

Distribution of the gill parasite *Discocotyle sagittata* (Monogenea: Polyopisthocotylea) in parr of Atlantic salmon *Salmo salar* and sea trout *S. trutta* in Norwegian rivers

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Mo TA. 2023. Distribution of the gill parasite *Discocotyle sagittata* (Monogenea: Polyopisthocotylea) in parr of Atlantic salmon *Salmo salar* and sea trout *S. trutta* in Norwegian rivers. *Fauna norvegica* 42: 31–36.

The monogenean gill parasite *Discocotyle sagittata* is reported from parr of Atlantic salmon *Salmo salar* and sea trout *S. trutta* in the anadromous part of 86 out of 223 Norwegian rivers. The prevalence in each river varied from 1.5% to 88.9%. This study has significantly increased our knowledge about the occurrence of this salmonid parasite in Norway. Most likely, *D. sagittata* has a much wider distribution all over the country and probably also occur in numerous inland lakes, rivers and streams.

doi: 10.5324/fn.v42i0.5063. Received: 2023-03-15. Accepted: 2023-08-27. Published online: 2023-10-24.
ISSN: 1891-5396 (electronic).

Keywords: ectoparasite, occurrence, salmonids, freshwater, Norway

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INTRODUCTION

The monogenean parasite *Discocotyle sagittata* (Leuckart, 1842) Diesing, 1850 occurs on gills of salmonids in lakes, rivers, and streams in the Northern Hemisphere. In most studies, only its presence, often given as prevalence and occasionally intensity, is presented (e.g., Barskaya & Ieshko 2005; Byrne *et al.* 2002; Muzzall & Whelan 2021; Paterson *et al.* 2019; Pippy 1969; Urquhart *et al.* 2010). However, *D. sagittata* may cause disease and mortality in farmed (Gannicott 1997; Tinsley *et al.* 2020) and wild salmonids (Huitfeldt-Kaas 1913; Rushton 1922; Southwell & Kirshner 1937).

Discocotyle sagittata belong to the subclass Polyopisthocotylea, which means that the attachment organ, the opisthaptor, is complex with several clamps or suckers. Adult *D. sagittata* has eight clamps organized as four pairs in two rows. In attached parasites on the gills, one row can be twisted so that it appears to be eight clamps in one row. Adults may be up to 10 mm long (Lewis *et al.* 2021), but adults with eggs are mostly 3–7 mm (Valtonen *et al.* 1990). *D. sagittata* use only one host, a salmonid, to complete its lifecycle. When a larvae, recently hatched from an egg, establish on the gills, it is less than 0.5 mm and has only one pair of clamps (Owen 1970). As the juvenile grows, a second, third and fourth pair of clamps gradually appears (Rubio-Godoy & Tinsley 2008). Thus, *D. sagittata* specimens of different developmental stages with variable sizes may occur on the gills of a host. *D. sagittata* often has a reddish brown colour, reflecting its blood feeding. As the colour of *D. sagittata* is similar to the colour of the host gills, and specimens can be small, a stereo microscope or other optical magnification is usually needed to detect the parasite.

In Norway, *D. sagittata* has been reported from all the six native salmonid species (Table 1) while the Norwegian Biodiversity Information Centre (NBIC) has only one record (NBIC 2023). The references presented in Table 1, also present the geographical locality for the observations of *D. sagittata*. In addition, the presence of *D. sagittata* was also reported by Huitfeldt-Kaas (1912), Mørch (1968), Borgstrøm (1970) and Vik (1984) without presenting the locality. As salmonids occur in many thousand streams, rivers and lakes in Norway, *D. sagittata* likely has a wider geographical distribution than hitherto reported.

This paper summarizes the results from analyses for the presence of *D. sagittata* on gills of Atlantic salmon parr *Salmo salar* Linnaeus, 1758 (hereafter referred to as salmon) and sea trout parr *S. trutta* Linnaeus, 1758 (hereafter referred to as trout) sampled for several years in the anadromous part of many Norwegian rivers.

MATERIAL AND METHODS

Fish sampling

All the fish included in this study were originally sampled to map the absence or presence of *Gyrodactylus salaris* Malmberg, 1957 in Norwegian rivers (Gyrodactylusprosjektet 1981, 1982, 1983; Mo *et al.* 2008, 2010). The fish were sampled by electrofishing in August–September. The number of salmon parr and trout parr sampled in each river, are presented in Table 2. The parr were in their second growth season (based on fish length), except a few trout parr that were in their third growth season. The fish were killed and stored in 10% formalin in the period 1980–1983 and in 96% EtOH in 2007–2009.

Table 1. Earlier reported observations of *Discocotyle sagittata* on the gills of native salmonids in Norwegian lakes and rivers. Atlantic salmon = *Salmo salar* Linnaeus, 1758, brown trout/sea trout = *Salmo trutta* Linnaeus, 1758, Arctic char = *Salvelinus alpinus* (Linnaeus, 1758), European whitefish = *Coregonus lavaretus* (Linnaeus, 1758), Vendace = *Coregonus albula* (Linnaeus, 1758), Grayling = *Thymallus thymallus* (Linnaeus, 1758). *Land-locked Atlantic salmon, **Marine locality.

Host species	Locality	Reference
Atlantic salmon	River Sandvikselva	Wilhelms (1983), Appleby (1988)
Atlantic salmon	River Tana (in estuary)	Bristow <i>et al.</i> (1996)
Atlantic salmon	River Ramstaddalselva	Isaksen <i>et al.</i> (2022)
Atlantic salmon*	Lake Byglandsfjord	Barlaup <i>et al.</i> (2018)
Atlantic salmon	River Batnfjordselva	NBIC (2023)
Brown trout	Lake Øvre Heimdalsvatn	Hatleli (2012), Borgstrøm <i>et al.</i> (2021)
Sea trout	River Sandvikselva	Wilhelms (1983), Appleby (1988)
Brown trout	Lake Storevann	Bjerkan (1916)
Sea trout	River Batnfjordselva	NBIC (2023)
Brown trout	Lake Lesjaskogsvann	Nybelin in Brinkmann jr. (1952)
Brown trout	Lake Stokkedalsvatnet	Hartvigsen and Halvorsen (1993)
Sea trout**	Fjord Hardangerfjorden**	Dalen (2011)
Arctic char	Lakes in Southern Norway	Huitfeldt-Kaas (1913)
Arctic char	Lake Spilderdalsvann	Kennedy (1977)
Arctic char	Lake Fustvatnet, Lake Ømmervatnet	Paterson <i>et al.</i> (2019)
European whitefish	Lake Mjøsa	Wilhelms (1983), Appleby (1988)
European whitefish	Lake Feragen	Appleby (1988)
Vendace	Lake Mjøsa	Wilhelms (1983), Appleby (1988)
Grayling	River Gudbrandsdalslågen	Appleby (1988)
Grayling	River Vefsna	Ieshko <i>et al.</i> (2001)

Fish examination

Each fish was submerged in water (to ease the detection of ectoparasites) and the gills examined *in situ* under a stereomicroscope at 10–20x magnification.

Parasite identification and terminology

Discocotyle sagittata was identified following Shaffer (1916) and Wilhelms (1983). *D. sagittata* is the only reported polyopisthocotylean on gills of salmonids in Norway and can be easily separated from monopisthocotyleans on gills of salmonids, such as *Tetraonchus* spp. or *Gyrodactylus* spp., by size, colour, and appearance of the attachment organ. The term prevalence is used in accordance with Bush *et al.* (1997).

RESULTS

In total for all years, 10,796 parr of salmon and sea trout, sampled in 223 Norwegian rivers, were examined for the presence of *D. sagittata*. This parasite was found on gills of either salmon parr or sea trout parr, or both, in 86 rivers (38.6%) (Table 2). Infected salmon and trout parr had mostly one *D. sagittata* specimen on their gills while some fish had 2–6 parasites. The highest number of *D. sagittata* on salmon (11.3 cm) and trout (10.0 cm) was 10 and 14, respectively.

In total, 8,239 salmon parr from 210 rivers were examined and *D. sagittata* was present in 69 rivers (32.9%). In the period 1980–1983, *D. sagittata* was found on salmon parr in 42 out of 144 rivers while in the period 2007–2009, it was found in 32 out of 109 rivers (Table 2). The prevalence of *D. sagittata* varied from 1.5% (4 out of 269 salmon parr)

to 88.9% (16 out of 18 salmon parr). Forty-five rivers were sampled in both periods. Twenty-three rivers were negative while 5 rivers were positive in both periods (Table 2). In 13 rivers, *D. sagittata* was found on the gills of salmon parr in the first period but not in the second, and vice versa in four rivers.

In total, 2,557 trout parr from 130 rivers were examined and *D. sagittata* was present in 43 rivers (33.1%) (Table 2). In the period 1980–1983, *D. sagittata* was found on trout parr in 37 out of 113 rivers while in 2009, it was found in 6 out of 19 rivers (Table 2). The prevalence of *D. sagittata* varied from 3.3% (1 out of 30) to 55.6% (10 out of 18). Only two rivers were sampled for trout in both periods. *D. sagittata* was not found on any of the trout parr examined (n=79) in these two rivers (not shown in Table 2).

In the period 1980–1983 or in 2007–2009, both salmon parr and trout parr were examined in 114 rivers. In 60 of these rivers both salmonids were uninfected by *D. sagittata*. In 16 rivers, *D. sagittata* was found on the gills of salmon parr but not on trout, while in 12 rivers, *D. sagittata* was found on gills of trout parr but not on salmon. In 26 rivers, *D. sagittata* was found on the gills of both salmon and trout parr in the same period, except in the river Eira (Table 2). In 13 of these rivers, the prevalence was higher in salmon parr compared to trout parr, while the opposite was observed in the other 13 rivers. In most of the rivers, the parasite prevalence in the two host species was comparable, i.e., when the prevalence was high or low in salmon parr in a river there was often a similar high or low prevalence in sea trout parr.

Table 2. Norwegian rivers with documented presence of *Discocotyle sagittata* in Atlantic salmon parr and/or sea trout parr in the surveys in 1980–1983 and 2007–2009. A position close to the river mouth is presented in EUREF89 and the recommended UTM sone. N = number analysed and prevalence is presented in %. *Adult sea trout returned from the marine environment. Prev.: Prevalence.

River name	County	UTM sone	Location of river mouth		<i>Salmo salar</i> parr				<i>Salmo trutta</i> parr			
					1980–1983		2007–2009		1980–1983		2007–2009	
					N	Prev.	N	Prev.	N	Prev.	N	Prev.
Lysakerelva	Oslo	32	591827	6642683			30	6.7		12	8.3	
Drammenselva	Buskerud	32	569610	6622200	35	11.4						
Selvikvassdraget	Vestfold	32	571515	6603458						20	40.0	
Sandevassdraget	Vestfold	32	570240	6604307	13	23.1						
Numedalslågen	Vestfold	32	560428	6544678	28	14.3	30	0				
Herreelva	Telemark	32	532342	6551901						4	25.0	
Skienselva	Telemark	32	535109	6554195	40	7.5	33	12.1		15	13.3	
Vegårsvassdraget	Agder	32	504164	6504680			60	1.7				
Tovdalselva	Agder	32	445532	6450668			30	20.0		20	40.0	
Audna	Agder	32	398546	6436064						10	20.0	
Otra	Agder	32	441928	6445095			60	5.0				
Kvina	Agder	32	376127	6460904			60	1.7				
Sokndalselva	Rogaland	32	340994	6467807			30	6.7				
Bjerkreimselva	Rogaland	32	324826	6485571	40	7.5	60	13.3	30	6.7		
Håelva	Rogaland	32	299576	6508444					7	14.3		
Figgjo	Rogaland	32	300637	6524150	30	3.3	30	0	12	8.3		
Årdalselva	Rogaland	32	338055	6559440	30	16.7	30	0	30	6.7		
Vormo	Rogaland	32	347975	6573348	30	6.7			30	23.3		
Hålandselva	Rogaland	32	342915	6582011	26	30.8						
Vikedalselva	Rogaland	32	324244	6599421	7	0	30	10.0				
Rosendalselva	Vestland	32	332983	6653481	17	5.9			30	10.0		
Jondalselva	Vestland	32	347866	6685420	29	6.9			23	8.7		
Granvinselva	Vestland	32	374547	6711740	30	6.7			24	4.2		
Loneelva	Vestland	32	307890	6714604	10	0			19	5.3		
Vosso	Vestland	32	333262	6726587	30	6.7	31	0	17	11.8		
Matreelva	Vestland	32	314410	6753490					30	13.3		
Nærøydalselva	Vestland	32	382915	6751436	14	21.4	60	0				
Lærdalselva	Vestland	32	417523	6775226	24	4.2						
Ytredalselva	Vestland	32	329112	6790204			60	50.0				
Gaula i Sunnfjord	Vestland	32	322190	6808300	30	16.7	30	0	26	7.7		
Nausta	Vestland	32	325439	6823495	25	40.0	60	16.7	7	28.6		
Hopselva i Hyen	Vestland	32	337195	6849082					10	10.0		
Osenelva	Vestland	32	308838	6829426			30	3.3				
Åelva-Ommedalselva	Vestland	32	337178	6848252	53	41.5			24	29.2		
Oldnelva	Vestland	32	384373	6857789					30	3.3		
Strynselfva	Vestland	32	379608	6865330					14	7.1		
Åheimselfva	Møre & Romsdal	32	318267	6883114	30	3.3	30	0				
Brandalselva	Møre & Romsdal	32	320767	6897731	6	33.3			11	54.5		
Kilselva	Møre & Romsdal	32	345401	6882895	28	3.6						
Ørstaelva	Møre & Romsdal	32	350394	6899318			29	6.9				
Tafjordelva	Møre & Romsdal	32	417755	6901283			30	3.3				
Stordalselva	Møre & Romsdal	32	395608	6917787			30	26.7				
Solnørelva	Møre & Romsdal	32	382793	6930573	43	55.8						
Tressa	Møre & Romsdal	32	404109	6933885			60	15.0				
Raumavassdraget	Møre & Romsdal	32	431820	6936930	57	22.8			52	9.6		

Table 2. Continued.

River name	County	UTM sone	Location of river mouth		<i>Salmo salar</i> parr				<i>Salmo trutta</i> parr			
					1980–1983		2007–2009		1980–1983		2007–2009	
					N	Prev.	N	Prev.	N	Prev.	N	Prev.
Herjeelva	Møre & Romsdal	32	424704	6949606					16	6.3		
Eira	Møre & Romsdal	32	455416	6950781	4	0	60	1.7	22	9.1		
Røa	Møre & Romsdal	32	419167	6955453			30	16.7				
Oppdølselva	Møre & Romsdal	32	423840	6961970	18	88.9	8	25.0	2	50.0		
Oselva	Møre & Romsdal	32	434754	6963116	30	60.0	60	8.3	33	36.4		
Malmeelva	Møre & Romsdal	32	409830	6965102					30	3.3		
Sylteelva	Møre & Romsdal	32	408536	6968442					28	3.6		
Vågsbøelva	Møre & Romsdal	32	420273	6975407					5	20.0		
Vassgårdselva	Møre & Romsdal	32	421128	6975707			60	3.3				
Batnfjordelva*	Møre & Romsdal	32	432841	6974857					8	37.5		
Angvikelva	Møre & Romsdal	32	453578	6973759	21	23.8			18	55.6		
Orkla	Trøndelag	32	542062	7021365	28	0	30	6.7				
Gaula	Trøndelag	32	561050	7024700					58	6.9		
Stjørdalselva	Trøndelag	32	594430	7037096	61	1.6	15	0				
Verdalsvassdraget	Trøndelag	32	621009	7077456	18	5.6	30	0				
Steinsdalselva	Trøndelag	32	572742	7131147			30	3.3				
Bogna	Trøndelag	32	615588	7142370	27	3.7	28	0				
Årgårdsvassdraget	Trøndelag	32	607538	7133734	105	2.9	26	0				
Namsen	Trøndelag	32	621500	7151100	115	1.7	60	0				
Salvassdraget	Trøndelag	32	616247	7176225			30	6.7				
Bjøråa	Trøndelag	32	660280	7202768	14	14.3						
Åelva	Nordland	33	380475	7219639	30	10.0			48	8.3		
Lakselvassdraget	Nordland	33	396249	7280259			15	73.3				
Hestdalselva	Nordland	33	394654	7304386			30	10.0				
Aunelva	Nordland	33	396064	7313886			60	23.3				
Hundåla	Nordland	33	406666	7313435	5	20.0			13	46.2		
Leirelvassdraget	Nordland	33	411909	7329723					20	20.0		
Bøelva	Nordland	33	402069	7328968			30	3.3				
Flostrandvassdraget	Nordland	33	427141	7358283			30	20.0				
Silavassdraget	Nordland	33	416951	7358247			16	18.8				
Spildervassdraget	Nordland	33	444472	7416346	22	4.5			30	20.0		
Lakselva i Valnesfjord	Nordland	33	507438	7464551	24	33.3			27	22.2		
Sagvatnanvassdraget	Nordland	33	536376	7532658	9	11.1			20	5.0		
Langvatnvassdraget	Troms	33	531110	7611763					8	25.0		
Lysbotnvassdraget	Troms	33	615559	7704157	17	0	60	5.0				
Vardnesvassdraget	Troms	33	598813	7679549	20	80.0						
Åndervassdraget	Troms	33	595605	7674747	6	66.7			14	50.0		
Å-vassdraget	Troms	33	579724	7664410	9	11.1						
Tanaelva	Finnmark	35	552100	7822200	60	0	269	1.5				
Skallelva	Finnmark	35	626287	7789990	30	20.0						
Klokkelva	Finnmark	35	591696	7751854	6	50.0						

DISCUSSION

In this survey, *D. sagittata* was found on the gills of salmon or trout parr in 38.6% (86) of the 223 sampled Norwegian rivers. In most rivers, each sample included 30 or less salmon or trout parr. This may be too few specimens to detect the occurrence of a parasite at a low prevalence. In the river Tana, *D. sagittata* was found in four out of 269 (1.5%) examined salmon parr. A similar low prevalence may also apply for other Norwegian rivers. Accordingly, despite the negative findings of *D. sagittata* in 137 rivers, it may still have been present in many of them. Consequently, it is of little value to compare the prevalence of the parasite in the first (1980–1983) and second (2007–2009) survey periods. Even though 23 rivers were negative for *D. sagittata* in both periods, its presence in these rivers cannot be ruled out. Likewise, it cannot be concluded that *D. sagittata* has disappeared from 13 rivers where it was found in the first but not the second period. Nor can it be concluded that the parasite has spread to the four rivers where it was not detected during the first period but occurred in the second period. However, such spread is still possible as *D. sagittata* survives on sea-migrating anadromous salmonids (see below).

In several studies, *D. sagittata* has been observed on the gills of anadromous salmonids in the sea. Based on observations in sea trout (Byrne *et al.* 1999; Dalen 2011; Slinn 1963; Urquhart *et al.* 2010), Atlantic salmon (Bristow *et al.* 1996; Pippy 1969) and Arctic char *Salvelinus alpinus* (Linnaeus, 1758) (Kennedy 1977), *D. sagittata* seem to be an euryhaline parasite, at least for some parasite populations living in sea run salmonid populations. Thus, straying of adult salmonids, may contribute to the spread between anadromous sections of rivers. Furthermore, Pippy (1969) observed *D. sagittata* with a single egg on the gills of an Atlantic salmon that had been more than one year in the sea (Appendix 1, p. 37). This observation may indicate that *D. sagittata* is able to reproduce at sea as well (Pippy 1969) or is prepared for egg-laying when the anadromous host return to freshwater.

Except for one record in the Norwegian Biodiversity Information Centre (NBIC 2023) and the localities presented in Table 1, the distribution of *D. sagittata* on salmon and brown trout in Norway has been virtually unknown until now. The present study documents a wide distribution of the parasite in Atlantic salmon and sea trout rivers in Norway. Undoubtedly, this parasite is also present in numerous inland lakes and rivers above the anadromous part of the water courses. Lack of identification and registration applies to most fish parasites in Norway. This problem is reinforced by the fact that animal taxonomists in general (Drew 2011; Hochkirch *et al.* 2022; Sangster & Luksenburg 2015) and parasite taxonomists in particular (Poulin & Presswell 2022), are disappearing and thus, the capability to identify these species is declining.

In conclusion, the polyopisthocotylean monogenean gill parasite *Discocotyle sagittata* was observed in parr of Atlantic salmon or sea trout in 86 out of 223 Norwegian rivers. Previously, this parasite has only been reported in a few Norwegian localities in connection with other studies of salmonid fish, and the Norwegian Biodiversity Information Centre has only one registered observation of *D. sagittata*. Consequently, this study has significantly increased our knowledge about the occurrence of this salmonid parasite in Norway. Likely, *D. sagittata* occurs on the gills of salmonids in numerous Norwegian lakes and rivers, both inland and along the coast, and is an example of the neglect of animals with a parasitic lifestyle in Norwegian biodiversity studies.

ETHICAL STATEMENT

The fish examined in this study had previously been sampled by Norwegian institutions in the surveillance for *Gyrodactylus salaris* in Norwegian rivers. These institutions took care of the permissions to collect and kill the fish. Before the fish were destroyed, the author took the opportunity to examine them for the presence of *D. sagittata*.

ACKNOWLEDGMENTS

This study has not been a part of a particular project and the author has exclusively examined the fish outside his working hours. I am grateful to Mathias G. Mo and Haavar S. Vive for help with the examination of Atlantic salmon parr sampled in 2007. The writing of the manuscript was partly supported by the NINA basic funding, financed by the Research Council of Norway, project no. 160022/F40.

REFERENCES

- Appleby C. 1988. Taksonomiske studier av *Discocotyle sagittata* (Leuckart, 1842) basert på marginalhaker og ankere. Cand. scient. thesis, Universitetet i Oslo.
- Barlaup B, Skoglund H, Pulg, U, Halvorsen GA, Velle G, Isaksen TE, Stranzl S, Postler C, Vollset KW, Birkeland I, Gabrielsen SE, Helle T, Johannessen A, Lehmann GB, Espedal EO, Normann ES, Skår B, Wiers T, Höglund E, Høgberget R, Hobæk A, Skancke LB, Kleiven E, Syrtveit ØK, Kile NB, Martinsen BO, Vethe A. 2018. Blekeprosjektet 2014–2017. Uni Research Miljø, LFI Statusrapport 317: 1–132.
- Barskaya YY, Ieshko EP. 2005. Formation of the parasite fauna in salmonidean fishes from the Paanajarvi-Olanga lake-river system. *Parasitology* 39: 25–37.
- Bjerkkan P. 1916. En ikte, som snylter paa gjællerne hos ørret. *Norsk Fiskeritidende* 35: 189–191.
- Borgstrøm R. 1970. Tre monogene ikter fra ferskvannsfisk. *Fauna* 23: 183–185.
- Borgstrøm R, Mestrand ØH, Brittain JE, Lien L. 2021. The helminth fauna of brown trout (*Salmo trutta*) from a sub-alpine lake revisited after 40 years with introduced European minnow (*Phoxinus phoxinus*). *Fauna norvegica* 41: 15–26. doi: [10.5324/fn.v41i0.3952](https://doi.org/10.5324/fn.v41i0.3952)
- Brinkmann jr. A. 1952. Fish Trematodes from Norwegian waters. Universitetet i Bergen Årbok 1952, Naturvitenskapelig rekke nr. 1.: 1–134.
- Bristow GA, Alvik T, Bohne H. 1996. Some parasites of marine salmonids from Tanafjorden, Finnmark, Norway. *Bulletin of the Scandinavian Society for Parasitology* 6: 25–32.
- Bush AO, Lafferty KD, Lotz JM, Shostak AW. 1997. Parasitology meets ecology on its own terms: Margolis *et al.* revisited. *Journal of Parasitology* 83: 575–583. <https://www.jstor.org/stable/3284227>
- Byrne CJ, Holland C, Tully O. 1999. Metazoan parasite community structure of sea trout on the west coast of Ireland. *Journal of Fish Biology* 55: 127–134. doi: [10.1111/j.1095-8649.1999.tb00662.x](https://doi.org/10.1111/j.1095-8649.1999.tb00662.x)
- Byrne CJ, Holland CV, Poole R, Kennedy CR. 2002. Comparison of the macroparasite communities of wild and stocked brown trout (*Salmo trutta* L.) in the west of Ireland. *Parasitology* 124: 435–445. doi: [10.1017/S0031182001001330](https://doi.org/10.1017/S0031182001001330)
- Dalen C. 2011. Parasittsamfunn hos sjøørret (*Salmo trutta* L.) i Hardanger og Steigen. Master thesis, Universitetet i Tromsø.
- Drew LW. 2011. Are We Losing the Science of Taxonomy? *BioScience* 61: 942–946. doi: [10.1525/bio.2011.61.12.4](https://doi.org/10.1525/bio.2011.61.12.4)
- Gannicott AM. 1997. The Biology of *Discocotyle sagittata* (Monogenea) Infecting Trout. PhD thesis, Bristol University, UK.
- Gyrodactylusprosjektet 1981. Rapport fra Gyrodactylusutvalget over virksomheten i 1980 og program for virksomheten i 1981. Ås, February 1981: 1–59 + 3 attachments.

- Gyrodactylusprosjektet 1982. Rapport fra Gyrodactylusutvalget over virksomheten i 1981 og program for virksomheten i 1982. Ås, April 1982: 1-43 + 3 attachments.
- Gyrodactylusprosjektet 1983. Rapport fra Gyrodactylusutvalget over virksomheten i 1982. Ås, April 1983: 1-15 + 1 attachments.
- Hartvigsen R, Halvorsen O. 1993. Common and rare trout parasites in a small landscape system. *Parasitology* 106: 101-105. doi: [10.1017/S0031182000074874](https://doi.org/10.1017/S0031182000074874)
- Hatleli Ø. 2012. The helminth fauna of brown trout (*Salmo trutta*) in the lake, Øvre Heimdalsvatn, before and after the establishment of a large population of the invasive species, European minnow (*Phoxinus phoxinus*). Master thesis, Norges miljø- og biovitenskapelige universitet. <http://hdl.handle.net/11250/186833>
- Hochkirch A, Casino A, Penev L, Allen D, Tilley L, Georgiev T, Gospodinov K, Barov B. 2022. European Red List of Insect Taxonomists. Luxembourg: Publication Office of the European Union. https://www.entomologica.es/cont/publicaciones/docs/Docpubli1_24.pdf
- Huitfeldt-Kaas H. 1913. Fiskeribiologiske undersøkelser i vande i Trondhjemsamterne. Det kongelige norske videnskabers selskaps skrifter 1912. Nr. 14. Aktietrykkeriet i Trondhjem.
- Ieshko EP, Johnsen BO, Shulman BS, Jensen AJ, Schurov IL. 2001. The parasite fauna of an isolated population of grayling, *Thymallus thymallus* (L.) in the River Vefsna, Northern Norway. *Bulletin of the Scandinavian Society for Parasitology* 11: 37-41.
- Isaksen TE, Kambestad M, Nylund A, Kleppe J. 2022. Forekomst av smittsomme fiskepatogener hos villaks fra utvalgte elver på Sunnmøre i 2020. NORCE LFI rapport nr. 461.
- Johnsen BO, Jensen AJ. 1991. The *Gyrodactylus* story in Norway. *Aquaculture* 98: 289-302. doi: [10.1016/0044-8486\(91\)90393-L](https://doi.org/10.1016/0044-8486(91)90393-L)
- Kennedy CR. 1977. Distribution and zoogeographical characteristics of the parasite fauna of char *Salvelinus alpinus* in Arctic Norway, including Spitsbergen and Jan Mayen islands. *Astarte* 10: 49-55.
- Lewis E, Führer H-P, Shahi-Barogh B, Harl J, El-Matbouli M. 2021. Emergence of *Discocotyle sagittata* (Monogenea: Polyopisthocotylea) in rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*) in an Austrian aquarium. *Journal of Fish Diseases* 44: 1643-1646. doi: [10.1111/jfd.13470](https://doi.org/10.1111/jfd.13470)
- Mo TA. 2020. Gyrodactylosis (*Gyrodactylus salaris*). In: Woo PTK, Leong A-L, and Buchmann K (eds). *Climate change and infectious fish diseases*. CAB International. pp 404-422.
- Mo TA, Norheim K, Jansen PA. 2008. The surveillance and control programme for *Gyrodactylus salaris* in Atlantic salmon and rainbow trout in Norway. Annual Report 2007. In: Brun E, Jordsmyr HM, Hellberg H, Mørk T (editors). *Surveillance and control programmes for terrestrial and aquatic animals in Norway. Annual report 2007*. Oslo: National Veterinary Institute. pp. 143-148.
- Mo TA, Kristensen AM, Hansen H, Norheim K, Jensen BB. 2010. The surveillance and control programme for *Gyrodactylus salaris* in Atlantic salmon and rainbow trout in Norway. Annual Report 2009. In: Karlsson AC, Jordsmyr HM, Hellberg H, Sviland S (editors). *Surveillance and control programmes for terrestrial and aquatic animals in Norway*. Oslo: National Veterinary Institute. 5 pp.
- Muzzall PM, Whelan GE. 2021. Parasites of coregonines in the genera *Coregonus* and *Prosopium* (Salmonidae, Coregoninae) in the Great Lakes. Retrieved from <http://www.glf.org/pubs/misc/2022-01.pdf>
- Mørch A. 1968. De vanligste makroskopiske parasitter i ørret og røye i Bergensdistriktet. *Bergen Sportsfiskere. Vårbok 1968*: 27-32.
- NBIC. 2023. Registered observation of *Discocotyle sagittata* in Norway. Norwegian Biodiversity Information Centre. <https://www.biodiversity.no/taxon/Discocotyle%20sagittata/146333>
- Owen IL. 1970. The oncomiracidia of the monogenean *Discocotyle sagittata*. *Parasitology* 61: 279-292. doi: [10.1017/S0031182000041111](https://doi.org/10.1017/S0031182000041111)
- Paterson RA, Knudsen R, Blasco-Costa I, Dunn AM, Hytterød S, Hansen H. 2019. Determinants of parasite distribution in Arctic charr populations: catchment structure versus dispersal potential. *Journal of Helminthology* 93: 559-566. doi: <https://doi.org/10.1017/S0022149X18000482>
- Pippy JHC. 1969. Preliminary report on parasites as biological tags in Atlantic salmon (*Salmo salar*). 1. Investigations 1966 to 1968. Fisheries Research Board Canada, Technical Report 134: 1-44.
- Poulin R, Presswell B. 2022. Is parasite taxonomy really in trouble? A quantitative analysis. *International Journal for Parasitology* 52: 469-474. doi: [10.1016/j.ijpara.2022.03.001](https://doi.org/10.1016/j.ijpara.2022.03.001)
- Rubio-Godoy M, Tinsley RC. 2008. Recruitment and effects of *Discocotyle sagittata* (Monogenea) infection on farmed trout. *Aquaculture* 274: 15-23. doi: [10.1016/j.aquaculture.2007.11.022](https://doi.org/10.1016/j.aquaculture.2007.11.022)
- Rushton W. 1922. Note on a trematode from rainbow trout. *Journal of the Royal Microscopical Society* 42: 161-163.
- Sangster G, Luksenburg JA. 2015. Declining rates of species described per taxonomist: slowdown of progress or a side-effect of improved quality in taxonomy? *Systematic Biology* 64: 144-151. doi: [10.1093/sysbio/syu069](https://doi.org/10.1093/sysbio/syu069)
- Shaffer E. 1916. *Discocotyle salmonis* nov.spec., ein neuer Trematode an den Kiemen der Regenbogenforelle (*Salmo irideus*). *Zoologischer Anzeiger* 46: 257-271.
- Slinn DJ. 1963. Occurrence of *Discocotyle sagittata* on sea trout. *Nature* 197: 306-306.
- Southwell T, Kirshner A. 1937. Parasitic infections in a swan and in a brown trout. *Annals of Tropical Medicine Parasitology* 31: 427-433. doi: [10.1080/00034983.1937.11684998](https://doi.org/10.1080/00034983.1937.11684998)
- Tinsley RC, Vineer HR, Grainger-Wood R, Morgan ER. 2020. Heterogeneity in helminth infections: factors influencing aggregation in a simple host-parasite system. *Parasitology* 147: 65-77. doi: [10.1017/S003118201900129X](https://doi.org/10.1017/S003118201900129X)
- Urquhart K, Pert CC, Fryer RJ, Cook P, Weir S, Kilburn R, McCarthy U, Simons J, McBeath SJ, Matejusova I, Bricknell IR. 2010. A survey of pathogens and metazoan parasites on wild sea trout (*Salmo trutta*) in Scottish waters. *ICES Journal of Marine Science* 67: 444-453. doi: [10.1093/icesjms/fsp271](https://doi.org/10.1093/icesjms/fsp271)
- Valtonen ET, Prost M, Rahkonen R. 1990. Seasonality of two gill Monogeneans from two freshwater fish from an oligotrophic lake in northern Finland. *International Journal for Parasitology* 20: 101-107. doi: [10.1016/0020-7519\(90\)90180-U](https://doi.org/10.1016/0020-7519(90)90180-U)
- Vik R. 1984. Parasittiske dyr hos våre ferskvannsfisker. In: Jensen KW (ed). *Sportsfiskernes leksikon*. Kunnskapsforlaget, Oslo. pp 504-533.
- Wilhelms B. 1983. Taksonomiske studier av slekten *Discocotyle* Diesing, 1850 hos fire laksefiskarter i Sør-Norge. *Cand. scient. thesis*, Universitetet i Oslo.

Editorial responsibility: Torkild Bakken.

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