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Transmission dynamics of *Discocotyle sagittata* (Monogenea) in farmed rainbow trout interpreted from parasite population age structure

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Abstract

Water temperature in the Isle of Man, Great Britain, is generally below 10 °C for half the year, from November to April. During 3 consecutive years, samples of rainbow trout, *Oncorhynchus mykiss* were taken at 2 fish farms in May (following 6 months <10 °C) and in November (after a semester >10 °C), to study the populations of the gill fluke *Discocotyle sagittata.* Four distinct types of parasite population structure were found, 2 in May, 2 in November. In the first May scenario, the majority of parasites found were adults, and almost no developing worms occurred: this indicates that no major transmission takes place during the cold season. In the second May scenario, large numbers of freshly-invaded larvae appeared alongside the established mature worms, indicating that intensive transmission can take place when permissive temperatures allow the mass hatching of eggs laid in winter/spring. The first pattern shown by sampling in November was characterised by the co-occurrence of all parasite developmental stages reflecting continuous transmission over several months. A second pattern of infection evident from November samples may indicate that despite recent, intense transmission, some hosts carrying relatively low burdens of adult parasites experienced little or no successful recruitment during preceding periods favourable for transmission. This may provide evidence of differences in susceptibility between hosts. Overall, the 4 contrasting patterns document the effects of temperature as a major factor shaping the population age structure of *D. sagittata*.

Keywords: Monogenea; *Discocotyle sagittata*; Trout; *Oncorhynchus mykiss*; Transmission

1. Introduction

Knowledge of annual variation in disease patterns can inform methods and policies for disease prevention and control (Altizer et al., 2006); this is particularly relevant to aquaculture, because several pathogens of farmed fishes exhibit seasonality: examples include gyrodactylid monogeneans infecting Atlantic salmon *Salmo salar* (Appleby and Mo, 1997) and brown trout *Salmo trutta* (Mo, 1997), the crustacean *Argulus coregoni* parasitizing rainbow trout *Oncorhynchus mykiss* (Hakalahti et al., 2004), and cryptosporidians infecting Spanish gilthead sea bream *Sparus aurata* and European sea bass *Dicentrarchus labrax* (Sitjà-Bobadilla et al., 2005).

Discocotyle sagittata is a gill-fluke infecting salmonids, which has caused lethal epizootics in fish farms located in the Isle of Man (IoM), Great Britain (Gannicott, 1997; Rubio-Godoy and Tinsley, 2008). Being a temperate island, the IoM has contrasting winter and summer environmental conditions which could have a powerful effect on the transmission of *D. sagittata*, a parasite whose reproductive biology is known to be regulated by temperature (Tinsley, 2004). Experimental studies on single worm burdens of *D. sagittata* on rainbow trout showed that egg production was strongly temperature-dependent (Gannicott and Tinsley, 1998): output increased from 1.5 eggs/day at 5 °C to 7 eggs/day at 13 °C and to 12 eggs/day at 20 °C. Since these temperatures approximate to winter, spring/autumn and mid-summer conditions in the IoM, this study was

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Table 1
Discocotyle sagittata mean abundance and range in different rainbow trout (*Oncorhynchus mykiss*) year classes

Fish	*n*	Total mean abundance			*Discocotyle sagittata* developmental category								
		All developmental categories			Juvenile			Intermediate			Mature		
		Prevalence	Worms/ host±SE	Range	Worms/ host±SE	Range	% of total (n)	Worms/ host±SE	Range	% of total (n)	Worms/ host±SE	Range	% of total (n)
1+ May	120	70%	3.7±0.52	0–33	0.03±0.01	0–1	0.7 (3)	0.9±0.19	0–12	25.6 (113)	2.7±0.46	0–33	73.7 (325)
2+ May*	70	98%	28.0±2.99	0–160	0.11±0.04	0–1	0.4 (8)	0.6±0.11	0–3	2.0 (40)	27.3±2.96	3–158	97.6 (1912)
Mass-infected 2+	22	100%	159±13.95	60–255	95.1±8.55	36–160	57.4 (2092)	0.3±0.16	0–3	0.1 (5)	70.4±11.84	2–214	42.5 (1548)
0+ November	120	52%	1.1±0.13	0–6	0.15±0.04	0–2	13.3 (18)	0.2±0.05	0–3	20.7 (28)	0.7±0.10	0–5	65.9 (89)
1+ November	109	100%	53.8±6.80	4–489	5.3±0.82	0–50	9.8 (575)	12.8±1.70	0–124	23.8 (1396)	35.8±4.80	1–359	66.4 (3898)
2+ November	60	100%	121.7±14.57	7–506	57.1±7.34	0–318	44.3 (3427)	24.6±3.15	0–105	19.1 (1477)	47.3±5.08	3–175	36.6 (2835)

Abundances are shown for the total parasite population, and for juvenile (1 to 2 pairs of clamps), intermediate (2.5 to 3.5 pairs of clamps) and mature (4 pairs of clamps and adults) parasites. Percentages indicate the contribution of the different developmental categories to the total worm population. Data pooled from 1999–2001. Notes: 0+, 1+ and 3+ refer to fish year (age) classes. *These statistics do not include mass-infected 2+ fish from farm 1 in May 2000, which are presented as a separate case.

designed to assess the influence of the natural fluctuations of temperature on parasite transmission in fish farms, and on parasite population age structure.

D. sagittata is distinctive in that developmental stages in the formation of the opisthaptor (the addition of clamps) provide a guide to parasite age: upon emergence from the egg, oncomiracidia possess a functional pair of sclerotised clamps on their haptors (Owen, 1970), and attached worms subsequently develop additional pairs of clamps (p.c.) until they have grown a total of 4 p.c. present on adults; sexual maturity is marked by the production of eggs visible in the uterus. This enables a detailed analysis of parasite population age structure, which in this study provided a "snapshot" of the sequence of invasions contributing to the parasite burdens of infected fish in the preceding months. At the same time, the record of age cohorts provides a guide to the growth and development of these burdens (and hence their pathogenic effects) over the following months.

2. Materials and methods

2.1. Fish

Rainbow trout (*O. mykiss*) samples were obtained on the Isle of Man (IoM), UK, from 2 fish farms (farm 1 in the South-West, farm 2 in the North-East) that have experienced mortality due to *D. sagittata*-induced anaemia (Gannicott,

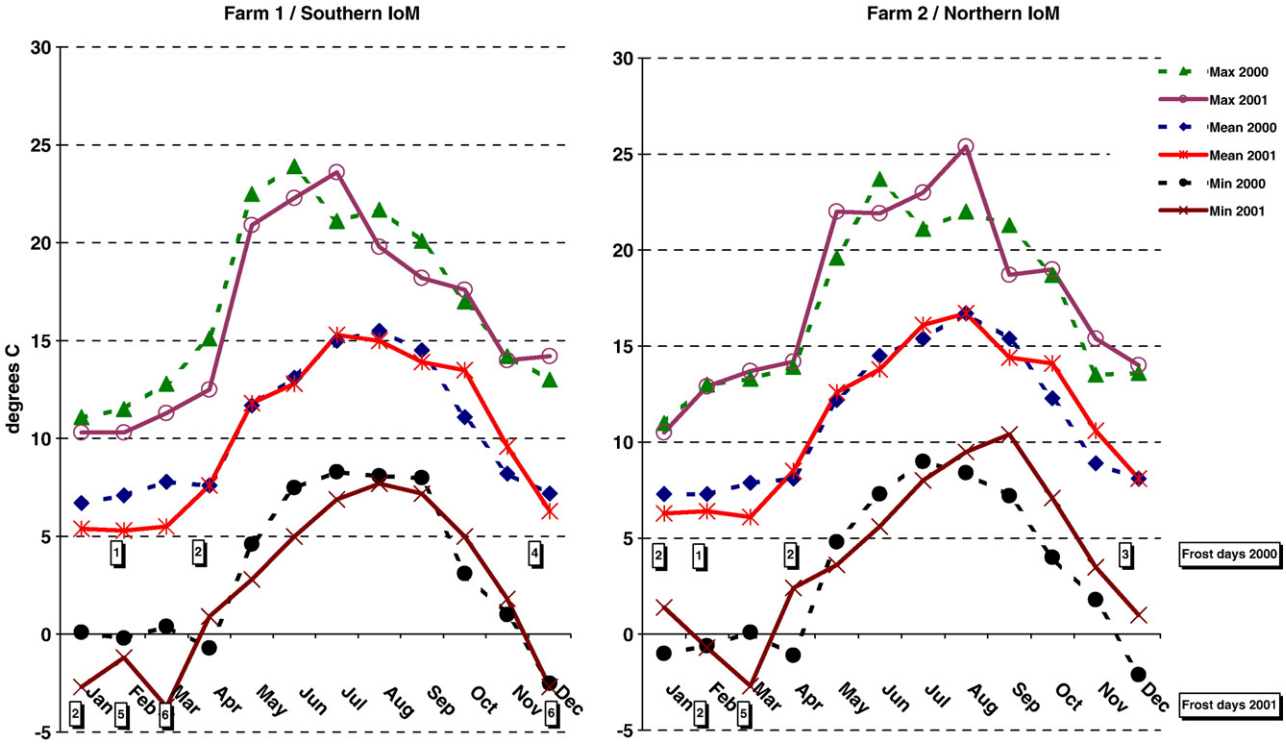

Fig. 1. Air temperature (monthly mean, minima and maxima) in the Isle of Man during the years 2000 and 2001. Southern data from Ronaldsway Airport, Ballasalla; Northern data from Point of Ayre. Weather data kindly provided by and reproduced with permission of the Meteorological Office, Isle of Man Government.