

NOTE

Validation of a rapid counting method for assessing treatment efficacy against *Lepidotrema bidyana* infecting silver perch *Bidyanus bidyanus*

James M. Forwood^{1,*}, James O. Harris¹, Marty R. Deveney²

¹School of Biological Sciences, Flinders University, Adelaide, South Australia 5001, Australia

²South Australian Research and Development Institute, SARDI Aquatic Sciences, and Marine Innovation South Australia (MISA), West Beach, South Australia 5024, Australia

ABSTRACT: We used a published sub-sampling method for estimating the abundance of the monogenean *Lepidotrema bidyana*, a gill parasite of silver perch *Bidyanus bidyanus*, and determined that it also accurately predicts parasite abundance post-treatment. Post-treatment parasite abundance estimates based on the number of parasites on the first left posterior hemibranch were compared to actual counts on fish after bath and oral treatment trials with praziquantel and fenbendazole. Post-treatment parasite abundance estimates were significantly correlated to real counts of all individual hemibranchs, accurately predicting the parasite abundance on an individual host. There was no significant difference in the post-treatment parasite abundance between individual hemibranchs, however, indicating that the treatment affected *L. bidyana* abundance on each hemibranch unequally. Use of this method is ineffective at predicting post-treatment abundance; however, it accurately predicts the remaining parasite abundance, aiding evaluation of treatment efficacy, while reducing post-treatment sampling time or facilitating larger sample sizes.

KEY WORDS: Monogenea · *Bidyanus bidyanus* · *Lepidotrema bidyana* · Abundance

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INTRODUCTION

Lepidotrema bidyana (Diplectanidae) is a gill-dwelling monogenean that infects an Australian freshwater fish, silver perch *Bidyanus bidyanus* (Terapontidae). Heavy infections can result in substantial economic loss in aquaculture (Rowland et al. 2007). *L. bidyana* is oviparous and has a direct lifecycle featuring a free-swimming ciliated larva, the oncomiracidium, which finds and attaches to a host (Whittington et al. 1999). Once attached, monogeneans often migrate to a preferred specific habitat, including parts of gill arches (reviewed by Rohde 1993).

Parasite management in aquaculture often relies on reactive chemotherapy to reduce infection levels and minimise economic loss. Potential drug candidates must go through a series of testing protocols before receiving regulatory approvals, including assessment of efficacy. Several methods using both prevalence and intensity as indicators have been used to assess the number of gill monogeneans remaining post-treatment. Methods include (1) sub-sampling of a section of gill tissue (Stephens et al. 2003, Katharios et al. 2006, Rowland et al. 2006); bathing the gills (Anshary et al. 2001, Kimura et al. 2006) or the whole host (Williams et al. 2007) in a

*Email: james.forwood@flinders.edu.au

known effective treatment and then filtering the bath solution and counting the parasites from the filtrate, and (2) manually counting all parasites (Sharp et al. 2004, Forwood et al. 2013). These methods can be time consuming and require the observer to count large numbers of individual worms. Observer fatigue can lead to inaccurate counts, and estimates based on unvalidated sub-sampling can be inaccurate (Forwood et al. 2012). A method was developed for determining *Lepidotrema bidyana* intensity *in situ* by counting the number of individual *L. bidyana* on the first left posterior hemibranch (L1p) and dividing the number by 0.13, which is the average proportional contribution (APC; Forwood et al. 2012).

This study was designed to examine the distribution of *Lepidotrema bidyana* on the hemibranchs and to evaluate the accuracy of the counting method of Forwood et al. (2012) in fish treated both orally and topically with praziquantel (PZQ) and fenbendazole (FBZ).

MATERIALS AND METHODS

Source of fish and parasites

We obtained 660 silver perch from Pioneer Fish Farm (Gloucester, New South Wales, Australia) and maintained them in a 10 000 l fibre glass recirculation tank at Flinders University, South Australia. Fish were infected with *Lepidotrema bidyana* prior to transport, and the infection was maintained by cohabitation of infected fish (Hirazawa et al. 2004). PZQ and FBZ were purchased from Sigma-Aldrich (lot nos. P4668 and F5396, respectively). Terminology for parasite infections follows Bush et al. (1997).

Experimental design

Silver perch ($n = 360$) were removed from the source population and underwent bath and oral treatment trials (Forwood et al. 2013). During bath trials, 180 fish were randomly divided among twelve 500 l tanks: 4 tanks were treated using 10 mg l^{-1} PZQ, 4 tanks were treated using 10 mg l^{-1} FBZ, and 4 tanks received no treatment. During in-feed (oral) trials, 180 fish were randomly divided into twelve 500 l tanks: 4 tanks were treated with medicated pellets using 75 mg kg^{-1} body weight (BW) PZQ, 4 tanks were treated with medicated pellets using 75 mg kg^{-1} BW FBZ, and 4 tanks received pellets with no treatment. At the completion of the treatment period,

fish were euthanized with an overdose (a 40 ml 1000 l^{-1} bath) of Aqui-S[®], and the gill baskets were removed, separated and examined under a dissecting microscope.

Validation of the counting methods

The total number of *Lepidotrema bidyana* on each individual hemibranch was recorded for 218 silver perch that received and survived the bath and in-feed treatments. Remaining parasite abundance estimations were made based on dividing the number of *L. bidyana* on L1p by the APC of 0.13 (Forwood et al. 2012) and compared to the actual remaining parasite abundance. Estimates of prevalence, based on the presence of *L. bidyana* on L1p for each treatment replicate, were generated and compared to the actual prevalence of each replicate.

Statistical analysis

Predicted and actual prevalence of each replicate, within each treatment group, was compared using a Mann-Whitney *U*-test. To achieve normality, the predicted and actual remaining parasite abundance data were \log_{10} transformed prior to analysis by linear regression. Overall differences in remaining parasite abundance between hemibranchs were analysed using a non-parametric Kruskal-Wallis test. The statistical software SPSS version 19.0 (IBM) was used for all analyses. Significance for all tests was judged at $p < 0.05$.

RESULTS

Prevalence of *Lepidotrema bidyana* on silver perch receiving no treatment was 100%, and the mean \pm SE intensity of remaining parasites was 272.3 ± 30.5 (range: 41–1116) to 537.3 ± 82.6 (18–2449; Table 1). After both the oral and the bath treatments, prevalence was 100% and the mean intensity of remaining parasites was 18.1 ± 1.8 (2–64) to 191.5 ± 28.8 (23–1045; Table 1). *L. bidyana* had a predicted prevalence of 98% in the groups receiving no treatment, and the predicted mean parasite abundance ranged from 250.1 ± 38.9 (0–1531) to 337.7 ± 56.6 (0–1515; Table 1). After all treatments, the predicted prevalence ranged from 57 to 98%, and the predicted remaining mean parasite abundance ranged from 6.4 ± 0.9 (0–31) to 113.3 ± 17.1 (0–600; Table 1).

Table 1. *Lepidotrema bidyana* infecting *Bidyanus bidyanus*. Actual and predicted prevalence, and actual intensity and predicted mean abundance of *L. bidyana* infecting silver perch (n = 218) with no treatment (NT) and after oral and bath treatment with praziquantal (PZQ) and fenbendazole (FBZ)

Treatment	Prevalence % (95% CI)		Mean \pm SEM intensity (range)	
	Oral	Bath	Oral	Bath
NT	100 (91–100)	100 (95–100)	537.3 \pm 82.6 (18–2449)	272.3 \pm 30.5 (41–1116)
PZQ	100 (93–100)	100 (93–100)	191.5 \pm 28.8 (23–1045)	18.1 \pm 1.8 (2–64)
FBZ	100 (94–100)	100 (92–100)	90.5 \pm 13.5 (9–543)	60.9 \pm 6.2 (6–273)
	Predicted prevalence % (95% CI)		Predicted mean \pm SEM abundance (range)	
	Oral	Bath	Oral	Bath
NT	98 (87–100)	98 (90–100)	337.7 \pm 56.6 (0–1515)	250.1 \pm 38.9 (0–1531)
PZQ	98 (90–100)	57 (43–71)	113.3 \pm 17.1 (0–600)	6.4 \pm 0.9 (0–31)
FBZ	92 (80–98)	95 (86–99)	58.8 \pm 11.7 (0–462)	32.2 \pm 3.6 (0–146)

There was no significant difference in the predicted and actual prevalence between replicates of fish treated with FBZ orally and by bath (Mann-Whitney, $p = 0.343$), or between replicates of fish treated with PZQ orally (Mann-Whitney, $p = 0.686$). There was, however, a significant difference between replicates of fish treated with PZQ by bath (Mann-Whitney, $p = 0.029$).

Estimated remaining parasite abundance and the actual remaining parasite intensity were strongly correlated in fish bathed in FBZ ($R^2 = 0.659$, 1-way ANOVA, $p < 0.001$; Fig. 1A) and in fish fed pellets medicated with FBZ ($R^2 = 0.444$, 1-way ANOVA, $p < 0.001$; Fig. 1B) or PZQ ($R^2 = 0.77$, 1-way ANOVA, $p < 0.001$; Fig. 1D) and significantly correlated in fish bathed in PZQ ($R^2 = 0.08$, 1-way ANOVA, $p = 0.037$; Fig. 1C).

The abundance of *Lepidotrema bidyana* between individual hemibranchs was significantly different in the non-treatment bath trial group (Kruskal-Wallis, $p < 0.001$) and in the non-treatment oral trial group (Kruskal-Wallis, $p = 0.008$). There was no significant difference in *L. bidyana* abundance between individual hemibranchs after treatment with FBZ administered both orally (Kruskal-Wallis, $p = 0.702$) and by bath (Kruskal-Wallis, $p = 0.851$) or after treatment with PZQ administered orally (Kruskal-Wallis, $p = 0.994$) or by bath (Kruskal-Wallis, $p = 0.659$).

DISCUSSION

Evaluation of a potential treatment for a parasite infection requires a rapid counting method specific to the target species, to determine parasite abundance so that treatment efficacy can be assessed (Grant 1983). We found that the method of Forwood et al.

(2012) provided accurate post-treatment abundance estimates when compared to real counts over a wide range of post-treatment parasite abundances. The abundance of *Lepidotrema bidyana* differed significantly between individual hemibranchs in the control groups, which is normal for monogenean populations (Rohde 1993). There was, however, no significant difference between individual hemibranchs post-treatment, indicating that parasite mortality is dissimilar across hemibranchs, but the accuracy of predicted abundances indicates that this variable was insufficiently different to affect abundance predictions.

Abundance estimates based on the number of worms in 5 fields of view (Rowland et al. 2006) are inaccurate (Forwood et al. 2012). Manual counting of all worms on each hemibranch is accurate (Forwood et al. 2013) but time consuming, and if sampling is prolonged, parasite recruitment can occur post-treatment, resulting in inaccurate efficacy estimations (Williams 2010). Extended counting of large numbers of parasites also requires multiple counters, further increasing potential variability between individuals who have different counting training or experience (Heuch et al. 2011).

Changes in prevalence have been used as indicators of treatment efficacy (Katharios et al. 2006, Rowland et al. 2006). We therefore evaluated estimates of prevalence using the counting method, but zero counts on L1p significantly affect the accuracy of the prediction, resulting in an underestimation of prevalence, particularly when post-treatment abundances are low.

Using the counting method described by Forwood et al. (2012) provides a rapid and accurate estimate of *Lepidotrema bidyana* abundance that can be used when evaluating the efficacy of treatments, but it does not accurately estimate post-treatment prevalence.

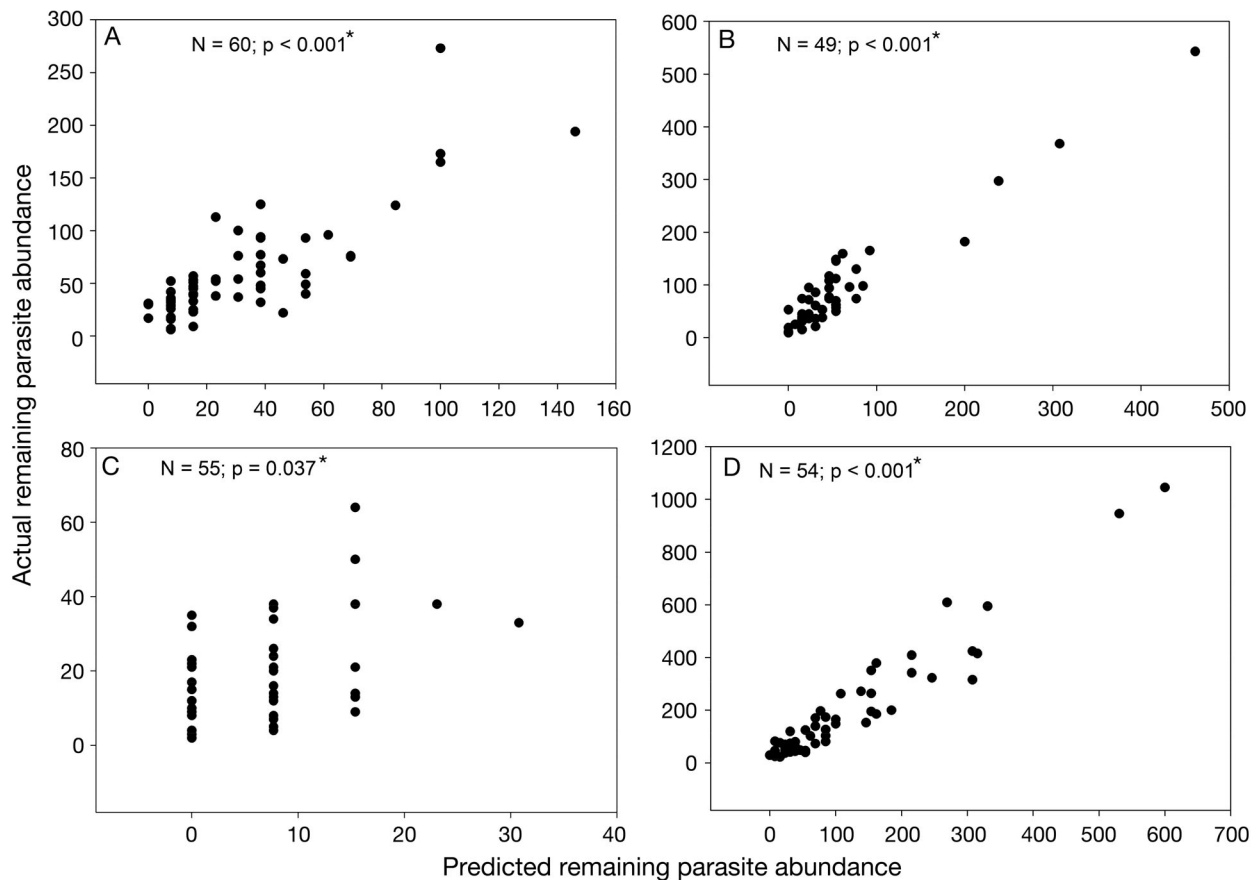


Fig. 1. *Lepidotrema bidyana* infecting *Bidyanus bidyanus*. Relationship between the estimated remaining abundance and the actual remaining abundance of *L. bidyana* in silver perch after treatment. *Significant relationships ($p < 0.05$) assessed by linear regression. (A) Bath treatment with fenbendazole (FBZ). (B) Oral treatment with FBZ. (C) Bath treatment with praziquantel (PZQ). (D) Oral treatment with PZQ

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LITERATURE CITED

- Anshary H, Ogawa K, Higuchi M, Fujii T (2001) A study of long-term changes in summer infection levels of Japanese flounder *Paralichthys olivaceus* with the monogenean *Neoheterobothrium hirame* in the central Sea of Japan, with an application of a new technique for collecting small parasites from the gill filaments. *Fish Pathol* 36: 27–32
- Bush AO, Lafferty KD, Lotz JM, Shostak AW (1997) Parasitology meets ecology on its own terms: Margolis et al. revisited. *J Parasitol* 83:575–83
- Forwood JM, Harris JO, Deveney MR (2012) Host impact of monogenean *Lepidotrema bidyana* infection and intensity estimates for onsite monitoring. *Dis Aquat Org* 100: 51–57
- Forwood JM, Harris JO, Deveney MR (2013) Efficacy of bath and orally administered praziquantel and fenbendazole against *Lepidotrema bidyana* (Murray), a monogenean parasite of silver perch, *Bidyanus bidyanus* (Mitchell). *J Fish Dis*, doi:10.1111/jfd.12089
- Grant AN (1983) Basic husbandry on fish farms. In: Brown LA (ed) *Aquaculture for veterinarians: fish husbandry and medicine*. Pergamon Press, Oxford, p 33–41
- Heuch PA, Gettinby G, Revie CW (2011) Counting sea lice on Atlantic salmon farms—empirical and theoretical observations. *Aquaculture* 320:149–153
- Hirazawa N, Mitsuboshi T, Hirata T, Shirasu K (2004) Susceptibility of spotted halibut *Verasper variegatus* (Pleuronectidae) to infection by the monogenean *Neobenedenia girellae* (Capsalidae) and oral therapy trials using praziquantel. *Aquaculture* 238:83–95
- Katharios P, Papandroulakis N, Divanach P (2006) Treatment of *Microcotyle* sp. (Monogenea) on the gills of cage-cultured red porgy, *Pagrus pagrus* following baths with formalin and mebendazole. *Aquaculture* 251: 167–171

- Kimura T, Sameshima M, Nomura Y, Morita J, Mizoguchi H, Ishihara M (2006) Efficacy of orally administered Febantel against monogenean *Heterobothrium okamotoi* infection of cultured tiger puffer *Takifugu rubripes*. *Fish Pathol* 41:147–151
- Rohde K (1993) Ecology of marine parasites, 2nd edn. CAB International, Oxford
- Rowland SJ, Nixon M, Landos M, Mifsud C, Read P, Boyd P (2006) Effects of formalin on water quality and parasitic monogeneans on silver perch (*Bidyanus bidyanus* Mitchell) in earthen ponds. *Aquacult Res* 37:869–876
- Rowland SJ, Landos M, Callinan RB, Allan GL and others (2007) Development of a health management strategy for the silver perch aquaculture industry. Rep Fish Res Dev Corp Proj 2000/267 and 2004/089. NSW Dep Prim Indust, Fish Final Rep Ser No. 93. NSW Department of Primary Industries, Cronulla
- Sharp NJ, Diggles BK, Poortenaar CW, Willis TJ (2004) Efficacy of Aqu-i-S, formalin and praziquantel against the monogeneans, *Benedenia seriolae* and *Zeuxapta seriolae*, infecting yellowtail kingfish *Seriola lalandi* in New Zealand. *Aquaculture* 236:67–83
- Stephens FJ, Cleary JJ, Jenkins G (2003) Treatments to control *Haliotrema abaddon* in the West Australian dhufish, *Glaucosoma hebraicum*. *Aquaculture* 215:1–10
- Whittington ID, Chisholm LA, Rohde K (1999) The larva of Monogenea (Platyhelminthes). *Adv Parasitol* 44: 139–232
- Williams RE (2010) Oral treatments for monogenean parasites of farmed yellowtails, *Seriola* spp. (Carangidae). PhD dissertation, University of Adelaide
- Williams RE, Ernst I, Chambers CB, Whittington ID (2007) Efficacy of orally administered praziquantel against *Zeuxapta seriolae* and *Benedenia seriolae* (Monogenea) in yellowtail kingfish *Seriola lalandi*. *Dis Aquat Org* 77: 199–205

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