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CURRENT SITUATION OF HUMAN DIPHYLLOBOTHRIASIS IN EUROPE

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Diphyllobothriasis, a parasitosis caused by the flatworm Diphyllobothrium latum, is contracted by consuming raw or undercooked freshwater fish. The aim of this study was to evaluate the situation of this parasitosis during the past 20 years in Europe through the analysis of databases and search engines (Medline, Cabi Helminthological abstracts,Yahoo, Google), and through a questionnaire sent to a network of European parasitologists and to microbiological laboratories located on the shores of the large Alpine lakes. This study has shown that several dozen cases have been reported each year in Finland and Sweden, that there have been numerous cases in the French or Italian speaking areas of subalpine lakes, and that sporadic cases only have been observed in Austria, Spain, Greece, Romania, Poland and Norway. Over 30 cases have been identified on the Swiss shores of Lake Maggiore since 1990, and 70 cases on the Swiss and French shores of Lake Léman between 1993 and 2002. Eight to 12% of perch fillets from Lake Leman and 7.8 % of perch from Lake Maggiore were infested with larvae. Contamination sources include marinated fish fillets in northern Europe, 'carpaccio di persico' in northern Italy, and perch and charr consumed raw or undercooked around Lake Léman. Factors allowing the continuation of the parasitic cycle include the continued dumping of wastewater into lakes, yachtsmen who also fish, and a possible animal reservoir.

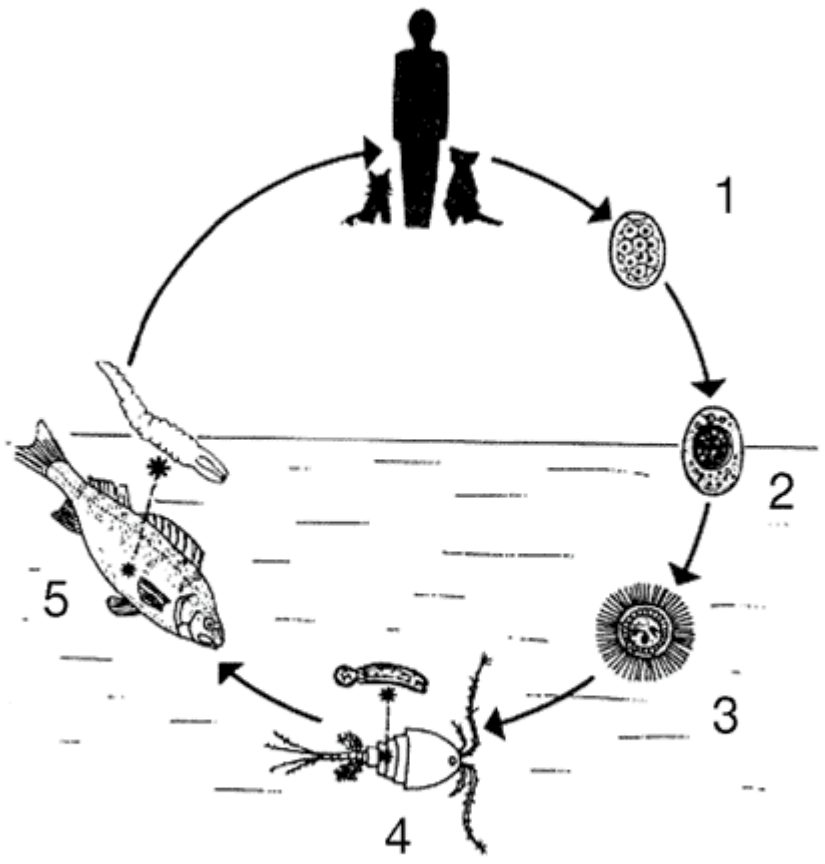
Introduction

Diphyllobothriasis is an intestinal parasitosis caused by the ingestion of mostly raw freshwater fish containing infectious larvae of the *Diphyllobothrium latum* (D. latum) cestode worm. The cycle of this parasite is complex and involves several hosts [1,2]. Released in water, the eggs mature within eight to 12 days at a water temperature of 16-20°C, and yield a procercoid larva that is ingested by a zooplanktonic copepod crustacean [FIGURE 1]. About 40 copepod species of the Eudiaptomus or Cyclops genus are likely to be the first intermediate hosts. This larva develops into a procercoid larva within the general cavity of the copepod. When carnivore fish ingest planktonic crustaceans, the larva develops into a plerocercoid larva a few millimetres long. It migrates into the fish musculature or viscera where it can remain inactive for several years, but can re-encyst several times in other predatory fish. In Europe, the types of fish susceptible to host the larvae are perch (Perca fluviatilis), pike (Esox lucius), charr (Salvelinus alpinus), and burbot (Lota lota). The Coregonidae (feras) and probably the Salmonidae of Salmo genus (except for the Canadian Salmonidae of the genus Onchorynchus) do not host D. latum larvae (TABLE 1). Man and other ichtyophagous mammals become contaminated by ingesting this undercooked fish. The plerocercoid larva can grow between 5 and 20 cm a day [2], and develops into an adult that yields its first eggs about one month after infestation. D. latum is the longest human parasite known (about 10 metres long) and can live for several years. Its symptomatology, although limited, is polymorphous: manifestations may include abdominal discomfort (abdominal pain, diarrhoea), weight loss, asthenia, and vertigo. Anaemia due to vitamin B-12 deficiency has been described in case of prolonged infestation [1]. Human experimental infestations have been practised [4]. Three volunteers, infected by

two to three plerocercoid larvae, did not present any obvious clinical symptoms except for the release of proglottis. The two non-treated subjects dewormed spontaneously seven months (in the first case), and four years and six months (in the second case) after being infected. The parasite is sensitive to praziquantel (15 mg/ kg/ day in one dose) and to niclosamide (2 g on an empty stomach in two doses an hour apart). In 1999, the world prevalence of diphyllobothriasis was estimated at 9 million cases [3], despite the difficulty of making precise evaluations because of the existence of other species either morphologically close or undistinguishable, such as D. pacificum in Peru, and D. nihonkaiense in Asia [4]. The earliest description of diphyllobothriasis prevalence in western Europe goes back to Von Bonsdorff's monograph of 1977 [1]. The objective of our study is to report the current situation of diphyllobothriasis in western European countries.

FIGURE 1

Diphyllobothrium latum Cycle



1: egg, 2: embryonated egg, 3: coracidium, 4: procercoid larva in a copepod, 5: plerocercoid larva in fish

TABLE 1

Name of fish species in some European languages

Latin name	French	English	German	Italian
Perca fluviatilis	perche	perch	Egli/Barsch	persico
Esox lucius	brochet	pike	Hecht	luccio
Lota lota	lotte	burbot	Trüsche	bottatrice
Coregonus fera	féra	big whitefish	Felchen	coregone
Salvelinus alpinus	omble chevalier	charr	Seesaibling	salmerino alpino
Salmo trutta lacustris	truite de lac	lake trout	Seeforelle	trota di lago
Onchorynchus mykiss	truite arc en ciel	rainbow trout	Regenbogenforelle	trota iridea

Material and methods

The analysis was carried out with data from literature published since 1980 using the following databases : Medline, Cabi Helminthological abstract, Inist Pascal, and the Yahoo and Google internet search engines. Information was collected for each of the 25 countries of the European Union (with the exception of Malta and Cyprus), and some adjacent European countries (Switzerland, Hungary, Croatia and Yugoslavia). In March 2003, we also contacted or sent a questionnaire to a network of European parasitologists (specialising mainly in food safety), to microbiological laboratories (those located near lakes and

food safety), to microbiological laboratories (those located near lakes and identified through professional directories) in Savoie, Isère, and Haute-Savoie (France), and Switzerland, and to university hospital parasitology laboratories in Besançon, Lyons and Grenoble. The questionnaire concerned the number of human cases observed in the course of the past 20 years as well as possible veterinary data (fish and mammal), either personal or published data.

Results

Information was obtained from a network of parasitologists, and from databases from 23 European countries. For France and Switzerland, data was completed by the network of laboratories that were contacted. There are three types of epidemiological situation in Europe: areas where parasitosis is frequent or relatively frequent, areas where sporadic or imported cases have been observed, and areas where no parasitosis was reported [FIGURE 2]. Specific surveillance of diphyllobothriasis exists only in Estonia, Lithuania, and Poland. In Finland, at least 20 cases are reported each year [S Meri, personal communication]. A study carried out between 1978-1989 by hospital practitioners showed that prevalence varied between 0.3 and 3.8% of patients [5]. In Sweden, 10 to 50 cases are observed each year [D Christensson, personal communication]. In Estonia, 440 cases were reported in 1997, compared with 715 cases in 1990 [6]. Cases are numerous in French and Italian speaking areas surrounding the Swiss, Italo-Swiss, and Franco-Swiss Alpine lakes. In 1990, one of the authors reported 18 cases on the Swiss shores of Lake Maggiore [7], bringing the total to 33 cases over the last 20 years [8]. Golay and Mariaux retrospectively identified seventy three cases around Lakes Léman, Bienne, and Morat between 1980 and 1994 [9]. Alpine lakes in northern Italy are subject to frequent contamination: in 1987, Magatelli [10] described eight cases on Lake Iseo [10], and in 2000, Terramocci et al [11] reported six cases on Lake Como [11]. Several further cases were reported on Lakes Como and Iseo in 2003 [A Raglio, E Pozio, personal communication]. On the French shores of Lake Léman, Gregory et al [12] diagnosed two cases in St Julien en Genevois and, in 2001, the authors published 22 cases diagnosed between 1993-2000 following a survey carried out in 50 laboratories located in Haute-Savoie [13]. Lake Léman seems to be particularly affected, with 48 cases identified on its shores in 2001 and 2002. The parasitosis is absent in Lake du Bourget, and the last case observed was in a professional fisherman six years ago [C Bernot, personal communication], Lake d'Annecy, Lake d'Aiguebelette and Lake de Paladru. Rare studies published on the prevalence of fish infection [7,9,14] have concerned only the Swiss and Italian Alpine lakes (TABLE 2), and showed a sometimes high infestation of pikes and perch. In other European countries, parasitosis is reported less frequently. In Romania, the historical foci of the Danube delta were subject to massive treatment campaigns, although cases continue to be reported [CM Cretu, personal communication]. A few cases are reported each year in Poland [15] and in Lithuania [V Jasulaitene, personal communication]. Five cases were observed in Vienna between 1991 and 2003 [H Aspock and H Auer, personal communication, [6]]. Two cases were reported in Spain, one caused by imported salmon from an unknown country [17,18]. Three cases were reported in Greece [19]. Cases have also been reported infrequently in Slovakia [20] and in Norway [L Robertson, personal communication]. An imported case was reported in the Czech Republic [21]. In addition to the foci of Lake Léman, at least six imported cases have been described in France since 1980 (A Cazin, ME Bougnoux, M Deniau, H Pelloux, P Marty, and C Tourte-Schaefer, personal communication). To our knowledge, no autochthonous human case was reported in Denmark, Croatia, Belgium, the United Kingdom, the Netherlands, Yugoslavia, Macedonia, Hungary or Germany.

FIGURE 2

Distribution of human diphyllobothriasis in Europe (since 1980)

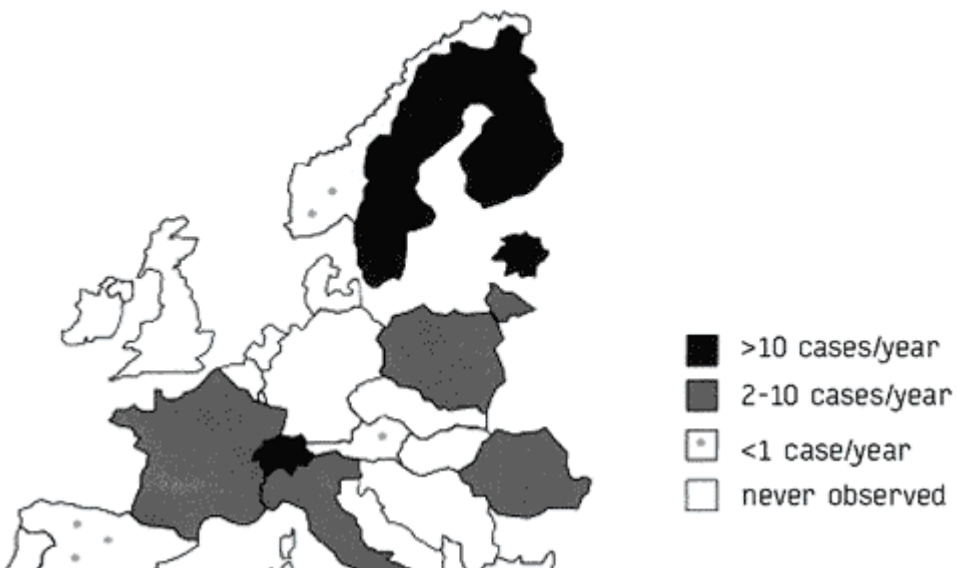


TABLE 2

Recent data (since 1980) available on human cases and fish infestation in sub-alpine lakes from Italy, Switzerland and France

Lake	Country	Presence of human cases	Prevalence in fish [ref]	Fish species
Lake Gardia	Italy	+	No data	
Lake Iseo	Italy	+	No data	
Lake Como	Italie	+	No data	
Lake Maggiore	Italy Switzerland	+	7.8 % [8]	*Perca fluviatilis*
Lake Lugano	Italy Switzerland	0	0 [8]	*Perca fluviatilis*
Lake Varese	Italy	?	0 [8]	*Perca fluviatilis*
Lake Orta	Italy	?	33.3 % [8]	*Perca fluviatilis*
Lake Morat	Switzerland	+	12.5% [9] 5.2 % [9]	*Esox lucius,* *Perca fluviatilis*
Lake Neuchatel	Switzerland	0	0 [9] 0 [9] 0 [9]	*Esox lucius,* *Perca fluviatilis* *Lotta lotta*
Lake Bienne	Switzerland	+	14.2 % [9] 3.7 % [9] 0 [9]	*Esox lucius,* *Perca fluviatilis* *Lotta lotta*
Lake Léman	Switzerland France	+	8-12 % *	*Perca fluviatilis*
Lake Annecy	France	0	No data	
Lake Bourget	France	+ **	No data	

* Analysis of 50 fillets in November 2003 and February 2004, Dupouy-Camet J unpublished data

** One case at the end of the 1990s

Discussion

The methodology used in this study, without being exhaustive, is original and could be used as a basis for further studies to evaluate evolution trends. Human diphyllobothriasis is still present in western Europe, but when compared with previous studies [1,5,6], can be seen to be decreasing in Baltic and Scandinavian countries. It seems to be either emerging or better diagnosed in the French and Italian speaking areas around Alpine lakes, as shown by the more than 200 cases that have been reported or published around Lake Léman, Lake de Morat, Lake de Bienne, Lake Maggiore, Lake Como, Lake Iseo, and Lake Gardia since 1987. German speaking areas around Alpine lakes did not seem to be affected: Golay and Mariaux [7] identified only rare cases in the cantons of Freiburg and Bern compared with around 30 cases in the cantons of Geneva and Vaud. In 1963 [22], human diphyllobothriasis was rare around Lake Léman: no cases had been reported for five years at the Lausanne Institute of Hygiene (Institut d'hygiène de Lausanne), four cases reported in nine years at the Lausanne Badoux, Bauer and Rochat Laboratory, one case in four years at the Geneva University Polyclinic (Polyclinique Universitaire de Genève).

Diphyllobothriasis is associated with ancestral eating habits: consumption of raw salted or marinated fish fillets in Baltic or Scandinavian countries, 'carpaccio di persico' in northern Italy, 'carpaccio d'omble chevalier' and 'poissons du lac façon nordique' in French-speaking areas. Fadish and extreme food choices such as "instinctotherapy" (a type of raw food diet) and the increasing popularity of sushi could also be contributory factors. The prevalence of fish infestation in the Alpine lakes is between 3.7% and 33% (TABLE 2). The continuation of the diphyllobothriasis cycle is an indicator of the faecal pollution of lakeside environment. The complex cycle is compensated by the prolificness of the parasite: one worm alone can yield between one and several million eggs a day that can infest zooplanktonic crustaceans, the first intermediary host. No data was found on zooplanktonic species involved in the transmission or on their level of infestation. Building waste water treatment

transmission or on their level of infestation. Building waste water treatment plants contributes to fighting the parasitosis [6] but there are other unrelated habitats. For instance, around Lake Léman, 89% to 98.6% (according to sources) of the inhabitants of the drainage basin are connected to 159 wastewater treatment plants [23,24]. These treatment plants purify only between 95% and 99% of eggs. The eggs not caught are viable, and the treatment plants may overflow during storms [1,2].

There is professional and leisure fishing on and around lakes. There are about 150 professional fishermen and 5000 fishermen on Lake Léman, who caught around 1000 tons of fish in 1999, of which 47% was perch and 6.5% was charr [25]. The fish is consumed directly by fishermen, or sold to fishmongers or to the many restaurants located on the shores of the lakes, which sometimes offer dishes made with raw fish. Veterinary data on fish infestation in Lake Léman is scarce and very old: 58% of perch and 95% of burbot were carriers of plerocercoid larvae in 1909 versus 12.5% of burbot in 1963 [22]. In 2003-2004, we found plerocercoid larvae in 8% to 12% of perch fillets analysed and the precise identification of the larvae was carried out with molecular biology techniques (polymerase chain reaction and sequencing). Faecal pollution of lakes by the many yachts that sail there can also be considered in the continuation of the cycle although regulations require that faecal matter is disposed of in appropriate sanitary facilities [26]. There is also the issue of faecal pollution of shores by fishermen or by wild or domesticated carnivores that are numerous on those shores. Cases of infestation of dogs have been reported in the Geneva area [B Gottstein, personal communication]. In 1963, around Lake Léman, Bouvier et al [22] found only two infected dogs out of the 259 one they had examined. No infestation was found in 179 cats and 31 foxes examined, but the incidence of parasitosis in man was low at that time. Some cases of fox infestation have recently been reported in the Tessin, Grisons and Geneva areas [Deplazes, personal communication]. A wild cycle would be ensured by trouts and foxes [D Gerdeaux and M Morand, personal communication]; the latter consuming dead genitors on spawning grounds. Elsewhere, diphyllobothriasis was found in 0.5% of foxes captured in Karlsruhe in Germany [27] and in 0.2% of dogs captured in Finland [28]. However, it seems that the parasite does not develop very well in those carnivores who, unlike man, may only play a minor role in the continuation of the cycle [1,2]. Our study has also shown the relative frequency of imported cases (contracted during travel abroad or after consumption of imported fish) that could in certain cases help to maintain the parasite, or to reintroduce it in areas it had previously disappeared from. This survey is certainly limited since we can not pretend to have made an exhaustive collection of cases. In fact, some laboratories from German speaking Switzerland did not respond to the invitation to participate in the survey. Moreover, many cases are likely to be treated by general practitioners either for diphyllobothriasis or for Taenia saginata taeniasis considering the relative similarity of the proglottis of both species. An in-depth study of eight clinical cases has shown that severe clinical symptoms can lead to specialised consultations and expensive complementary analyses, resulting in an average cost of €400 for the management of a single diphyllobothriasis case [13]. Finally, comparing the incidence of different countries is difficult since it would be necessary to know the size of the exposed populations to calculate the risk. For example, in France and Italy, exposed populations are limited to the shores of the lakes, whereas in Finland, the entire population is at risk of exposure. Consumption studies could be carried out in each of the countries to learn about eating habits and therefore evaluate a possible risk behaviour.

Conclusion

Diphyllobothriasis is decreasing in Baltic and Scandinavian countries, but is emerging in French and Italian speaking Alpine areas. The fashion for carpaccio, sushi and recipes based on raw fish, as well as the proliferation of restaurants serving these kinds of dishes, will certainly not slow down this emergence. Work towards ending the disposal of waste water in lakes has been done, but the imperfect efficiency of waste water treatment plants, and the many yachtsmen who also fish explain the continuation of the parasitic cycle. It is therefore necessary to inform consumers of the risks linked to the consumption of raw or undercooked fish as well as prophylactic methods. Cooking fish at a temperature of 55°C kills the plerocercoid larvae in five minutes, and freezing it at -10°C kills the larvae within 8 to 72 hours, depending on the thickness of the fish [29]. Smoking fish does not kill the parasite [30]. Changing food habits is illusory especially when such habits are ancestral as shown by the discovery of diphyllobothriasis eggs in the archaeological sediments of neolithic lakeside villages of these areas [31]. Finally, it would be interesting to monitor the infestation in man and in fish with regular prevalence surveys to study the evolutive nature of diphyllobothriasis.

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