

Geographical distribution of cercarial dermatitis in Norway

A. Soleng^{1*} and R. Mehl²

¹Norwegian Institute of Public Health, Department of Pest Control,
PO-Box 4404 Nydalen, NO-0403 Oslo, Norway: ²Armed Forces Medical
Services, Institute of Microbiology, PO-Box 4302 Nydalen,
NO-0402 Oslo, Norway

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Abstract

Bird schistosomes can cause a disease called cercarial dermatitis, or swimmer's itch, in humans. The disease occurs when people have direct contact with fresh water or sea water containing the free-swimming cercariae of the flukes. The symptoms are well known, and include intense itching, maculae, papulae, urticariae and, in some cases, local oedema with enlarged lymph nodes and fever. In this study, we present the geographical distribution of freshwater cercarial dermatitis in Norway. The study is based on random reports obtained from both individuals and physicians treating patients with itching skin rash after freshwater bathing. The first case of cercarial dermatitis in Norway was reported in 1980 and was traced to a lake near Trondheim in the central part of Norway. In the following years, an increasing number of cases were reported, especially in southern Norway. However, case reports are distributed almost all over the country, even from lakes in northern Norway. As far as we know, these are the northernmost case reports in Europe. So far, only one fluke species (*Trichobilharzia franki*) from a single infected snail (*Radix auricularia*) has been identified in Norway. However, unidentified schistosomatid ocellate cercariae have been found on several occasions in snails collected from six lakes where swimmer's itch is frequently reported. Future studies should be performed to identify the fluke species, as well as the most important snail and bird hosts, in Norwegian lakes.

Introduction

Cercarial dermatitis, commonly called swimmer's itch, in humans is an allergic response of the skin following penetration of cercariae of the trematode family, Schistosomatidae, which can infect birds or mammals. The disease develops after host sensitization resulting from repeated contact with the cercariae (Olivier, 1949). The similarity in skin lipid composition between aquatic birds and humans may contribute to the abnormal penetration of human skin (Haas & Van de Roemer, 1998). Cercarial penetration of the human skin results in a

prickling sensation (primary itching) within 4–20 min which persists for approximately 1 h. The clinical symptoms are well known and include intense itching, maculae, papulae, urticariae and, in some cases, limb swelling, local oedema with enlarged lymph nodes, fever, nausea and diarrhoea (see review by Horák *et al.*, 2002). Cercarial dermatitis occurs seasonally, and is most prevalent during the warmer months when the release of cercariae from the intermediate snail hosts coincides with people's increased contact with water (cf. Horák *et al.*, 2002). In Europe, cercarial dermatitis seems to be mainly caused by bird schistosomes (Kolářová *et al.*, 1997). It is recognized that cercarial dermatitis affects both sexes and all age groups (Chamot *et al.*, 1998; Verbrugge *et al.*, 2004). In a prospective study, Verbrugge *et al.* (2004)

*Fax: + 47 21 07 65 31
E-mail: arnulf.soleng@fhi.no

found that onset and severity of swimmer's itch were affected by how people interacted with the lake, e.g. how long, where and when people used the lake. Age and gender had no effect on incidence or severity. However, Appleton & Lethbridge (1979) concluded that children between 5 and 9 years of age are at the highest risk because their exposure to water during recreational activities is the highest, and Lévesque *et al.* (2002) found that the symptoms mainly affected children under 10 years of age. Schets *et al.* (2008) also reported that longer and more frequent exposure to fresh water resulted in an increase in reported symptoms of swimmer's itch among children.

The disease has been reported from every continent except Antarctica (Mulvihill & Burnett, 1990), especially in lakes of temperate regions. However, cercarial dermatitis has also been reported from cold areas in northern latitudes around the world. In northern Europe the disease has been reported from Denmark (Berg & Reiter, 1960), Sweden (Thors & Linder, 2001), Finland (Pirilä & Wikgren, 1957; Aldhoun *et al.*, 2009), Russia (Voronin *et al.*, 2002), Iceland (Kolářová *et al.*, 1999; Skirnisson *et al.*, 2009) and Norway (Mehl, 1982, 1985, 1988; Thune, 1994). Cercarial dermatitis is common in the USA (see Jarcho & van Burkalow, 1952; Leighton *et al.*, 2000), especially in the Great Lakes region, but it has also been reported from northern latitudes in Canada and Alaska (see Jarcho & van Burkalow, 1952; Harkema, 1953; Hoeffler, 1977). In Norway, cercarial dermatitis is mainly diagnosed and reported during the summer months (June, July and August) when people take baths, play and swim in freshwater lakes. This parasitic zoonosis is now considered an emerging disease in European countries (de Gentile *et al.*, 1996; Kolářová, 2007; Skirnisson *et al.*, 2009) and its public health impact needs to be evaluated globally (de Gentile *et al.*, 1996).

During the summer months, the Norwegian Institute of Public Health receives random reports from both physicians and the general public suspecting cercarial dermatitis. The aim of our study presented here was to describe the occurrence and geographical distribution of this particular zoonosis in Norway, based on case reports that were obtained from 1980 to 2009.

Materials and methods

The data in the present study are based on random reports to the Norwegian Institute of Public Health from physicians and the general public suspecting cercarial dermatitis. An interview was performed with the person reporting swimmer's itch in order to eliminate other possible causes of the skin rash, such as bites from insects and ticks, stinging nettles, algae, bacteria, etc. Cercarial dermatitis was suspected when the persons reported a tingling, itching sensation of the skin immediately after swimming and experienced small, red, itching parts of the skin that reached a maximum after 24 h or later. Furthermore, when the correct clinical symptoms only appeared on parts of the body that had been in direct contact with fresh water, was evenly distributed over the exposed skin, and did not appear on parts covered by tight swim suits (e.g. neoprene swim suits), cercarial

dermatitis was diagnosed. The clinical symptoms included maculopapular skin eruption accompanied by intense itching. Data were omitted from the study when the interview made us doubt that cercariae were the cause of the dermatitis, in cases where an interview was impossible to perform, and in a few cases where the persons could not state the name of the lake where the bathing took place. No serological studies were performed. The name and the location (county) of the lake or river where the bathing took place were noted.

Freshwater snails were collected on several occasions from selected lakes where swimmer's itch had been reported, in order to look for emerging cercariae. Snails were sampled from the following lakes: Lake Eikeren in 1982, Lake Sognsvann in 1987, 2001 and 2005–2009, Lake Bogstadvannet in 2003, 2005 and 2008, Lake Lutvann in 2003, Lake Middelalderdammen in 2003 and Lake Stordammen in 1992, all near Oslo in southern Norway, and from Lake Soløyvannet in 2003 near Bodø in northern Norway. The collected snails belonged to the genera *Lymnea*, *Radix* and *Physa*. No closer species identification was made as snail systematics are full of confusion, a condition that remains to be solved (cf. Horák *et al.*, 2002). All snails were transported back to the laboratory in lake water. They were subsequently isolated individually in small glass vessels containing lake water and placed under light. Emerging cercariae were examined by microscope, and determined to be schistosomatid bifurcated ocellate cercariae or not, as identification to the species level is only possible with molecular methods. Only one infected snail (collected in Lake Bogstadvannet in 2008) and its cercariae have been identified to species level. The identification of the snail was based on shell morphology, anatomy of the reproductive system, and ITS2 sequences. The cercariae were identified to species level by sequencing of the internal transcribed spacer (ITS) region of rDNA (this contains partial 18S and 28S and whole ITS1, 5.8S and ITS2). The sequences have not been submitted to GenBank.

Results

The first case report of cercarial dermatitis in Norway came in 1980 from Lake Jonsvatnet (see fig. 1) near Trondheim in the middle of Norway (Mehl, 1982). The following year cercarial dermatitis was reported from another lake (Lake Utnesvatn) in the same geographical area. In the summer of 1982 an outbreak of the disease was reported from four lakes in southern Norway. Physicians reported between 5 and 15 patients being treated each day during week 31 that year after bathing in Lake Eikeren (Mehl, 1982). The outbreak coincided with a very warm period in this part of the country. The causative agent was at that time unknown, and articles in newspapers reported the problem to be caused by 'fleas', 'sand fleas', 'mosquitoes', 'stinging worms', 'sucking worms' and/or 'parasites', etc. Mehl (1982) identified the problem as cercarial dermatitis after isolation of schistosomatid cercariae from snails located at one of the affected lakes. The publication by Mehl (1982) resulted in several new case reports from another 15 lakes in the south and central parts of Norway during the same

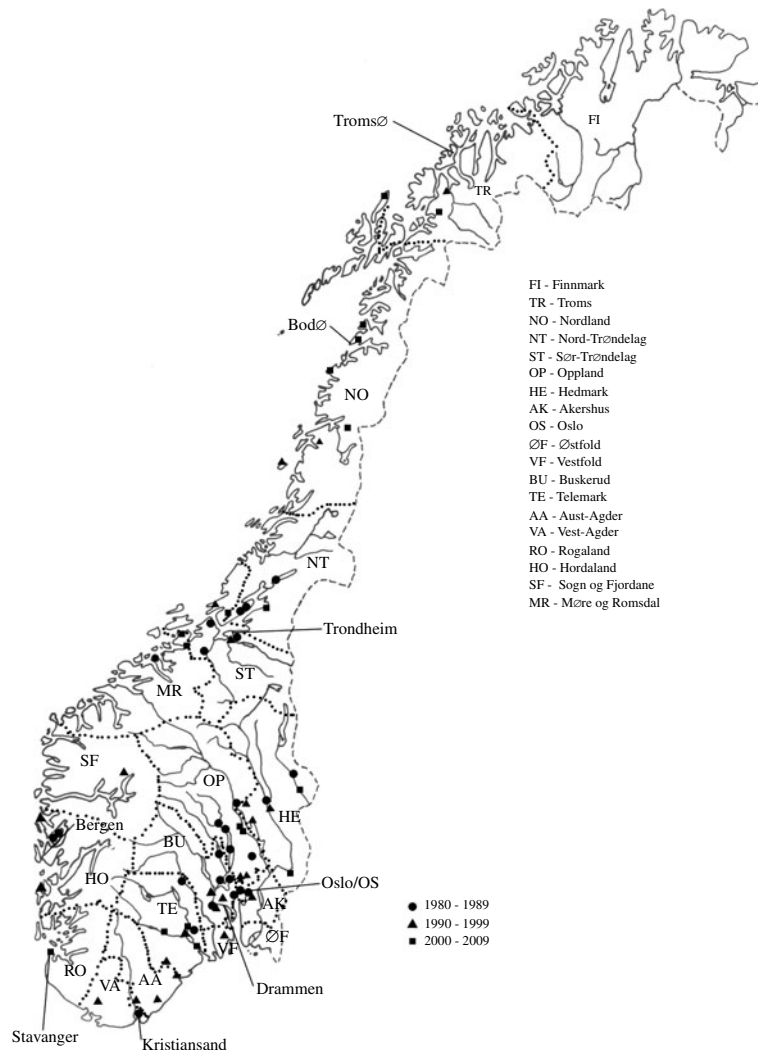


Fig. 1. The geographical distribution of the 87 case reports of cercarial dermatitis in Norway from 1980 to the end of 2009. The first two reports were from the central part of the country near the city of Trondheim. Note that a single dot might represent several adjacent lakes in some areas. The locations of counties mentioned in tables 1 and 2 are indicated on the map.

summer (see fig. 1). In retrospect, reported cases of itching skin rash after freshwater bathing had appeared several years before 1980 in some lakes in Norway without recognition of the aetiology of the condition.

The summers of 1983 and 1984 were cooler, and cercarial dermatitis was reported from only two new lakes in 1983. In 1985, 1986 and 1988, cases of swimmer's itch were reported in only one new lake each year. Published notes on the problem (Mehl, 1985, 1988) resulted in a few new case reports, as opposed to the situation in 1982. In 1989, people reported cercarial dermatitis after bathing in two new lakes. Up to this date the disease had only been reported from the south and central part of Norway, and the area around Trondheim, at 63.3°N latitude, was the northernmost affected area.

In the 10-year period from 1990 until the end of 1999, cercarial dermatitis was reported from 28 new lakes (fig. 1). This zoonosis was by now reported even from

lakes at high latitudes in northern Norway. Case reports from Lake Bleiksvatnet in Nordland County and Lake Finnfjordvatnet in Troms County are both as far north as approximately 69.2°N latitude. In Lake Bleiksvatnet, the only bird species observed at the time of the cercarial dermatitis report was the black-legged kittiwake (*Rissa tridactyla*).

After the millennium, the increase in new affected lakes continued. In 2001 cercarial dermatitis was reported from one new lake, in 2002 from three new lakes, in 2003 from three new lakes, and in 2004 from seven new lakes. During the summers of 2003 and 2004 many reports came from lakes in northern Norway, which experienced two warm summers in succession. Furthermore, in 2005 cercarial dermatitis was reported from two new lakes. We have no reports from new lakes in 2006, but again in 2007 four new lakes were affected, in 2008 seven new lakes, and in 2009 four new lakes were reported. In total,

cercarial dermatitis was reported from 87 freshwater ponds, lakes and rivers distributed all over the country during the past 30 years from 1980 to 2009.

Figure 2 demonstrates the cumulative number of lakes involved with reported cercarial dermatitis in the 30-year period from 1980 to the end of 2009. In tables 1 and 2, the names of the lakes, the geographic location and the year of the first report of cercarial dermatitis are given.

Snails of the genera *Lymnea*, *Radix* and *Physa* have been sampled from a number of lakes on several occasions and examined for the presence of cercariae. Schistosomatid ocellate cercariae were found in snails from Lake Eikeren in 1982 and Lake Stordammen in 1992 after reports of cercarial dermatitis. Several snails sampled in Lake Sognsvann were infected in both 1987 and 2001. Schistosomatid ocellate cercariae have also been found in snails from both Lake Lutvann in 2003 and Lake Soløyvannet in 2003. No cercariae were found in a limited number of snails from Lake Middelalderdammen in Oslo. Between 20 and 30 *Radix auricularia* were sampled from Lake Bogstadvannet in 2003, 2005 and 2008, and infected snails were found in each year. A single infected snail collected in 2008 was examined by polymerase chain reaction (PCR) for species determination of both the snail host and the cercariae. The snail species was determined to be *R. auricularia*, and the cercariae shed from this snail were *Trichobilharzia franki*. No birds or faecal samples from birds were examined, but in all the lakes where snails were sampled, we observed birds belonging to the Anseriformes and Lariformes.

Discussion

Based on the present study, cercarial dermatitis has been reported from 87 freshwater ponds, lakes and rivers in Norway during the 30-year period from 1980 to the end of 2009. As the case reports were based on random phone calls or e-mails from private persons or physicians suspecting cercarial dermatitis, the geographical

distribution presented in this study can be misleading in some cases, as the disease could have been misidentified. Differential diagnosis of cercarial dermatitis is difficult due to the fact that several different agents can cause dermatitis (Hoeffler, 1977), e.g. bites from ticks, bed bugs, mosquitoes and black flies, stings from stinging nettles, exposure to different algae and bacteria, as well as stings from different jellyfish in sea water. However, all persons interviewed in the present study experienced different degrees of the well-known skin symptoms of cercarial dermatitis only after freshwater bathing and swimming, and the symptoms appeared only on parts of the body that had been submerged in water and not on skin covered by tight neoprene swimming suits. Many persons reported a tingling, itching sensation of the skin immediately after swimming, and all experienced small, red, itching parts of the skin that reached a maximum after about 24 h or later. Furthermore, in cases where we could not perform an interview, or when we doubted that cercariae had caused the dermatitis, data were omitted from the study. However, it is likely that many cases of swimmer's itch are often not reported. Therefore, we believe that the geographical distribution is, in fact, underestimated. Based on the case reports, cercarial dermatitis is distributed nearly all over Norway, from the south to as far north as 69.2° latitude. The case reports from northern Norway are, to our knowledge, the northernmost reports of cercarial dermatitis in Europe.

Horák *et al.* (2002) suggest that the disease is most prominently distributed along the major flyways of migratory birds. Consistently, it is not necessary for the birds to be permanently present in order to establish the parasites in the intermediate snail hosts, as parasite eggs can be released during the transient presence of infected migrating birds. For *Trichobilharzia* species, it seems that the spectrum of final bird hosts is broader than that of the intermediate snail hosts, and it is also clear that these fluke species can infect bird species other than waterfowl (Anseriformes) (Horák *et al.*, 2002). In Lake Bleiksvatnet, at 69.2°N latitude, the only bird species observed during the day at the time of the cercarial dermatitis report was the black-legged kittiwake (*Rissa tridactyla*). However, the prepatent period in snails is about 4 weeks and can be longer if in cold water. Therefore, the source of infection could potentially be a bird species that was present in the lake many weeks prior to the report of swimmer's itch.

The total number of case reports from each lake was variable. From some of the lakes, we received case reports every summer (e.g. Lake Sognsvann and Lake Bogstadvannet near Oslo, Lake Tyrifjorden and Lake Eikeren near Drammen), but from other lakes, we received only one single report. Thus, the disease seems to be endemic in some lakes, whereas in others it seems to appear more sporadically. This can be explained by the variation in water temperature in some cases, especially the sporadic reports from lakes at high altitudes and in northern Norway. These lakes are normally very cold and, subsequently, it is difficult for the flukes to complete their life cycle. Environmental temperature is an important factor influencing both the development and transmission of these parasitic

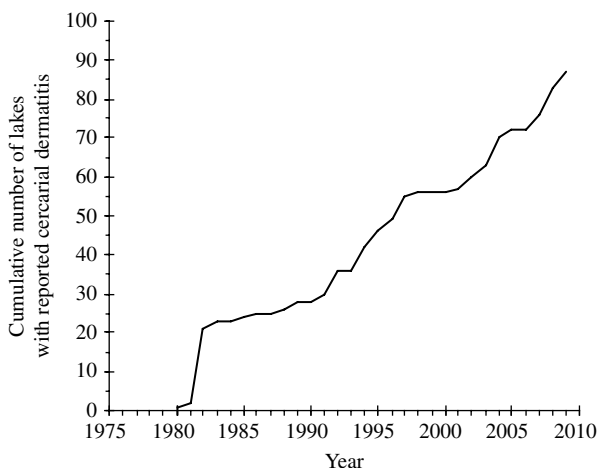


Fig. 2. Cumulative number of lakes with reported cercarial dermatitis in Norway during the 30-year period since the first report in 1980 to the end of 2009.

Table 1. Lakes and rivers showing the occurrence of cercarial dermatitis in Norway from 1980 to 1995; each year indicates the timing of the first case report. See fig. 1 for the location of each county.

Year	Name of lake/river	Location	County
1980	Lake Jonsvatnet	Trondheim	Sør-Trøndelag
1981	Lake Utnesvatn	Agdenes	Sør-Trøndelag
1982	Lake Sperillen	Nes	Buskerud
1982	Lake Eikeren*	Hokksund	Buskerud
1982	Lake Bogstadvannet*†	Oslo	Oslo
1982	Lake Sognsvann*	Oslo	Oslo
1982	Lake Fløafjorden	Leira	Oppland
1982	Lake Fiskumvannet	Hokksund	Buskerud
1982	Lake Steinsfjorden	Hønefoss	Buskerud
1982	Lake Tyrifjorden	Hønefoss	Buskerud
1982	Lake Skraprudtjern	Oslo	Oslo
1982	Lake Flensjøen	Trysil	Hedmark
1982	River Glomma/Rena	Rena	Hedmark
1982	Lake Aurdalsfjorden	Aurdal	Oppland
1982	Lake Randsfjorden	Brandbu	Buskerud
1982	Lake Grønnsjøen	Åsen	Nord-Trøndelag
1982	Lake Hammervannet	Åsen	Nord-Trøndelag
1982	Lake Storavatn	Osterøy	Hordaland
1982	Lake Vestrevatn	Osterøy	Hordaland
1982	Lake Stærnestjønn	Rollag	Buskerud
1982	Lake Snåsavatn	Snåsa	Nord-Trøndelag
1983	Lake Tretjønn	Kristiansand	Aust-Agder
1983	Lake Øverbøtjern	Siljan	Telemark
1985	Lake Skrukkelisjøen	Hurdal	Akershus
1986	Lake Nord-Mesna	Ringsaker	Hedmark
1988	Lake Hostonvatnet	Svorkmo	Sør-Trøndelag
1989	Lake Lillevatnet	Bærum	Akershus
1989	Lake Konneruddammen	Drammen	Buskerud
1991	Lake Hafsløvatn	Luster	Sogn og Fjordane
1991	Lake Finnfjordvatn	Finnfjordbotn	Troms
1992	Lake Harestuvannet	Harestua	Oppland
1992	Lake Ulsrudvannet	Oslo	Oslo
1992	Lake Sør-Mesna	Ringsaker	Hedmark
1992	Lake Stordammen*	Drammen	Buskerud
1992	River Drammenselva	Drammen	Buskerud
1992	Lake Damtjern	Lier	Buskerud
1994	Lake Tokevannet	Drangedal	Telemark
1994	Lake Store Jølgavatn	Bjugn	Sør-Trøndelag
1994	Lake Mjøsa	Hamar	Hedmark
1994	Lake Sveavann	Lunner	Oppland
1994	Lake Ømmervatnet	Mosjøen	Nordland
1994	Lake Semsvannet	Asker	Akershus
1995	River Sauarelv	Sauherad	Telemark
1995	Lake Lygnevannet	Hægebostad	Vest-Agder
1995	Lake Rebnorvannet	Austrheim	Hordaland
1995	Lake Elgsjøen	Roa	Oppland

* Schistosomatid ocellate cercariae found in sampled snails (see Results for sampling year).

† Cercariae identified as *Trichobilharzia franki* (from one specimen of *Radix auricularia* sampled in 2008).

organisms. McCarthy (1989) showed that the emergence of *Echinoparyphium recurvatum* cercariae is completely inhibited at 10°C, and that the transmission efficiency is zero at 5°C. At low temperatures the exposure of humans to cercariae is also very limited, as there is a positive correlation between frequency and duration of bathing and increasing water temperature. In the study presented here, reports of swimmer's itch appeared very frequently when the water temperature reached 20°C and above in July and August. This indicates that water temperature is an important factor explaining the incidence of swimmer's itch. Furthermore, observed differences in case reports between lakes and from different areas

in the same lake can also be due to other general environmental conditions. For example, water currents and wind exposure, which cause cercariae to accumulate in certain areas of the lakes, can lead to great differences in human exposure to the parasite. Leighton *et al.* (2000) used plastic markers to measure surface water currents at Cultus Lake in Canada and suggested that large concentrations of cercariae could accumulate at the surface in hyperendemic areas and subsequently be transported into swimming areas of the lake. These authors suggest that such concentrations of cercariae could explain why the number of cercarial dermatitis reports is much greater on some days and from some

Table 2. Lakes and rivers showing the occurrence of cercarial dermatitis in Norway from 1996 to 2009; each year indicates the timing of the first case report. See fig. 1 for the location of each county.

Year	Name of lake/river	Location	County
1996	Lake Hestsjøen	Heimdal	Sør-Trøndelag
1996	Lake Hemsjøen	Åmot	Hedmark
1996	Lake Groruddammen	Oslo	Oslo
1997	Lake Oggevatn	Kragerø	Telemark
1997	Lake Sørsjøen	Arendal	Aust-Agder
1997	Lake Ådlandsvatnet	Stord	Hordaland
1997	Lake Birketveittjern	Iveland	Aust-Agder
1997	Lake Vikevannet	Hof	Vestfold
1997	Lake Årvollammen	Oslo	Oslo
1998	Lake Holmvatnet	Vega	Nordland
2001	River Porsgrunnselva	Porsgrunn	Telemark
2002	Lake Middelalderdammen	Oslo	Oslo
2002	Lake Lutvann*	Oslo	Oslo
2002	Lake Rauvatnet	Mo i Rana	Nordland
2003	Lake Lutsivatnet	Stavanger	Rogaland
2003	Lake Soløyvannet*	Bodø	Nordland
2003	Lake Mjøsa	Gjøvik	Oppland
2004	Lake Bleiksvatnet	Andøya	Nordland
2004	Lake Nøkle vann	Oslo	Oslo
2004	Lake Heimsvatnet	Hemne	Sør-Trøndelag
2004	Lake Vatnvatnet	Kjerringøy	Nordland
2004	Lake Fjærvatnet	Kjerringøy	Nordland
2004	Lake Markvatnet	Meløy	Nordland
2004	River Skjærhøla	Meløy	Nordland
2005	Lake Grønliavatnet	Surnadal	Møre og Romsdal
2005	Lake Vingersjøen	Kongsvinger	Hedmark
2007	Lake Andedammen	Drammen	Buskerud
2007	Lake Einafjorden	Toten	Hedmark
2007	Lake Stortvatnet	Leksvik	Nord-Trøndelag
2007	Lake Mylla	Oslo	Oslo
2008	Lake Tømmerholdtdammen	Trondheim	Sør-Trøndelag
2008	Lake Svartputten	Asker	Akershus
2008	Lake Brusdalsvannet	Skodje	Møre og Romsdal
2008	River Leira	Nannestad	Akershus
2008	Lake Movatnet	Levanger	Nord-Trøndelag
2008	Lake Byavatnet	Ekne	Nord-Trøndelag
2008	Lake Vesletjern	Oslo	Oslo
2009	Lake Tjønna	Nybergsund	Hedmark
2009	Lake Seljordvatnet	Seljord	Telemark
2009	Lake Åbbortjern	Bardu	Troms
2009	Lake Norsjø	Akkerhaugen	Telemark

*Schistosomatid ocellate cercariae found in sampled snails (see Results for sampling year).

parts of the lake compared to others. The most frequent reports of cercarial dermatitis in Norway were from Lake Sognsvann near Oslo, where cercarial dermatitis is reported every year by a large number of people. In this particular lake the most popular beaches, as well as the water outlet, are located at the southern part of the lake, where we would expect cercariae to accumulate. Furthermore, the density of potential host birds is larger in this part of the lake, suggesting that this is a hyperendemic area which is in close proximity to the bathing areas.

Most of our case reports of cercarial dermatitis are from lakes and ponds, but we have a few reports from rivers, a situation which is not normally reported as we would not expect lymnaeids (and their schistosomes) in fast-flowing rivers. However, these rivers are either slow flowing or in close proximity to lakes, probably explaining our findings of cercarial dermatitis.

Cercarial dermatitis is considered an emerging zoonosis in Europe (de Gentile *et al.*, 1996; Kolářová, 2007; Skirnisson *et al.*, 2009). This seems to also be the case in Norway, even though it is reported that people have experienced the problem of itching skin rash after freshwater bathing many years before our first case report in 1980. In Iceland, retrospective enquiries indicate that swimmer's itch has affected humans for almost a century (Skirnisson *et al.*, 2009). Nevertheless, several factors can explain why we have recognized an increase in the number of case reports in Norway during more recent years. First, we have observed that an increased focus on the problem in reports and the media increases the number of phone calls and e-mails from people and physicians suspecting cercarial dermatitis. Therefore, the increase in new case reports in 1982 is certainly partly a result of a published report distributed to physicians (Mehl, 1982) and several newspaper articles that focused

on the problem. The internet has made it easier for people to find information about cercarial dermatitis, and people might feel that the threshold for contacting our institute is lower when using e-mail in recent years, as compared to phone calls which were more common before. Furthermore, during recent years we have encouraged the public and physicians to report cases of cercarial dermatitis.

Second, recent changes in environmental factors might have increased the problem, at least in the southern parts of Norway. Historically, southern Norway has been heavily influenced by freshwater acidification; the first reports documenting fishkills came as early as 1920 (Dahl, 1921). According to estimates, Norwegian lakes and rivers within an area of 86,000 km² were severely influenced by acidification (Henriksen & Hesthagen, 1993), leaving a lot of lakes deprived of fish and invertebrates (Jensen & Snekvik, 1972; Økland & Økland, 1981; Muniz, 1984; Rosseland *et al.*, 1986; Hesthagen & Hansen, 1991). Freshwater snails are known to be even more sensitive than fish to low pH values (Økland, 1990). In acidic waters with low pH (4.0–5.0), H⁺ is a major toxin for freshwater invertebrates (Havas, 1985; Frick & Herrmann, 1990). Furthermore, low pH, caused by acidification, leads to the release of aluminium from the soil into freshwater bodies, and aqueous aluminium is a major factor responsible for the demise of biotic communities (Burrows, 1977; Havas, 1985; Gensemer & Playle, 1999). Subsequently, many lakes in southern Norway have been deprived of the snail intermediate hosts, making it impossible for the avian flukes to complete their life cycle. Furthermore, ectoparasites in general are influenced by abiotic environmental factors, and some species are very sensitive to aqueous aluminium and low pH (cf. Soleng *et al.*, 1999). The free-swimming miracidium and cercariae might also be more sensitive than snails to these environmental factors, thus limiting the existence of parasites even in places where snails are capable of living. The liming of lakes and rivers in the south of Norway, together with decreased problems of acid rain during recent years, could have led to a recent increase in both potential snail hosts, as well as an increase in bird life in general, as the ecosystems recovered. Thus, the environmental conditions are now more suitable for avian schistosomes in the southern parts of Norway, and this might lead to more case reports of cercarial dermatitis in humans in the future.

In Norway, information about swimmer's itch is given to the general public on the internet from the Norwegian Institute of Public Health. In some areas, where the problem is abundant, the local health authorities inform the public through newspaper articles and posters placed at popular bathing places. People are encouraged to limit their swimming or playing on wind-exposed beaches where the cercariae frequently accumulate, and to avoid marshy areas where snails are commonly found. If possible, people should swim in the deeper parts of the lakes. Furthermore, people are encouraged to towel dry (or take a shower if possible) immediately after leaving the water. As infections may be prevented to some degree by the use of water-resistant topical formulations that inhibit skin penetration by the cercariae (Wulff *et al.*, 2007), such information is also given.

Based on the present study, it seems that cercarial dermatitis is uniformly distributed in Norway. However, the presence of schistosomatid cercariae should be demonstrated to verify the actual geographical distribution, as there is some uncertainty in the interpretation of the human skin symptoms of cercarial dermatitis. Information about the most important snail and bird hosts and their flukes is virtually absent in Norway, although schistosomatid ocellate cercariae have been found in snails sampled from six different lakes. Only one snail has been examined in detail in order to identify the species of both the snail host and the cercariae. Identification of the causative agent is important for estimating the potential health risk and designing appropriate control measures (Horák *et al.*, 2002). Thus, future studies should be planned that address this issue and thereby contribute to this important knowledge.

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References

- Aldhoun, J.A., Faltýnková, A., Karvonen, A. & Horák, P. (2009) Schistosomes in the North: A unique finding from a prosobranch snail using molecular tools. *Parasitology International* **58**, 314–317.
- Appleton, C.C. & Lethbridge, R.C. (1979) Schistosome dermatitis in the swan estuary, western Australia. *Medical Journal of Australia* **131**, 141–144.
- Berg, K. & Reiter, H.F.H. (1960) Observations on schistosome dermatitis in Denmark. *Acta Dermato-Venerologica* **5**, 369–380.
- Burrows, W.D. (1977) Aquatic aluminium: chemistry, toxicology, and environmental prevalence. *CRC Critical Reviews in Environmental Control* **7**, 167–216.
- Chamot, E., Toscani, L. & Rougemont, A. (1998) Public health importance and risk factors for cercarial dermatitis associated with swimming in Lake Lemán at Geneva, Switzerland. *Epidemiology and Infection* **120**, 305–314.
- Dahl, K. (1921) Undersøkelse over ørretens utdøen i det sydvestlige Norges Fjeldvand. *Norsk Jæger og Fiskerforænings Tidsskrift* **50**, 249–267 (in Norwegian).
- de Gentile, L., Picot, H., Bourdeau, P., Bardet, R., Kerjan, A., Piriou, M., Le Guennic, A., Bayssade-Dufour, C., Chabasse, D. & Mott, K.E. (1996) La dermatite cercarienne en Europe: un problème de santé publique

- nouveau? *Bulletin of the World Health Organization* **74**, 159–163 (in French with English summary).
- Frick, K.G. & Herrmann, J.** (1990) Aluminium and pH effects on sodium-ion regulation in mayflies. pp. 409–412 in Mason, B.J. (Ed.) *The surface waters acidification programme*. Cambridge, Cambridge University Press.
- Gensemer, R.W. & Playle, R.C.** (1999) The bioavailability and toxicity of aluminium in aquatic environments. *CRC Critical Reviews in Environmental Control* **29**, 315–450.
- Haas, W. & Van de Roemer, A.** (1998) Invasion of the vertebrate skin by cercariae of *Trichobilharzia ocellata*: penetration process and stimulating host signals. *Parasitology Research* **84**, 787–795.
- Harkema, R.** (1953) *Study of Alaskan schistosomes*. 25 pp. USAF School of Medicine, distrib. No. 1935, Government Printing Office.
- Havas, M.** (1985) Aluminium bioaccumulation and toxicity to *Daphnia magna* in soft water at low pH. *Canadian Journal of Fisheries and Aquatic Sciences* **42**, 1741–1748.
- Henriksen, A. & Hesthagen, T.** (1993) *Critical load exceedance and damage to fish populations*. 12 pp. Norwegian Institute for Water Research, Report 2900, Oslo, Norway.
- Hesthagen, T. & Hansen, L.P.** (1991) Estimates of the annual loss of Atlantic salmon, *Salmo salar* L., in Norway due to acidification. *Aquaculture and Fisheries Management* **22**, 85–91.
- Hoeffler, D.F.** (1977) Swimmers' itch (cercarial dermatitis). *Cutis* **19**, 461–466.
- Horák, P., Kolářová, L. & Adema, C.M.** (2002) Biology of the schistosome genus *Trichobilharzia*. *Advances in Parasitology* **52**, 155–233.
- Jarcho, S. & van Burkalow, A.** (1952) A geographical study of swimmer's itch in the United States and Canada. *Geographical Review* **42**, 212–226.
- Jensen, K.W. & Snekvik, E.** (1972) Low pH levels wipe out salmon and trout populations in southernmost Norway. *Ambio* **1**, 223–225.
- Kolářová, L.** (2007) Schistosomes causing cercarial dermatitis: a mini-review of current trends in systematics and of host specificity and pathogenicity. *Folia Parasitologica* **54**, 81–87.
- Kolářová, L., Horák, P. & Sitko, J.** (1997) Cercarial dermatitis in focus: schistosomes in the Czech Republic. *Helminthologia* **34**, 127–139.
- Kolářová, L., Skirnisson, K. & Horák, P.** (1999) Schistosome cercariae as the causative agent of swimmer's itch in Iceland. *Journal of Helminthology* **73**, 215–220.
- Leighton, B.J., Zervos, S. & Webster, J.M.** (2000) Ecological factors in schistosome transmission, and an environmentally benign method for controlling snails in a recreational lake with a record of schistosome dermatitis. *Parasitology International* **49**, 9–17.
- Lévesque, B., Giovenazzo, P., Guerrier, P., Laverdière, D. & Prud'homme, H.** (2002) Investigation of an outbreak of cercarial dermatitis. *Epidemiology and Infection* **129**, 379–386.
- McCarthy, A.M.** (1989) The biology and transmission dynamics of *Echinoparyphium recurvatum* (Digenea: Echinostomatidae). PhD thesis, King's College London, University of London.
- Mehl, R.** (1982) Swimmer's itch. *MSIS – ukerapport* nr 32/1982 (in Norwegian).
- Mehl, R.** (1985) Cercarie-dermatitt. *MSIS – ukerapport* nr 26/1985 (in Norwegian).
- Mehl, R.** (1988) Cercarie-dermatitt. *MSIS – ukerapport* nr 25/1988 (in Norwegian).
- Mulvihill, C.A. & Burnett, J.W.** (1990) Swimmer's itch: a cercarial dermatitis. *Cutis* **46**, 211–213.
- Muniz, I.P.** (1984) The effects of acidification on Scandinavian freshwater fish fauna. *Philosophical Transactions of the Royal Society of London Series B* **305**, 517–528.
- Økland, J.** (1990) *Lakes and snails: Environment and gastropoda in 1500 Norwegian lakes, ponds and rivers*. 516 pp. Oegstgeest, Netherlands, Universal book services/Dr W. Backhuys.
- Økland, J. & Økland, K.A.** (1981) Acidification threatens trout diet. Studies of 1000 lakes in Norway. *Research in Norway* **1980**, 21–26, 56.
- Olivier, L.** (1949) Schistosome dermatitis, a sensitization phenomenon. *American Journal of Hygiene* **49**, 290–302.
- Pirilä, V. & Wikgren, B.J.** (1957) Cases of swimmer's itch in Finland. *Acta Dermato-Venerologica* **37**, 140–148.
- Rosseland, B.O., Skogheim, O.K. & Sevalrud, I.H.** (1986) Acid deposition and effects in Nordic Europe. Damage to fish populations in Scandinavia continues apace. *Water Air and Soil Pollution* **30**, 65–74.
- Schets, F.M., Lodder, W.J., Van Duynhoven, Y.T.H.P. & de Roda Husman, A.M.** (2008) Cercarial dermatitis in the Netherlands caused by *Trichobilharzia* spp. *Journal of Water and Health* **6**, 187–195.
- Skirnisson, K., Aldhoun, J.A. & Kolářová, L.** (2009) A review on swimmer's itch and the occurrence of bird schistosomes in Iceland. *Journal of Helminthology* **83**, 165–171.
- Soleng, A., Poléo, A.B.S., Alstad, N.E.W. & Bakke, T.A.** (1999) Aqueous aluminium eliminates *Gyrodactylus salaris* (Platyhelminthes, Monogenea) infections in Atlantic salmon. *Parasitology* **119**, 19–25.
- Thors, E. & Linder, E.** (2001) Swimmers' itch in Sweden. *Helminthologia* **38**, 244.
- Thune, P.** (1994) Cercarierdermatitt eller svømmekløe – et lite kjent, men hyppig forekommende sykdomsbilde I Norge. *Tidsskrift for den Norske Lægeforening* **114**, 1694–1695 (in Norwegian).
- Verbrugge, L.M., Rainey, J.J., Reimink, R.L. & Blankespoor, H.D.** (2004) Prospective study of swimmer's itch incidence and severity. *Journal of Parasitology* **90**, 697–704.
- Voronin, M.V., Beer, S.A. & Dobrovolskiy, A.A.** (2002) Schistosomatidnye cercarii gruppy *Trichobilharzia* cf. *ocellata* iz populyatsiy megapolisov Moskvy i Sankt-Peterburga. *Teoreticheskiye i prikladnye problemy parazitologii*. Rossiyskaja akademiya nauk, Institut parazitologii, Nauka, Moscow (in Russian).
- Wulff, C., Haeblerlein, S. & Haas, W.** (2007) Cream formulations protecting against cercarial dermatitis by *Trichobilharzia*. *Parasitology Research* **101**, 91–97.