# 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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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.

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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 (Lewisch *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 *et al*. (1996) |
| Atlantic salmon | River Ramstaddalselva | Isaksen *et al*. (2022) |
| Atlantic salmon* | Lake Byglandsfjord | Barlaup *et al*. (2018) |
| Atlantic salmon | River Batnfjordselva | NBIC (2023) |
| Brown trout | Lake Øvre Heimdalsvatn | Hatleli (2012), Borgstrøm *et al*. (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 *et al*. (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 *et al*. (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.

| | | | | | *Salmo salar* parr | | | | *Salmo trutta* parr | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | UTM | Location of river | | 1980–1983 | | 2007–2009 | | 1980–1983 | | 2007–2009 | |
| River name | County | sone | mouth | | 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 | | |
| Oldenelva | Vestland | 32 | 384373 | 6857789 | | | | | 30 | 3.3 | | |
| Strynselva | Vestland | 32 | 379608 | 6865330 | | | | | 14 | 7.1 | | |
| Åheimselva | 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.

| | | | | | *Salmo salar* parr | | | | *Salmo trutta* parr | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | UTM | Location of river | | 1980–1983 | | 2007–2009 | | 1980–1983 | | 2007–2009 | |
| River name | County | sone | mouth | | 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 | | |
| Lakselvvassdraget | 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 | | |
| Leirelvvassdraget | 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 | | | | | | |
| Klokkerelva | 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 egglaying 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*.

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