individuals tested in the previous round) were negative (Table III-1). Negative PCR results were also obtained from samples collected in the western

Baltic Sea near Maasholm, in the Kiel Fjord near Friedrichsort and in the freshwater Lake Plön.

Herpesvirus anguillae surveys in European eel have so far been restricted to western and central European freshwater habitats. The high prevalence of the virus within the investigated areas with local prevalences of up to 48% (Scheinert & Baath, 2006), partly led to the conclusion that HVA was ubiquitous within Europe (van Nieuwstadt et al., 2001; Haenen et al., 2002; Scheinert & Baath, 2004). This study is the first viral investigation of eels in northern Germany. Even though HVA was detected in two of the five water bodies investigated, the overall infection prevalence of 2% is remarkably low compared with similar investigations in the Netherlands (van Ginneken et al. 2004) and southern (Scheinert & Baath, 2004, 2006) and western Germany (Lehmann et al., 2005). Virus infection was only detected by direct PCR testing of tissues and not by virus isolation. None of the three HVA PCR-positive eels showed any clinical sign of disease. The low virus loads of the three positive eels could represent levels characteristic of an HVA carrier state (van Nieuwstadt et al., 2001).

It might be that the low prevalence of infection is related to a temperature effect on detection methodology. Eels were caught at water temperatures between 8 °C (Friedrichsort, Lake Plön) and 20 °C (Maasholm, Helgoland). PCR-positive eels at Helgoland were collected in July when water temperatures were approximately 20 °C and at the Eider location in October at water temperatures around 12–14 °C. A temperature-dependent reactivation of latent HVA infection has been widely discussed, for example by Scheinert & Baath (2004, 2006), who observed mortalities associated with HVA isolation in eels from Bavarian waters mainly during summer. In addition, Davidse et al. (1999) recorded clinical signs of HVA infection in farmed eels at 24 °C. The European eel is considered to be adapted to warm waters with an optimal temperature of about 26 °C (Tesch, 2003). Thus, summer temperatures between 20 and 24 °C would not be considered as stressful for eels and predisposing latently infected eels to reactivation of virus shedding. A possible factor for reactivation might be found in the temperature-dependent replication of HVA. In tissue culture experiments, HVA replicated at temperatures between 15 and 30 °C, but not at 10 °C (Jakob et al. unpublished data), with a more rapid replication at higher temperatures. This would facilitate the spread of HVA infection during the warm summer months. In the present study, HVA was not detected in eels collected at Maasholm at the end of June 2006 at water temperatures of approximately 18 °C, which would be within a “permissive” temperature range of 15 to 30 °C. It seems unlikely that the low prevalence of HVA-positive eels in northern Germany in the present study is related only to a temperature effect, but rather reflects the distribution of the infection in the area under investigation. However, when considering negative HVA results from wild eel samples, the effect of water temperature on virus replication and reactivation needs to be taken into account.

Based on the results of this study, we conclude that HVA is established in local populations of eels in freshwater and, as shown for the first time, also in marine habitats in northern Germany. Latent HVA infections were found in apparently healthy eels, which harboured low virus concentrations at a very low prevalence in marine and brackish water habitats. This is of particular importance for management options such as the choice of suitable locations for restocking.

Acknowledgements

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CHAPTER IV

Detection of *Herpesvirus anguillae* (HVA) in European eel by nested-PCR

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Abstract

For the detection of latent infections of *Herpesvirus anguillae* (HVA) in European eels from natural waters, a nested PCR was developed. With this assay, an improvement in sensitivity compared to a standard PCR assay was achieved.

Using this method, latent infections with HVA could be detected in eels caught in Lake Pönitz (northern Germany) during July 2007. In eels which were collected from the same lake in June, and eel from the River Elbe, latent HVA infections could not be detected. This indicates that HVA is present in various waters in Germany and can be traced using sensitive diagnostic methods.

Introduction

Since the first detection of *Herpesvirus anguillae* (HVA) in European eel (Sano et al., 1990), this virus was isolated from cultured eels in several countries world-wide, like Japan (Sano et al., 1990), Taiwan (Ueno et al., 1992; Chang et al., 2002) and the Netherlands (Davidse et al., 1999; van Nieuwstadt et al., 2001; Haenen et al., 2002) where even elvers for restocking were found virus positive (van Ginneken et al., 2004). More recently, HVA was also detected in eels from natural habitats in rivers and lakes in the Netherlands (Haenen et al., 2002) and Germany (Lehmann et al., 2005; Scheinert & Baath, 2004, 2006; Jakob et al., 2009b), but also in one eel sampled at the marine locality Helgoland in the North Sea (Jakob et al., 2009b).

Some authors (Davidse et al., 1999; Lehmann et al., 2005) consider HVA as the most significant viral threat for the European eel due to its high pathogenicity in farmed as well as in wild eels (Scheinert & Baath, 2004, 2006). Symptoms of HVA infections include dermal haemorrhagic lesions mainly in the pectoral fin and opercular regions as well as congestion and destruction of gill filaments (van Nieuwstadt et al., 2001). HVA can also establish a latent infection in eel (van Nieuwstadt et al., 2001) but can be reactivated by immune suppression caused by endogenous or exogenous factors (Mossman & Ashkar, 2005).

During the latent phase the production of infectious virus particles is suppressed and verification by serological methods or via cell culture not possible (Cohrs & Gilden, 2001).

Since the establishment of a HVA PCR by Rijsewijk et al. (2005) virus DNA was detected in farmed and wild eels from many European countries, even in eels without pathological findings. This method had an enhanced sensitivity compared to serological or cell culture procedures and therefore seemed to be appropriate to detect HVA DNA not only in eels with an acute aetiopathology and high virus concentrations but also latent infections or asymptomatic carriers. In the presence of eel DNA, background bands may appear which made it difficult to detect faint bands resulting from tissue samples with low virus load.

Latently infected eels, which harbour low virus copy numbers, can be considered as a large threat as they can serve as carrier for the virus. Restocking of these, apparently healthy eels, can lead to virus introduction into so far pristine habitats. As part of the EU regulation (EC, 2007) for protection and sustainable use of the European eel stock 60% of eels less than 12 cm in length caught annually should be reserved for restocking to suitable habitats. Screening of these eels for HVA is necessary and a reliable method essential to avoid a further viral spread and to support a successful restocking.

The present study was undertaken to develop a more reliable and sensitive method for the detection of HVA with a high probability even in latently infected eels.

Therefore a nested-PCR was developed. Using this method samples from feral European eels from two freshwater localities in northern Germany (River Elbe and Lake Pönitz) were tested for the presence of HVA.

The advantage of a nested-PCR over a conventional PCR is a 10 to 100 times raised sensitivity combined with a higher specificity (Noda et al., 1998, Porter-Jordan et al., 1990) to eliminate false negative results with a high probability.

Material and methods

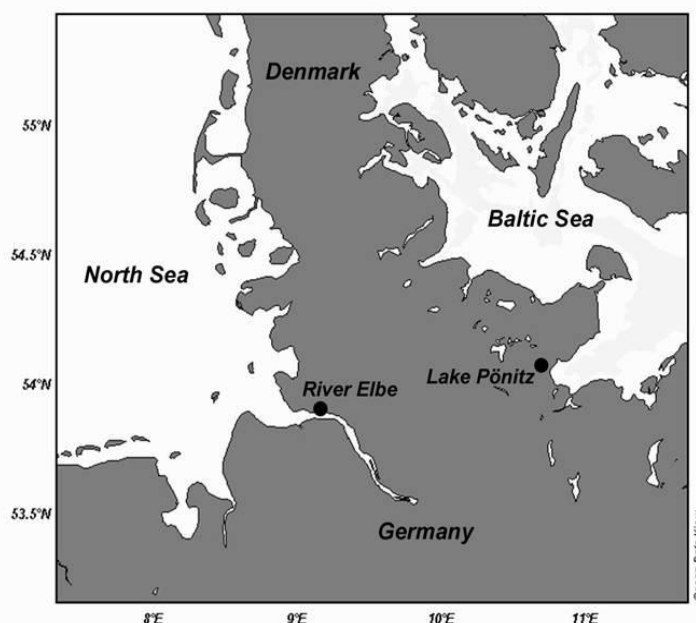


Figure IV-1 Eel sampling sites in northern Germany including the freshwater localities Lake Pönitz and River Elbe. Map Source: Ocean Data View, Schlitzer, 2007.

Genomic DNA of HVA was extracted from virus tissue culture supernatants obtained from eel kidney 1 (EK-1) cell cultures infected with the virus using DNAeasy kits (Qiagen, Germany). Genomic DNA from virus free fish was isolated from carp kept in recirculated water under specific pathogen free conditions (Fish Disease Research Unit, University of Veterinary Medicine Hannover). Additionally genomic DNA was extracted from European eels (n=45) from two sampling site (Figure IV-1) in northern Germany, River Elbe estuary and Lake Pönitz. The eels were sampled in June and October 2007 (Table IV-1). Tissue samples from liver, kidney, spleen and gills were collected from individual fish and analysed for infection with HVA

by means of tissue culture methods as well as by PCR based assays. For virus isolation, pooled tissue samples were homogenised and the material was tested on monolayer cultures of the EK-1 cell line as described earlier (Jakob et al., 2009). For PCR based analysis, aliquots (25 mg) of the pooled tissue samples from all eel specimens were taken and the total DNA was extracted using DNAeasy Kits (Qiagen, Hilden) following manufactures instructions.

Table IV-1 Sampling sites of European eels in northern Germany. n=number of eels, TL=total length, TW, total weight, S.D.=standard deviation.

Sampling site	n	TL (cm) ± S.D.	TW (g) ± S.D.	Date of catch
River Elbe Estuary	30	78 ± 5.6	1016 ± 195	October 2007
Lake Pönitz	16	57 ± 4.8	337 ± 96	June-July 2007

All DNA samples were submitted to a first round-PCR using primers based on the DNA dependent DNA polymerase gene (Rijsewijk et al., 2005, Table IV-2). The reaction was performed in a 30 µl reaction mixture with following cycle parameters: initial denaturation at 94°C for 10 min, followed by 30 cycles of denaturation at 94°C for 30 sec, annealing at 60°C for 45 sec and extension at 72°C for 1 min with a final extension at 72°C for 5 min. . Subsequently, 2µl amplification product of the initial-PCR was re-amplified in a second round PCR using the internal primer pair (Table IV-3). The reaction was done in a total volume of 25µl containing Taq polymerase and with an annealing temperature of 68 °C. PCR products were separated in a 1% agarose gel, stained with ethidium bromide (Chemicals: Sigma, Munich, Germany) and visualised under UV illumination (Biometra, Goettingen, Germany).

Table VI-2 External primer pairs used for the first round HVA-PCR (after Rijsewijk et al., 2005).

External Primer	Sequence	Length
HVAPOLVPSD (forward)	5'-GTGTCGGGCCTTTGTGGTGA-3'	394 bp
HVAPOLOOSN (reverse)	5'-CATGCCGGGAGTCTTTTTGAT-3'	

Table IV-3 Internal primer pairs used for the second round HVA-PCR.

Internal Primer	Sequence	Length
AHVn_FW1 (forward)	5'-AGAATAGGGAGTACGGGGAGG-3'	255 bp
AHVn_RV1 (reverse)	5'-ACATCTGACAGATCGGATCCG-3'	

Results and discussion

HVA detection by the nested PCR assay

From HVA genomic DNA fragments of the appropriate size (394 bp for the initial PCR, 255 bp for the nested PCR) were amplified. The PCR conditions were optimised by using different DNA polymerases and gradient PCR for adjustment of annealing temperatures for external and internal primer pairs. The primers selected did not amplify genomic DNA from carp or eel tissue or from CyHV-3. The nested PCR detected HVA DNA up to a dilution of 10⁻⁸, while the detection limit for the first round PCR was 10⁻⁴ (Figure IV-2).

Nucleotide sequence alignments between the fragment amplified in the nested PCR and the DNA dependent DNA polymerase gene (Rijsewijk et al., 2005, GenBank Accession

No.AF333066.1) revealed 100 % homology. BLAST search also showed 100 % homology with the HVA DNA dependent DNA polymerase gene.

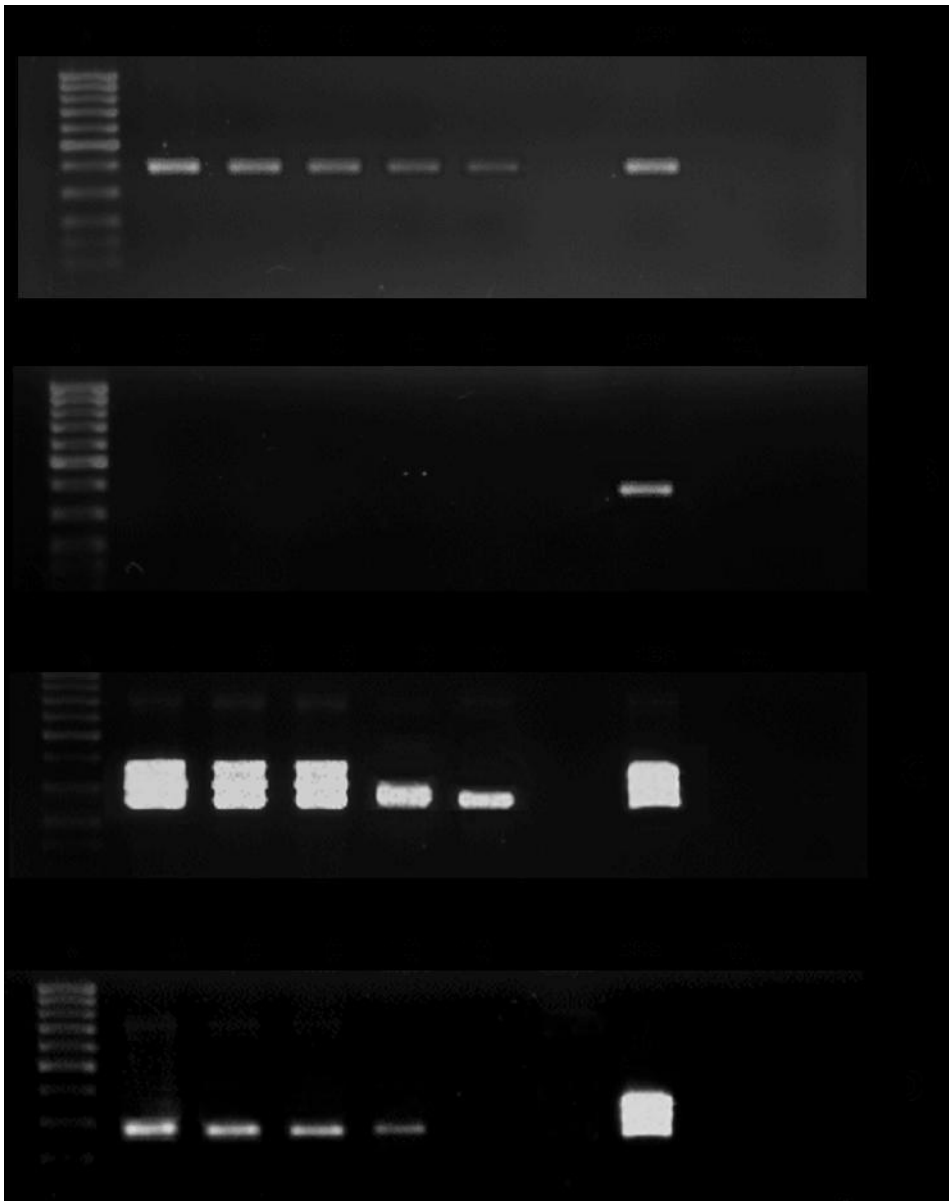


Figure IV-2 PCR detection of *Herpesvirus anguillae* (HVA) by PCR. A, B: Agarose gels showing detection limits of Rijsewik's (2005) assay by amplifying 10 fold serial dilutions of a genomic DNA isolated from tissue culture raised HVA. This assay was able to detect virus DNA up to a dilution of 10^{-4} . C, D: Agarose gels showing detection limits of the nested PCR of the same DNA preparation. This assay was able to trace virus DNA up to a dilution of 10^{-8} . M: 100 bp DNA ladder, 1 to 10^{-9} : serial tenfold DNA dilution used as template in the PCR assays, pos: positive, neg: negative (non template) control.

Detection of HVA infection in eels from field samples

Cell culture examination did not reveal HVA infection in any of the tested tissue samples of eels from the Lake Pönitz or the River Elbe. Results of previous studies indicated that the sensitivity of cell culture based methods is not sufficient to detect HVA in latent infected eels. This became first evident when eels, which were tested negative for HVA by means of

cell culture based virus isolation were found virus positive after dexamethasone treatment (van Nieuwstadt et al., 2001). In field studies, latent HVA infections in feral eels were detected only by PCR examination, but not by virus isolation methods (Jakob et al., 2009). In many cases, tissue samples from latent infected eels however gave very faint signals in the PCR assay.

Therefore we developed a 2- round PCR with external and internal primers specific to the DNA polymerase. As external primers, previously designed sequences were used (Rijsewik et al., 2005). With the 2 round PCR assay, the detection limit of HVA DNA could be improved by several powers of ten (see Figure IV-2). In addition, the specificity of this assay reduced the amplification of background DNA bands, which sometimes occurred in the initial PCR when genomic DNA of eels was present in the reaction mixture. These background bands made it difficult to clearly identify faint bands from tissue samples with low virus load. The nested PCR assay reduced the possibility of false positive results as mis-interpretation of background bands from the initial PCR, because the internal primers used in the second round amplification act as internal controls and allow to confirm the presumptive product of the initial amplification (Porter-Jordan et al., 1990). Because of its high sensitivity, the nested PCR assay, however is extremely prone to contamination and therefore needs to be performed under extremely clean conditions.

In the present study, tissue pools from the same individuals were analysed for the presence of HVA by both PCR assays. Although HVA could not be detected by the first round PCR, in the nested PCR 2 of 46 eel samples were found HVA positive. The positive eels were caught from Lake Pönitz in July 2007, while in individuals, which were collected from the same lake in June, and all eels from the River Elbe an infection with HVA could not be detected.

This together with previous reports from other sites (Scheinert & Baath, 2006; Jakob et al., 2009) indicates that latent HVA infections are present in eel populations from several waters in Germany. They can be traced by applying sensitive detection methods. Latent infections could be reactivated under stress conditions and infective HVA virus particles could be shed (van Nieuwstadt et al., 2001). These eels might be responsible for further spread of the infection. Whether elevated water temperature, social stress or migration activities might act as stressors and can reactivate latent infections has to be clarified.

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GENERAL DISCUSSION

Over the last decades the recruitment of European eel, *Anguilla anguilla*, decreased remarkably with observed losses of up to 99%. To consider the reasons for the eel decline, all possibilities have to be evaluated to determine their potential impact. A combination of high fishing pressure, habitat loss, migration barriers, possible oceanic changes, contaminations and the impact of parasites and viruses needs to be considered for a successful management of this highly endangered species.

In order to implement a successful fishery management plan it is essential to understand the biology and the processes driving the population dynamics of the target species.

This study aimed to add knowledge on the distribution and detection of parasites and viruses of the European eel from different habitats in northern Germany. Furthermore, the abundance of eel pathogens was determined for each habitat as potential quality indicators for restocking suitability.

Parasite composition and community structure

In summary, the results of **Chapter I** and **Chapter II** generally confirm previous studies (e.g. Kjøie, 1988b; Kennedy et al., 1997; Di Cave et al., 2001) and further provide evidence that helminth communities in eels within their European distribution are of high similarity in composition and structure for specific habitats. In addition, salinity-dependent specificities of parasite communities are well supported by the present study and thus reflect the life history of individual eels. Eels, living most of their life in fresh water habitats, were mainly infested by cestodes and nematodes, whereas the parasite community of eels originating from marine habitats were dominated by digenean parasites. The habitat specific composition of parasite communities was well supported by a cluster analysis. This test of similarity reveals a marine, a brackish, and a freshwater group, which was further divided into River and Lake (**Figure I-2, Chapter I**) in accordance to the sampled localities. The assumption of Kennedy et al. (1997) that helminth communities of eels are generally characterised by low species diversity and high dominance of single parasite taxa could be confirmed for two localities (River Eider and Helgoland). In addition, a decline in species richness and diversity with increasing salinity (Kennedy et al., 1997) can be supported for the marine location Helgoland, but not for the sampling sites in the Baltic Sea. On the contrary, especially eels caught in the brackish environment of the Baltic Sea harboured the most diverse taxa composition (**Table I-3, Chapter I**) consisting of marine and freshwater parasites (**Table I-2, Chapter I**). The brackish water environment of the Baltic Sea is characterized by decreasing salinity from 30 PSU in the Skagerak, to 10 PSU in the Belt Sea, to 6-8 PSU in the Gulf of Finland and freshwater conditions in the north eastern part. With its changing salinities, the Baltic Sea can be seen as a transition zone for many parasite species. The distribution boundaries of parasites species are dependent of their own or of their host's salinity tolerance (Zander, 1998). Some freshwater parasite species like the digenean *Diplostomum spathaceum* or the nematode *Anguillicoloides crassus* are able to fulfil their lifecycle even in waters of lower salinity (Zander, 1998). The same has been observed for marine parasites like the digeneans *Podocotyle atomon* and *Deropristis inflata*, which are distributed as far as Bornholm and the Fehmarn Belt, respectively (Zander, 1998). These distribution patterns were also verified for the analyzed Baltic Sea samples of the present

study (**Chapter I**) and further verified by the compiled checklist (**Chapter II**). The majority of eel specific parasites can be found in European freshwaters (Marcogliese & Cone, 1993). Out of the eleven known specific species, eight were identified for northern German freshwater habitats (**Chapter I & II**). On the contrary, only one eel specific parasite (*Deropristis inflata*) was found in the marine location of Helgoland (**Chapter I**). These findings indicate that most of the co-evolutionary and adaptation processes in the parasite-host system of the European eel evolved in freshwater systems. Similar observations were made for rainbow trout (*Oncorhynchus mykiss*) with parasite communities composed to 52% - 72% of salmonid specialists in its area of origin, but with increasing distance from the heartland, the proportion of specialist decreased and were replaced by generalists (Bush et al., 2001).

Parasites as biological tags

These habitat dependent specificities make parasitological studies to appropriate tools for answering questions of the host's biology. In fisheries, parasites are often used as biological tags for fish stock separation (MacKenzie et al., 2008) or as indicators for migratory routes (Williams et al., 1992). When studying migratory fish species, parasites are indicative for the recent habitat of their host. This was also found for the eels of the Fehmarn Belt, investigated in the present study (**Chapter I**). Although these eels were caught in a brackish water environment, their parasite fauna reflected a freshwater background of most of the eels. This result clearly indicate, that these silver eels were most probably an assemblage of eels originating from the Baltic Sea proper and adjacent river systems on their spawning migration to the Sargasso Sea. On the contrary, the parasite community of eels caught around Helgoland, solely consistent of marine species, indicates a more resident behaviour in the marine environment. These assumptions were verified by micro chemistry otolith analyses conducted on the same eel specimen (Hanel et al., in prep).

Invasive parasites

Since the introduction of aquaculture in Europe, nearly 100 pathogens have been introduced into European water bodies (Blanc, 1997). For the European eel *Anguillicoloides crassus*, introduced in German waters in 1982 (Neumann, 1985), can be regarded as the only harmful parasite species for wild eels (Kennedy, 2007). This very successful invader has by now already been recorded for 25 European countries (**Chapter II**) and can be found in fresh- and brackish waters. The two introduced monogenean species *Pseudodactylogyrus anguillae* and *P. bini*, originated from the Japanese eel, are presently recorded for the European eel in 16 countries (**Chapter II**) in fresh- and brackish waters. Although *A. crassus* and *Pseudodactylogyrus* spp. were found with high prevalence of infection at all investigated fresh- and brackish water sampling sites, infestation intensities were mostly moderate to low (**Chapter I**). Pathological alterations of the swimbladder caused by *A. crassus* were rarely observed in the eel of northern Germany and the gills were without pathological findings. Furthermore, a correlation analysis of infection with *A. crassus* as well as with *Pseudodactylogyrus* spp. related to condition indices (I_G , I_L , I_{GU} and K) revealed no relationship (**Chapter I**). However, a negative effect on the fitness of eels cannot be excluded and might have a delayed effect during the oceanic spawning migration (Dekker, 2004). Furthermore, parasite accumulation is a time-driven process and intensity of infection increases with age or size of the host (Dogiel et al., 1958). Especially for eels with their undetermined continental life span, like the highly variable timing of maturation (van Ginneken & Maes, 2006), it is unpredictable if and how intense an impairment caused by parasites may be. This is of particular interest for considering the deleterious effect of *A.*

crassus on the swimbladder, which increases with intensity, duration and frequency of infestation. Owing to the long distant spawning migration eels are highly dependent on a functional swimbladder, maximum fitness and health to contribute to recruitment success.

The same three species, *A. crassus*, *P. anguillae* and *P. bini*, also successfully invaded *Anguilla rostrata* in American brackish and fresh water habitats (Kennedy, 2007). For wild American eels, *A. crassus* can be considered as an equivalent pathogen as for the European eel (Kennedy, 2007). Since its first occurrence in 1995 in North America (Fries et al., 1996) *A. crassus* has been recorded from river systems from South Carolina to Maine with infestation rates up to 90% (COSEWIC, 2006) and since 2007 also in American eels caught in Nova Scotia, Canada (Rockwell et al., 2009).

Apart from these invaders, the pathogenic potential of the remaining parasite species of eels are negligible (Kennedy, 2007). These autochthonous parasites were found with low intensities of infection (**Chapter I & II**). Thus, due to co-evolutionary processes of these autochthonous parasites a negative effect on the health of the eels is not likely to occur. Furthermore, parasites which reduce the gonadal development of their host and therefore inhibit a successful reproduction are not known for the European eel. This is for example the case in cyprinid fish, which are infested as second intermediate host with the tapeworm *Ligula intestinalis* (Carter et al., 2005). The gonads of infected fish, both male and female, remain in an immature state and therefore inhibit their reproduction (Carter et al., 2005).

Detection of *Herpesvirus anguillae*

The evaluation of the occurrence and dispersal of *Herpesvirus anguillae* in eels from northern German water bodies revealed a remarkably low prevalence of infection of only 2% in two out of five investigated water bodies (**Chapter III**). The assumption of previous studies of an omnipresence of HVA (Scheinert & Baath, 2004; van Nieuwstadt et al., 2001; Haenen et al., 2002) is therefore challenged by the present findings. However latent infections of HVA were found in the investigated water bodies and as proven for the first time, also in a marine habitat of northern Germany (**Chapter III**). These latent infections often remain undetected (Cohrs & Gilden, 2001) and therefore prevalence of infection might be underestimated. For detection of latent infections, virus isolation methods were found less reliable than assays based on molecular biological tests such as PCR or in situ hybridisation. In the case of HVA, target cells or tissues still are not identified, and therefore PCR based analyses often are performed on tissue pools, which contain combined material from different organs (Steinhagen, pers. com). This may result in a "dilution" of virus genome below the detection limit of the assay and therefore has some limitations in respect of reliability (**Chapter III & IV**). For the detection of HVA DNA in eels, Rijsewijk et al. (2005) established a PCR protocol. However, even by using this method, in many cases tissue samples from latent infected eels gave only faint signals in the PCR assay (**Chapter IV**). For the verification of even low virus copy numbers in asymptomatic carriers, a more sensitive detection method was developed (**Chapter IV**). A second round PCR was established by using the amplification product from the first round PCR, following the protocol of Rijsewijk et al. (2005), whereby the detection limit could be improved by several powers of ten (**Chapter IV**). This method was tested on eel samples from two freshwater localities in northern Germany (Lake Pönitz (n=16) and River Elbe (n=30)). But even with this high sensitive nested-PCR, HVA positive eels were only detected in 2 eels from Lake Pönitz (**Chapter IV**). Hence, the rate of HVA infection seemed to be quite low among northern German eel stocks. But the source of infection is present in at least three of the seven studied localities (**Chapter III & IV**) and under favourable conditions for virus replication like high water temperature or stress a reactivation and further dispersal of HVA might be induced.

Outlook

Methodological constraints

The detection of virus infections often fails with the method in use. The comparative examination with distinct PCR methods for the detection of Koi Herpes Virus DNA revealed strong variations in sensitivity and detection limit dependent on DNA extraction method and the combination of primer pairs and polymerase (Meyer, 2007). Differences in PCR sensitivity were also shown for the detection of HVA (Fabian, 2008). Therefore the implementation of a standardized method of high quality and sensitivity for the estimation of viral spread among European eel stocks is essential for future management considerations. Furthermore, induced stress, like simulated transport, can lead to a raised detection probability of latent infections due to virus reactivation and shedding (Meyer, 2007; Bergmann, 2008). In conclusion a combination of stress trials together with sensitive PCR methods should be used as pre-screening for stocked eels before their release in wild waters.

Vaccination and immunisation

Against HVA

Until now a standard vaccination of eels against HVA does not exist. However, an immunisation of eels with heat-inactivated antigen preparation is in use in at least one eel farm in Germany (Bergmann, pers.com). A vaccination containing live attenuated *Herpesvirus anguillae* is under development, but is not completed yet (Bergmann, pers.com). Although this vaccine could not build-up a protective immunity in eels against infections with the wild type-virus, it has the ability to reduce the mortality rates of this infectious disease (Bergmann, pers.com). Interestingly even glass eels were found to be HVA positive, raising concerns, that the virus is already present in these early live stages (Bergmann, pers. com.). Until now, the transmission pathway of HVA is not fully understood. Whether the virus is transmitted horizontal – from eel to eel - or vertical – from mother to offspring – or both ways, is still an open question as well as if eels get already infected in the sea or as early as entering the freshwater systems. Further research to address this issue is needed to develop reasonable advises for management measures.

Against *Anguillicoloides crassus*

Until now there is no evidence, that the population of the European eel developed a resistance against *A. crassus* (Knopf, 2006). However, with an ongoing co-evolution of *A. crassus* and *A. anguillae*, the immune system of the European eel will likely develop effective defence mechanisms, leading to a balanced parasite-host system, as it is known from Japanese eel (Knopf pers. com; Knopf & Mahnke, 2004). Although Knopf et al. (2008) detected an activation of phagocytes in European eels after infection with *A. crassus*, it is questionable if this host reaction implies a protective function. Furthermore, a vaccination with irradiated L₃ of *A. crassus* successfully induced resistance in the original host *Anguilla japonica*, but failed in the newly acquired host *Anguilla anguilla* (Knopf & Lucius, 2008). Therefore the only method to control *A. crassus* is by medication with the anthelmintic drug L-Levamisole, either as bath treatment or mixed with the feed resulting in a complete immobilisation of the nematodes (Hartmann, 1989; Kamstra, 2007). However, this treatment is only applicable in eel farms, but not in the wild (Kennedy, 2007).

Conclusion

Implications for the management of eels

The collected data help to evaluate the suitability of the here studied localities for potential restocking purposes regarding the presence of pathogens.

The abundance of *Herpesvirus anguillae* appeared to be very low within northern German eel. However latent HVA infections in apparently healthy eels were present in fresh and marine waters, which should be considered as a potential risk.

On the contrary, eels inhabiting freshwater habitats are at high risk for infections with *Anguillicoloides crassus* as well as with *Pseudodactylogyrus* spp. These neozoans are already an integral part of the eel parasite fauna and even prominent in brackish waters, but absent in habitats of higher salinity. Eels that stay in a purely marine environment are therefore of selective advantage and favoured in reaching their spawning grounds in good condition, with respect to parasite infection. Therefore, the common practice of catching glass eels in river estuaries for restocking solely in inland waters as management measure for stock recovery should be critically considered. This approach might worsen the problem of declining eel stocks by further diluting the number of eels that would stay in marine coastal habitats and therefore escape an infection with *A. crassus*. Moreover, uncontrolled restocking further intensifies the risk of transferring diseases and parasites to pristine areas. Although pathogens might be controllable in aquaculture by chemotherapy or vaccination, they cannot be eliminated from wild eel populations. Therefore monitoring programs and screening of the seed stock for pathogens, especially when stocking with ongrown eels from aquaculture or wild caught yellow eels, are essential to prevent a further spread of these pathogenic organisms.

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ANNEX

List of figures

Figure 1 Distribution of European eel	1
Figure 2 Life cycle of European eel.....	2
Figure 3 Eel migration and possible spawning location	2
Figure 4 Global capture (a) and aquaculture (b) production for <i>Anguilla anguilla</i>	3
Figure 5 Typical parasites of the European eel.	6
Figure 6 Heavily infected swim bladder with <i>A. crassus</i>	7
Figure 7 <i>Pseudodactylogyus bini</i>	7
Figure 8 HVA infected eels. a „redhead disease“, b haemorrhagic fin lesions.	9
Figure I-1 Sampling sites for eels in northern Germany.....	15
Figure I-2 Hierarchical cluster analysis	17
Figure I-3 Prevalence and intensity of infection for <i>Anguillicoloides crassus</i> and <i>Pseudodactylogyus</i> spp.	18
Figure II-1: Dates of first reported records of <i>Anguillicoloides crassus</i>	25
Figure II-2 Overview of studied localities with records for <i>Anguillicoloides crassus</i>	26
Figure III-1 Eel sampling sites in northern Germany	78
Figure IV-1 Eel sampling sites in northern Germany	84
Figure IV-2 PCR detection of <i>Herpesvirus anguillae</i> (HVA) by PCR.	86

List of tables

Table I-1 Mean values (\pm s.d.) of total length (LT), body mass (M), pectoral fin length (LPF), mean eye diameter (ED), Fulton's condition factor (K), gonadosomatic index (IG), gut index (IGU), and hepatosomatic index (IL) for eels from two fresh-water (F), three brackish (B), and one marine (M) locality.....	16
Table I-2 Composition of parasite communities with information on prevalence (P, percentage of eels infected), mean intensity (mI, mean number of parasite individuals per infected host), and intensity (I, number of parasite per infected host) of infection in eels from the fresh-water (F) localities Lake Plön and River Eider, the brackish (B) localities Friedrichsort, Maasholm, and Fehmarn Belt, and the marine (M) locality Helgoland.	19
Table I-3 Component community structure of helminth parasites and their diversity characteristics in eels from the fresh-water (F) Lake Plön and River Eider, the brackish (B) water Friedrichsort, Maasholm, and Fehmarn Belt, and the marine (M) locality Helgoland.	20

Table I-4 Mean total length (LT± s.d.) and percentage of eels in each of five stages of maturation for eels collected from two freshwater (F), three brackish (B), and one marine (M) locality. Undifferentiated stage Mean total length (± S.D.) and percentage of eels in each of five stages of maturation for eels collected from two freshwater (F), three brackish (B), and one marine (M) locality. Undifferentiated stage I and female stage II (FII), growth phase; female stage III (FIII), pre-migrant stage; female stages IV and V (FIV, FV), migrant stages.	20
Table II-1 Checklist of the protozoan and metazoan parasites of the European eel (<i>Anguilla anguilla</i>). Parasite species are arranged by phylum and family. Species within the families are listed in alphabetical order. Each species is listed with its site of infection in/on the eel, habitat (salinity), locality, country (alphabetical order) and author of record. If available the number of examined eels (n), prevalence (in %) (P), mean intensity (mI), intensity (I) and mean abundance (mA) of infection and the respective standard deviation (SD) is given.....	28
Table II-2 Sampling localities of European eel studied in 2006 and 2007 by the first author. n = total number of eels examined, TL = Total length, SD = Standard deviation.	24
Table II-3 Countries and dates and of first reported records of <i>Anguillicoloides crassus</i> from European eels (<i>Anguilla anguilla</i>).	25
Table III-1 <i>Herpesvirus anguillae</i> detection in pooled tissue samples from eels collected from the freshwater (F) localities Lake Plön and River Eider, the brackish (B) water localities Friedrichsort and Maasholm and the marine (M) location Helgoland. n = number of eels, PCR = polymerase chain reaction, TL = total length, S.D. = standard deviation.....	79
Table III-2 <i>Herpesvirus anguillae</i> detection in individual tissue samples from River Eider eels.	79
Table IV-1 Sampling sites of European eels in northern Germany. n=number of eels, TL=total length, TW, total weight, S.D.=standard deviation.	85
Table VI-2 External primer pairs used for the first round HVA-PCR (after Rijsewijk et al., 2005).	85
Table IV-3 Internal primer pairs used for the second round HVA-PCR.....	85

LIST OF PUBLICATIONS

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Chapter III:

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Chapter IV:

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04/2001 – 03/2003 Assistant for molecular cancer genetics and andrological research at the University Clinic, Duesseldorf

PROJECTS/TRAINING

2009 Research stay at the Friedrich-Loeffler-Institute (20.01-06.02.2009) Topic: Characterization of monoclonal antibodies against rainbow trout.
2008 Research stay at the Hellenic Centre of Marine Research Crete supported by “IKYDA” (15.11-05.12.2008) Topic: Population genetics of the eel parasite species *Bothriocephalus claviceps* and *Proteocephalus macrocephalus*.
2007 Research Cruise FS “Alkor” - AL299 (22.05-03.06.2007) Baltic Sea (Euroceans/Globec)
2007 Research stay at the University of Veterinary Medicine Hannover, Fish Disease Research Unit (15.01-16.02.2007) Topic: Diagnostic of virus infections (HVA, EVEX) of the European eel.

2004 Research stay at the IPB Bogor, Java, Indonesia (05/04-09/04) within the framework of my Master Thesis

PUBLICATIONS

Palm HW, Jakob E (in prep) Teratology of attachment organs in marine cestodes: How reliable is the tentacular armature as a morphological character in trypanorhynch taxonomy?

Fabian M, Jakob E, Luckhardt B, Hanel R, Steinhagen D (in prep) Detection of *Herpesvirus anguillae* (HVA) in European eel by nested-PCR.

Jakob E, Walter T, Hanel R (accepted) Checklist of the protozoan and metazoan parasites of the European eel. *Journal of Applied Ichthyology*.

Jakob E, Neuhaus H, Steinhagen D, Luckhardt B, Hanel R (2009) Monitoring of *Herpesvirus anguillae* (HVA) infections in European eel in northern Germany. *Journal of Fish Diseases*, 32: 557-561.

Jakob E, Hanel R, Klimpel S, Zumholz (2009) Salinity dependence of parasite infestation in the European eel *Anguilla anguilla* in northern Germany. *ICES Journal of Marine Science*, 66: 358-366.

Jakob E, Palm HW (2006) Fish parasites of commercial fish species from the southern Java coast, Indonesia, including the vertical distribution pattern of trypanorhynch cestodes. *Verhandlungen der Gesellschaft für Ichthyologie*, 5, 165-191.

Kruse R, Rutten A, Schweiger N, Jakob E, Mathiak M, Propping P, Mangold E, Bisceglia M, Ruzicka T (2003) Frequency of microsatellite instability in unselected sebaceous gland neoplasias and hyperplasias. *Journal of Investigative Dermatology*, 120(5), 858-64.

PRESENTATIONS/POSTER

Jakob E, Neuhaus H, Steinhagen D, Hanel R (2008) Monitoring der Parasiten- und Virenlast des Europäischen Aals (*Anguilla anguilla*) aus norddeutschen Gewässern. XII. Gemeinschaftstagung der Deutschen, Österreichischen und Schweizer Sektionen der European Association of Fish Pathologists (EAFP), Jena, Germany, 08. - 10.10.2008 (Presentation).

Jakob E, Hanel R, Steinhagen D (2008) Habitat bedingte Parasitierung und Virenlast des Europäischen Aals (*Anguilla anguilla*) aus norddeutschen Gewässern. 24. Ichthyoparasitologisches Symposium der Deutschen Gesellschaft für Parasitologie, Boiensdorf, Germany, 23.05.2008 (Presentation).

Jakob E, Zumholz K, Hanel R (2007) Habitat dependent parasite infestations and virus infections of the European eel *Anguilla anguilla* (L.) in northern Germany. ICES/PICES Early Career Scientists Conference "New Frontiers in Marine Science", June 2007, Baltimore, Maryland, U.S.A. (Presentation).

Jakob E, Zumholz K, Hanel R (2006) Parasite infestation and migration behaviour of the European Eel. Neues aus dem Meer, Oktober 2006, Büsum, Germany (Poster).

Jakob E, Zumholz K, Hanel R (2006) The influence of habitat choice on parasite infestation of European eel in northern Germany. ICES Annual Science Conference September 2006, Maastricht, The Netherlands (Poster).

Jakob E (2005) Parasiten von kommerziell genutzten Fischarten vor Indonesien. 5. Tagung der Gesellschaft für Ichthyologie, Bonn, Germany (Poster).

MEMBERSHIP IN SCIENTIFIC ORGANISATIONS

ICES WGPDMO: Working group on Pathology and Diseases of Marine Organisms (since 2007)

European Association of Fish Pathologists (since 2008)

ERKLÄRUNG

Hiermit erkläre ich, dass die vorliegende Dissertation selbständig von mir angefertigt wurde. Die Dissertation ist nach Form und Inhalt meine eigene Arbeit und es wurden keine anderen als die angegebenen Hilfsmittel verwendet. Diese Arbeit wurde weder ganz noch zum Teil einer anderen Stelle im Rahmen eines Prüfungsverfahrens vorgelegt. Die Arbeit ist unter Einhaltung der Regeln guter wissenschaftlicher Praxis der Deutschen Forschungsgemeinschaft entstanden. Dies ist mein einziges und bisher erstes Promotionsverfahren. Die Promotion soll im Fach Fischereibiologie erfolgen.

Kiel, den 23. Juli 2009

Eva Jakob