The microecology of dactylogyrids (Monogenea: Dactylogyridae) on the gills of wild spotted rose snapper *Lutjanus guttatus* (Lutjanidae) from Mazatlan Bay, Mexico

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**Abstract:** The spatial distribution and coexistence of monogenean dactylogyrids was assessed on the gills of 63 specimens of wild spotted rose snapper, *Lutjanus guttatus* (Steindachner), caught in the Mazatlan Bay, Sinaloa, Mexico. Five species are reported: *Euryhaliotrema perezponcei* Garcia-Vargas, Fajer-Ávila et Lamothe-Argumedo, 2008, *Euryhaliotremaeidotes spinatus* Krisky et Mendoza-Franco, 2009, *H. plectridium* Krisky et Mendoza-Franco, 2009, and *H. guttati* Garcia-Vargas, Fajer-Ávila et Lamothe-Argumedo, 2008. All except *E. perezponcei* and *H. guttati* represent new geographical records for the Pacific coast. The most prevalent dactylogyrid species was *E. perezponcei* (100%), *H. plectridium* and *H. spinatus* had >80% prevalence, and *H. guttati* and *Euryhaliotremaeidotes* sp. had the lowest prevalence. The mean abundance of *H. plectridium* and *E. perezponcei* was close to 60 parasites/fish, whereas *Euryhaliotremaeidotes* sp. and *H. guttati* had the lowest abundance. The dactylogyrid species exhibited a tendency for attachment to gill arch 2; 25% attachment occurring on gill arch 1, 30% on 2, 27% on 3 and 18% on 4, and showed a significant preference for the central sector of the gill (42%). *Haliotremaeidotes plectridium* had a preference for attachment to gill arches 2 and 3 and the central sector. *Euryhaliotremaeidotes spinatus* tended to settle on the gill arches 2 and 3 and had a preference for the central sector. *Euryhaliotremaeidotes perezponcei* tended to settle on the gill arches 1 and 2 and the anterior gill sector. *Euryhaliotremaeidotes* sp. and *H. guttati* did not show a preference for any gill arch or sector. The intraspecific aggregation was stronger than the interspecific aggregation, indicating that all the dactylogyrid species on spotted rose snapper were aggregated, and there was no evidence of competition among the species.

**Keywords:** microhabitat, distribution, Pacific coast, *Euryhaliotrema perezponcei*, *Euryhaliotremaeidotes spinatus*, *Haliotremaeidotes plectridium*, *Haliotremaeidotes guttati*.
The lack of information on the basic ecological features of the dactylogyrids that infect wild spotted rose snapper has hindered comparisons with cultured fish. The aim of this study was to determine which dactylogyrid species infect adult wild spotted rose snapper from Mazatlan Bay, Sinaloa, and their abundance and spatial distribution on the gills. We also attempted to analyse which factors are involved in site selection based on the relative importance of intra- and interspecific interactions.

MATERIALS AND METHODS

Host collection. A total of 63 adult spotted rose snapper, *L. guttatus*, were sampled and examined from October to December 2006 and from February to April 2007 at Mazatlan Bay, Sinaloa, Mexico (23°14′29″N, 106°24′35″W). All fish were caught by hook and line by local fishermen and were immediately transported to the laboratory for examination within 12 hours of capture. The total length (TL) from the mouth to the end of the caudal fin of each fish was measured with a conventional ichthyometer (precision ± 0.1 cm), and the wet weight was determined on a digital balance (LS 5000) (precision ± 0.1 g).

Parasite data. Monogeneans found on fresh gills were isolated, counted, and observed alive with an OLYMPUS BX51 light microscope (Center Valley, PA, USA) using the 100× objective. All dactylogyrid species were identified using sclerotized parts of the parasite haptor (anchors, connective bars and marginal hooks) and reproductive organs (male copulatory organs and vaginal armaments) according to Plaisance and Kritsky (2004), García-Vargas et al. (2008) and Kritsky et al. (2009). Some helminth specimens were mounted unstained in Grey and Wess medium (Humason 1979) for the study of sclerotized structures, and others were stained with Gomori’s trichrome (Humason 1979) and mounted in Canada balsam for the observation of internal structures. Voucher specimens from lutjanid hosts from the U.S. National Parasite Collection (USNPC; Beltsville, USA) were obtained for direct comparison and measurement. Voucher specimens of helminths were deposited in the National Collection of Helminths, Institute of Biology, National Autonomous University of Mexico (UNAM) as *Euryhalistematoides* sp. (CNHE 7290), *Halistematoides spinatus* (CNHE 7291), *Haliotrematoides plectridium* (CNHE 7292) and *Haliotrematoides guttati* (CNHE 7293).

Spatial distribution on fish gills. Only gills from the left side of the fish were dissected. The gill arches were numbered 1 to 4 from external to internal and divided into three sectors: anterior, central and posterior (Fig. 1). Each gill sector was individually placed in a separate Petri dish with several drops of filtered marine water and was monitored using a dissecting microscope (Leica Microsystems, Wetzlar, Germany) using the 2× objective (total magnification 20×). Monogeneans found on fresh gills were isolated, identified and counted from each of the twelve sectors separately. The position of each individual of the dactylogyrid species was recorded.

The association among dactylogyrid species was measured by the “aggregation model of coexistence” for parasites (modified by Morand et al. 1999), which analyses intra- and interspecific aggregation and their relative strengths in a pair of species.

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**Fig. 1.** Schematic drawing of gill arch showing division into three arbitrary areas.
RESULTS


Composition of parasite species. *Halioptrematoidea plectridium* and *E. perezponcei* represented 42% and 41%, respectively, of the total number of dactylogyrids found. *Halioptrematoidea spinatus* and *H. guttata* corresponded to 14% and 2%, respectively, and *Euryhaliotrematoidea* sp. corresponded to 1%. The most prevalent was *E. perezponcei* (100%), with at least one individual on each fish sampled, followed by *H. plectridium* and *H. spinatus*, each of which with >80% prevalence (Table 1). The mean abundance of *H. plectridium* and *E. perezponcei* was close to 60 parasites per fish, whereas *Euryhaliotrematoidea* sp. and *H. guttata* had the lowest values. The mean intensity of *H. plectridium* and *Euryhaliotrematoidea* sp. was 69 and 4 parasites per fish, respectively.

Parasite aggregation. All dactylogyrid species had a value of $J > 0$, which indicated that individuals of each species were aggregated. The highest levels of intraspecific aggregation were recorded for *H. guttata* and *H. plectridium* and the lowest for *E. perezponcei* (0.47). Of the 10 values of species pairs, 8 pairs had a positive interspecific aggregation (*C > 0*), and two, *E. perezponcei* – *H. spinatus* and *E. perezponcei* – *H. guttata*, had a negative interspecific aggregation (*C < 0*). The relative strength of intraspecific aggregation on interspecific aggregation (*A*) was greater than 1, which indicates that intraspecific aggregation was stronger than interspecific aggregation.

Microhabitat selection. The mean abundance of all the dactylogyrids on the different gill arches did not show any statistically significant difference among gill arches 1, 2, and 3, whereas significantly fewer dactylogyrids were found on gill arch 4 (*F = 7.9, p<0.001*). The distribution of parasites revealed an overall tendency of preferential settlement on the gill arches 2 and 3: 25% of all worms were found on gill arch 4 (*F = 7.9, p<0.001*). The mean abundance of total dactylogyrids was significantly higher (*F = 17.9, p<0.001*) in the central sector than in the anterior and posterior sectors of the gill, where 42% of the parasites were located (Fig. 2A). Because

![Fig. 2](image_url). Percentage of dactylogyrids on the gill arches and sectors of *Lutjanus guttatus*. Total dactylogyrids (A), *Euryhaliotrema perezponcei* (B), *Euryhaliotrematoidea* sp. (C), *Halioptrematoidea spinatus* (D), *H. plectridium* (E), *H. guttata* (F).
of their rare occurrence, Euryhaliotremaidae sp. and H. guttati were not included in the general analysis.

The distribution of some dactylogyrid species across microhabitats was not random. The analysis for E. perezponcei showed significant differences in the number of parasites in arches 1 and 2 relative to arch 4 (F = 4.34, p<0.05), which had the lowest number of parasites. However, this species had a tendency of preference to be found on gill arches 1 and 2, with 27% on gill arch 1, 29% on 2, 25% on 3 and 20% on 4. On the anterior gill sector, a significantly higher abundance of E. perezponcei (36%) compared with the posterior sector (29%) was found (F = 3.37, p<0.05), whereas the central sector (35%) did not show a difference between the anterior and posterior arches (Fig. 2B). Euryhaliotremaidae sp. apparently did not have a preference for a gill arch or sector but had a tendency to be located on gill arch 1 (39% on gill arch 1, 26% on 2, 18% on 3 and 17% on 4) and the central sector (37%) (Fig. 2C). Haliotremaidae spinatus did not show a preference for any gill arch but tended to be located on arches 2 and 3 (22% on gill arch 1, 29% on 2, 29% on 3 and 20% on 4); however, a significant increase of individuals was found on the central (44%) and posterior (37%) sectors (F = 18.1, p<0.001) (Fig. 2D). Haliotremaidae spinatus preferred gill arches 2 and 3 (24% on gill arch 1, 31% on 2, 28% on 3 and 17% on 4) compared with 4 (F = 4.68, p<0.001) and the central sector (49%) (F = 16.31, p<0.001) (Fig. 2E). Haliotremaidae haliotremaidae plectridium showed a significant preference for gill arches 1 (39%) and 2 (33%) compared with 3 (17%) and 4 (11%) (F = 7.35, p<0.001) as well as for the central (40%) and posterior (40%) sectors (F = 4.12, p<0.005) (Fig. 2F).

**DISCUSSION**

The largest genus in the family Lutjanidae is Lutjanus, with 68 valid species (Froese and Pauly 2010), 20 of which have been found infected by dactylogyrids. Three dactylogyrid genera, Euryhaliotrema Kritsky et Boeger, 2002, Haliotremaidae Kritsky, Tingbao et Yuan, 2009 and Tetrancistrum Goto et Kikuchi, 1917, include species that have been found on the gills of snappers (Kritsky et al. 2009). Fifteen species of Euryhaliotrema are currently known from snappers worldwide (Kritsky and Boeger 2002, Li 2005, 2006, Li et al. 2005, Pan and Zhang 2006, Fuentes Zambrano and Silva Rojas 2006, Garcia-Vargas et al. 2008) and 22 of Haliotremaidae (Kritsky et al. 2009). In Mexico, four species of Haliotremaidae have been found on lutjanids from the Atlantic (Zhukov 1976). Euryhaliotrema perezponcei and H. guttati were described from the spotted rose snapper, L. guttatus, on the north-western coast of Mexico (García-Vargas et al. 2008). The morphological characteristics of the dactylogyrid species found in this study matched the descriptions of E. perezponcei and H. guttati by García-Vargas et al. (2008) and of H. plectridium and H. spinatus by Kritsky et al. (2009). The description of a new Euryhaliotremaidae species is underway.

Most populations of fish parasites in natural waters are limited by transmission events (Kennedy 1997). Ecotoparasitic metazoans on fish in natural waters often occur in low numbers; for these parasites, site specificity can facilitate mating in these low-density populations (Rohde 1994). The intensity of infection by dactylogyrids on the gills of spotted rose snapper varied according to the dactylogyrid species. In this study, H. spinatus had an intensity of infection (25 parasites per fish infected) similar to that found for H. johnii (Tripathi, 1959) (= Euryhaliotrema johni (Tripathi, 1959) (Kritsky et Boeger, 2002)) (29 parasites per fish infected) in the wild golden snapper Lutjanus johnii (Bloch) (see Leong and Wong 1987). However, H. plectridium and E. perezponcei had the highest intensity of infection (59 and 69 parasites per fish, respectively), which is in contrast with the value (10.6; n = 17) previously reported by Bosques Rodriguez (2004) for Heteracanthus (Zhukov, 1976) on Lutjanus syngnathus (Linnaeus). The prevalence of Haliotremaidae spp. in the present study was high, but the prevalence of H. plectridium (89%) and H. spinatus (81%) was similar to that reported for Haliotrema abaddon Kritsky et Stephens, 2001 from Glaucosoma hebraicum Richardson (see Kritsky and Stephens 2001) and for Pseudohaliotrema sp. on Siganus sutor (Valenciennes) (Geets et al. 2005). The prevalence of E. perezoncei (100%) was similar to the value previously reported (94.73%) on this host species (García-Vargas et al. 2008). These results are consistent with other data on the frequency of the occurrence of dactylogyrid species on the gills of snappers (Kritsky et al. 2009).

The microhabitat of gill-living monogeneans has been investigated by many authors (Dzika 1999, Lo and Morand 2000, Simková et al. 2000, Šimková et al. 2002, Matejusová et al. 2002), and it has been shown that many species have clearly defined microhabitats (Wootten 1974, El Hafidi et al. 1998, Dzika 1999, Lo and Morand
In the present study, the most abundant dactylogyrid species, *H. plectridium*, preferred the gill arches 2 and 3, whereas the second-most abundant species, *E. perepzoneci*, tended to settle on the gill arches 1 and 2, indicating that these two dactylogyrid species were the main contributors to the microhabitat distribution. The least-abundant species, *Euryhaliotrema* sp. and *H. guttati* (35%), *H. spinatus* (44%), *Euryhaliotrema* sp. and *Euryhaliotrema* sp. (37%) found on the central gill sector, in contrast with anterior and posterior sectors, matches the greater surface area available for the settlement of parasites on the gill arches and corresponds with the locations on those gill arches that receive the strongest water flow (Paling 1968, Lo and Morand 2000).

In terms of inter- or intraspecific interaction, the ‘aggregation model of coexistence’ postulates that if species using the same type of resource are distributed in such a way that interspecific aggregation is reduced relative to intraspecific aggregation, species coexistence is facilitated. In the present study, there was no observed overlap in the use of the microhabitats. Moreover, the species of monogeneans studied here exhibited a weak positive interspecific association, and the value of intraspecific aggregation (J>0) of dactylogyrid species indicated an aggregated distribution. The restriction in the selection of monogenean microhabitats to specific gill arches and sectors could facilitate species coexistence and opportunities to mate (Rohde 1991, Lo and Morand 2001), avoid competition (Šimková et al. 2000) and reinforce the reproductive barriers to prevent hybridisation (Šimková and Morand 2008). The reduction in competition is also reflected by the relative strength of intraspecific aggregation versus interspecific aggregation (A>1), facilitating the coexistence of species.

The increase of parasite load favours the aggregation of congeners within the hosts, which could be pathogenic in farmed fish. However, the main factor that contributes to settlement in a specific microhabitat has not been defined, and the spatial preference might be correlated with physiological, environmental, ecological and physical factors (Rohde 1994). More studies are required to clarify this.

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