

# Monthly variation in the parasite communities of the intertidal fish *Scartichthys viridis* (Blenniidae) from central Chile: are there seasonal patterns?

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**Abstract** Monthly variation in parasite populations and communities, from the blenniid fish *Scartichthys viridis*, were assessed during two consecutive years in order to examine monthly and seasonal temporal patterns. A total of 969 *S. viridis* was collected from September 2006 to August 2008 in central Chile. Sample size and fish total length (TL) varied among months. The *S. viridis* parasite community included 17 parasite taxa, of which five species were present throughout the year: a leech (Piscicolidae gen. sp.), two copepods (*Lepeophtheirus zbigniewi* and *Colobomatus* sp.), a monogenean (*Microcotyle* sp.) and a trematode (Lecithasteridae gen. sp.). The parasite prevalence, abundance and biovolume varied among months. More precisely, the leech and the copepod *Colobomatus* sp. were the most prevalent and abundant parasites, reaching their maxima between November and January (austral spring–summer). The parasite communities also showed seasonal patterns; prevalence, abundance and species richness of parasites were higher between October and January (spring–summer) than between March and May (autumn–winter). The population and community descriptors of parasites were significantly correlated with fish TL. Consequently, the variation in parasite populations and communities was associated with fish growth throughout

the year. Postlarval settlement of *S. viridis*, in the intertidal rocky pools, occurs in autumn, with fish reaching larger body size in summer.

## Introduction

Spatial and temporal variations in populations are associated with natural changes in climate, environmental conditions and interspecific relationships occurring in every ecosystem (Begon et al. 1996). Parasite populations are not unresponsive to these changes because they are directly exposed to the environment at some stage of their lives (Rohde 1993). Besides this, parasites are in contact with different hosts (those harbouring parasites), according to their development stages, implying that any biological change in the host would also affect their parasites. Several biological changes of the host are predictable over time, such as growth, diet, body size, and habitat. Additionally, abiotic components of their environment, such as season, upwelling events and tides, are also predictable. Temporal patterns in parasite population and community structure can be affected by host biology (Rohde 1993; Muñoz et al. 2006; Poulin 2006) and environmental characteristics (Rohde and Heap 1998), especially those associated with annual/seasonal changes.

Several studies have observed seasonal variations in parasite populations. However, high and low parasite abundance may be associated with different seasons depending on the parasite and host species studied. For instance, several trematode populations of the snail *Helisoma anceps* reach their highest prevalence during the spring (Negovetich and Esch 2007), whereas nematode populations of the wild Red deer *Cervus elaphus* reach their highest prevalence and abundance during the winter months

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(Santín-Durán et al. 2008). Although seasonal variations in parasite populations have been associated, generally, with environmental conditions, few studies have effectively identified specific factors as affecting the dynamics of parasite populations (Bauer and Karimov 2006). This is because parasite species, their development stages, hosts and transmission pathways may respond differently to physical and chemical cues of their environment. However, host biological features, e.g., reproductive periods, food availability, mortality (Negovetich and Esch 2007) and abundance of the hosts (Fellis and Esch 2004) have been considered as determinants of temporal variation in the dynamics of parasite populations.

Changes in parasite populations ultimately lead to changes in parasite communities. However, different parasite populations may show dissimilar seasonal patterns, i.e. some species are more abundant and prevalent in certain months or seasons, whereas other species may not vary significantly over time. For instance, the prevalence of some parasites of the Patagonian toothfish *Dissostichus eleginoides* was higher during the winter, while it was higher during the summer in other parasite species (Brickle et al. 2005). Consequently, considering that variations in abundance, prevalence, and species richness of parasites communities correspond to the sum of the variation in populations, it is possible to notice different temporal patterns between parasite populations and communities, as observed in goby fishes (Zander and Kesting 1998).

This study focuses on parasites populations and communities of the blennioid fish *Scartichthys viridis*. This species is a resident and abundant fish in the rocky intertidal zone of central Chile (Muñoz and Ojeda 1997, 2000; Pulgar et al. 2005). Moreover, parasite abundance and species richness are positively correlated with body size in *S. viridis* (Díaz and George-Nascimento 2002; Flores and George-Nascimento 2009). Generally, the Chilean intertidal is home to different cohorts of this fish (Hernández-Miranda and Ojeda 2006). Juveniles arrive to the intertidal during the autumn, starting in April, and stay there for several months, whereas adults are generally found during the spring and summer distributed between the inter- and subtidal zones (Hernández-Miranda and Ojeda 2006). These fish reach up to 45 cm in total length (Muñoz-Muga and Muñoz 2010), reach maturity at ~12 cm (Williams 1990) and spawn in the spring and summer (Hernández-Miranda et al. 2003).

Although the interannual variation in parasite communities of *S. viridis* has been studied (Díaz and George-Nascimento 2002), seasonal variation has not. It is expected that parasite populations and communities of *S. viridis* will undergo seasonal changes as juveniles (autumn) grow into adults (spring and summer). Host body size has been identified as a key determinant of parasite abundance and

species richness in this host species (Díaz and George-Nascimento 2002; Muñoz-Muga and Muñoz 2010); therefore, we expect that peaks in prevalence, abundance, and species richness will be observed in the spring and summer when adults are found in the intertidal. The objective of this study is to measure the monthly variation in parasite populations and communities in *S. viridis*, over the course of two consecutive years, in order to examine patterns in seasonal variation.

## Materials and methods

Monthly sampling on the intertidal rocky shores of El Tabo, central Chile (33°30'13" S, 71°36'15" W) between September 2006 and December 2008. Fish were collected with hand nets from rocky intertidal pools, bagged individually to avoid losing ectoparasites, and subsequently, most were frozen. A few fresh specimens were examined in order to obtain parasites in good condition for staining and mounting.

Eumetazoan ectoparasites were collected from the body surface, gills and opercular ducts, whereas endoparasites were collected from the gut, body cavity and muscles. The identification of parasites was carried out in consultation with Bray (2002); Castro and Baeza (1981); Cressey and Cressey (1985); Cressey and Schotte (1983); Cribb (2005); Gibson (2002); Muñoz (2010); Overstreet and Curran (2005); Petrochenko (1971).

Prevalence, mean intensity and abundance data for each parasite species were determined *sensu* Bush et al. (1997). Biovolume, a surrogate for biomass, was also calculated as described by George-Nascimento et al. (2004). For monthly variation in parasite populations, the prevalence and abundance were determined for the commonest parasites in order to display the months that had greatest changes during the two sampling years. For monthly variation in parasite communities, the total prevalence (percentage of host parasitized with any parasite species) and averages for abundance, biovolume and species richness of parasite infracommunities (average number of parasite species), in addition to component community richness (total number of parasite species) were calculated (*sensu* Bush et al. 1997; Díaz and George-Nascimento 2002) for each month.

The infra-community abundance (number of parasite per host individual), biovolume (volume of parasites per host individual) and species richness of parasites (number of parasite species per host individual) were analysed separately using a generalized linear model (previously transformed to  $\log_{10}(x+1)$ ), with these three descriptors as the dependent variables, months and years as fixed factors, and fish body length as the covariate. Spearman's correlations were performed between parasitological descriptors (for

populations and communities) and the average total length (TL) of fish (Zar 1996) for each month in order to determine the importance of TL throughout the year.

A hierarchical cluster analysis was performed for parasitological community descriptors from each sample ( $n=24$ ) in order to detect which months were more similar to one another. Prior to this analysis, correlations were applied between community descriptors (total prevalence, average abundance, average biovolume, average infra-community species richness and the component community richness) to identify determinants of temporal variation in parasite communities. The similarity of parasite community descriptors, between months, was examined using Ward's similarity algorithm and represented by Euclidean distances. A group of months, showing high similarity to one another ( $>50\%$ ) was identified as a cluster. The description profiles of the different clusters and fish TL were compared using a one-way analysis of variance (ANOVA) (Zar 1996). All statistical analyses were performed using Statistica software 8.0 (Statsoft, Inc. 2010).

## Results

A total of 969 *S. viridis* individuals were collected. Between 17 and 86 individuals were sampled each month (Fig. 1). Of the total individuals examined, 604 were parasitized with at least one parasite species (total prevalence=62.3%) and the average parasite abundance was 3.2 ( $\pm 5.3$  standard deviation) individuals per fish. In total, 17 parasite species were recorded, of which 6 are undescribed (Table 1). Of these 17 species, five can be considered common in *S. viridis* since they had the greatest prevalence, abundance, and biovolume in nearly all months sampled (Fig. 2): (1) the leech Piscicolidae gen sp.; the copepods (2) *L. zbigniewi* and (3) *Colobomatus* sp.; (4) the monogenean

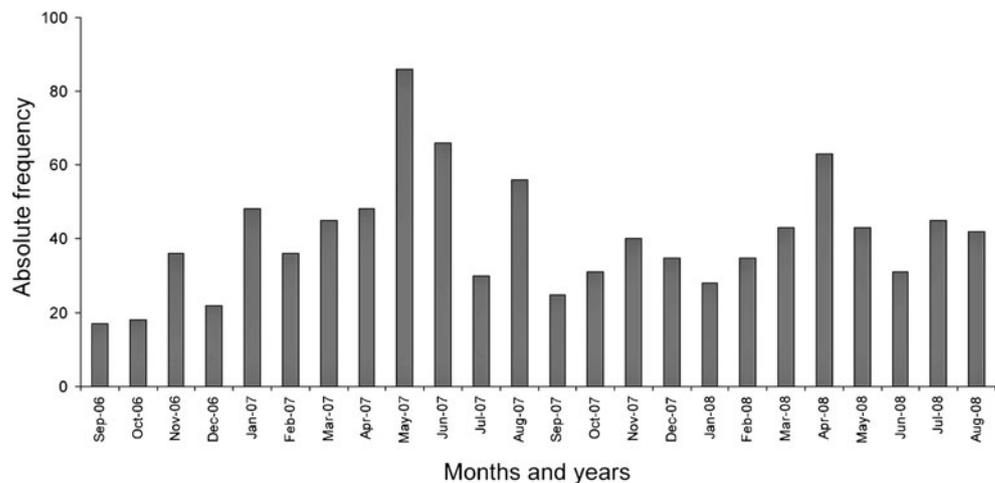
*Microcotyle* sp.; and (5) an unidentified trematode Lecithasteridae gen. sp. (Table 1). The monogenean, *Gyrodactylus* sp., was more prevalent from March to August 2008 (85 to 97%), than in January and February 2009 (22 to 68%). Because this parasite was detected late in our sampling, it was not possible to observe temporal variation throughout the year for this species; therefore, this parasite was excluded from our analyses.

## Monthly variation of parasite populations

The prevalence, abundance and biovolume of the 5 most common parasites varied throughout the year (Fig. 2). Most parasite species, chiefly Piscicolidae gen. sp. and *Colobomatus* sp., had the lowest prevalence between March and May (austral autumn) and highest between October and January (austral spring and summer), in both years sampled (Fig. 2a). Piscicolidae gen. sp. was the parasite with the highest abundance, particularly between December and January. The other parasite species, *L. zbigniewi*, *Colobomatus* sp., *Microcotyle* sp., and Lecithasteridae gen. sp. showed less variability in prevalence and abundance throughout the year, generally peaking during the summer months (Fig. 2a, b).

Across all species, most parasites of *S. viridis* were small-bodied, averaging  $0.51 \pm 1.3 \text{ mm}^3$  (range=0.01–5.59  $\text{mm}^3$ ). The leech Piscicolidae gen. sp. had the largest average body size and the highest average abundance; therefore, leeches had the greatest average biovolume than any other parasite species during this two year survey (Table 1, Fig. 2c). The biovolume of leeches was high from October to January (austral spring and summer), whereas the biovolume of the other 4 parasite species was less variable, with some weak peaks from November to January, and the lowest values in April–May 2007 and March 2008 (Fig. 2c).

**Fig. 1** Fish sample size of *Scartichthys viridis* collected monthly over 2 years of sampling. Months and years are abbreviated (considering the three first letters of each month, and 06, 07 and 08 refer to 2006, 2007 and 2008, respectively)



**Table 1** Parasite community of *Scartichthys viridis* (N=969) from El Tabo, Central Chile

	SUM	Prevalence (%)	Average abundance (SD)	Average intensity (SD)	Average biovolume (SD)
<b>HIRUDINEA</b>					
Piscicolidae gen. sp. (a) <sup>a</sup>	1,107	38.2	1.14 (2.88)	2.99 (4.02)	6.391 (16.102)
<b>COPEPODA</b>					
<i>Lepeophtheirus zbigniewi</i> (a)	133	6.9	0.13 (0.67)	1.99 (1.67)	0.037 (0.177)
Caligidae (ju) <sup>b</sup>	9	0.6	0.01 (0.15)	1.50 (1.22)	0.0003 (0.005)
<i>Colobomatus</i> sp. (a) <sup>a</sup>	726	43.3	0.75 (0.97)	1.73 (0.69)	0.095 (0.123)
<i>Holobomolochus chilensis</i> (a)	12	0.8	0.01 (0.15)	1.50 (0.76)	0.003 (0.032)
<b>TURBELLARIA</b>					
Unidentified species	2	0.1	<0.01(0.06)	2.00 (–)	0.0002 (0.006)
<b>MONOGENEA</b>					
<i>Microcotyle</i> sp. (a) <sup>a</sup>	360	18.4	0.37 (1.06)	2.02 (1.68)	0.104 (0.297)
<i>Neobenedenia melleni</i>	28	2.6	0.03 (0.19)	1.12 (0.33)	0.036 (0.233)
<i>Gyrodactylus</i> sp. (a) <sup>a</sup>	–	83.1	Not available	Not available	Not available
<b>TREMATODA</b>					
Lecithasteridae gen. sp. (a) <sup>a</sup>	710	22.2	0.73 (2.13)	3.30 (3.45)	0.031 (0.090)
<i>Helicometrina nimia</i> (a)	3	0.2	<0.01 (0.07)	1.50 (0.71)	0.0003 (0.006)
Hemiuridae gen. sp. (ju)	1	0.1	<0.01 (0.03)	1.00 (–)	<0.0001 (0.001)
<i>Monascus filiformis</i> (a)	15	0.6	0.01 (0.28)	2.50 (2.81)	0.007 (0.121)
<i>Hemipera</i> sp. (a)	33	1.4	0.03 (0.47)	2.36 (3.23)	0.0003 (0.004)
<i>Megasolena</i> sp. (a)*	21	1.4	0.02 (0.22)	1.50 (1.09)	0.002 (0.016)
<b>CESTODA</b>					
Pseudophyllidea gen. sp. (l)	1	0.10	<0.01 (0.03)	1.00 (–)	0.0001 (0.002)
<b>ACANTHOCEPHALA</b>					
<i>Corynosoma</i> c.f. <i>australe</i> (l)	7	0.5	0.01 (0.11)	1.40 (0.55)	0.001 (0.020)
<b>NEMATODA</b>					
<i>Pseudodelphis chilensis</i> (a)	17	1.4	0.02 (0.17)	1.31 (0.63)	0.005(0.052)

a adult, ju juvenile, l larva, SD standard deviation

<sup>a</sup> Undescribed species

<sup>b</sup> It may be *L. zbigniewi*

### Monthly variation of parasite communities

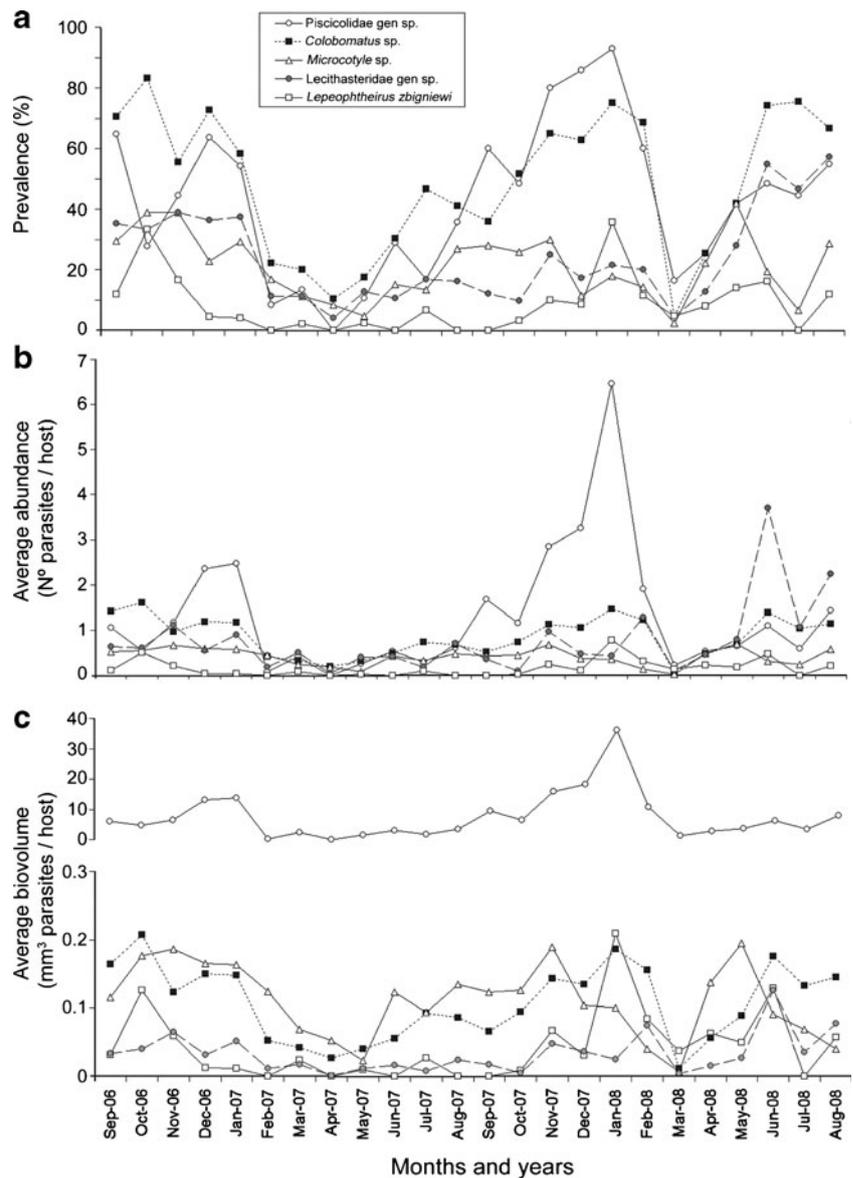
There were monthly variations in prevalence, average abundance, species richness and biovolume of parasite infracommunities throughout the 24 months considered. However, the highest and lowest values of these descriptors were not observed in the same months. Nevertheless, it is possible to generalize that higher prevalence (Fig. 3a), species richness (Fig. 3b) and abundance (Fig. 3c) were detected from November to February (austral spring and summer). Component community richness varied among months, with a low of 4 species in December 2007 and highs of 10–11 species in January, June and August 2007, but without showing any seasonal pattern (Fig. 3b). Monthly variation of parasite community biovolume was less noticeable than for total abundance, although these two descriptors showed similar trends (Fig. 3c). Parasite

community biovolume reached maximum values in January (2007 and 2008).

The abundance, biovolume and species richness of parasite infracommunities varied significantly with fish TL, between months and year of sampling (Table 2). Additionally, except for biovolume, all varied significantly between years. However, the fish TL, explained the majority of the observed variance for the 3 parasitological descriptors (Table 2).

In the cluster analysis, two different groups of months were distinguished, cluster 1 included months from October to February (austral spring and summer), whereas cluster 2 comprised months from February to October (austral autumn and winter) (Fig. 4). The common months between the two clusters (specifically February and October) belonged to different sampling years (Fig. 4). Subsequently, the profiles of the community descriptors and body size of

**Fig. 2** Monthly variations of population descriptors: **a** prevalence, **b** average abundance and **c** average biovolume of the five most common parasite species found in *Scartichthys viridis*. Months and years as in Fig. 1



fish, obtained from the cluster analysis, were different between groups (Table 3); the ANOVA indicated that all community descriptors, except for the component community richness, were significantly different between groups (Table 3). The highest values of the community descriptors occurred in cluster 1, mainly corresponding to the austral spring and summer (Fig. 4).

#### Host body size

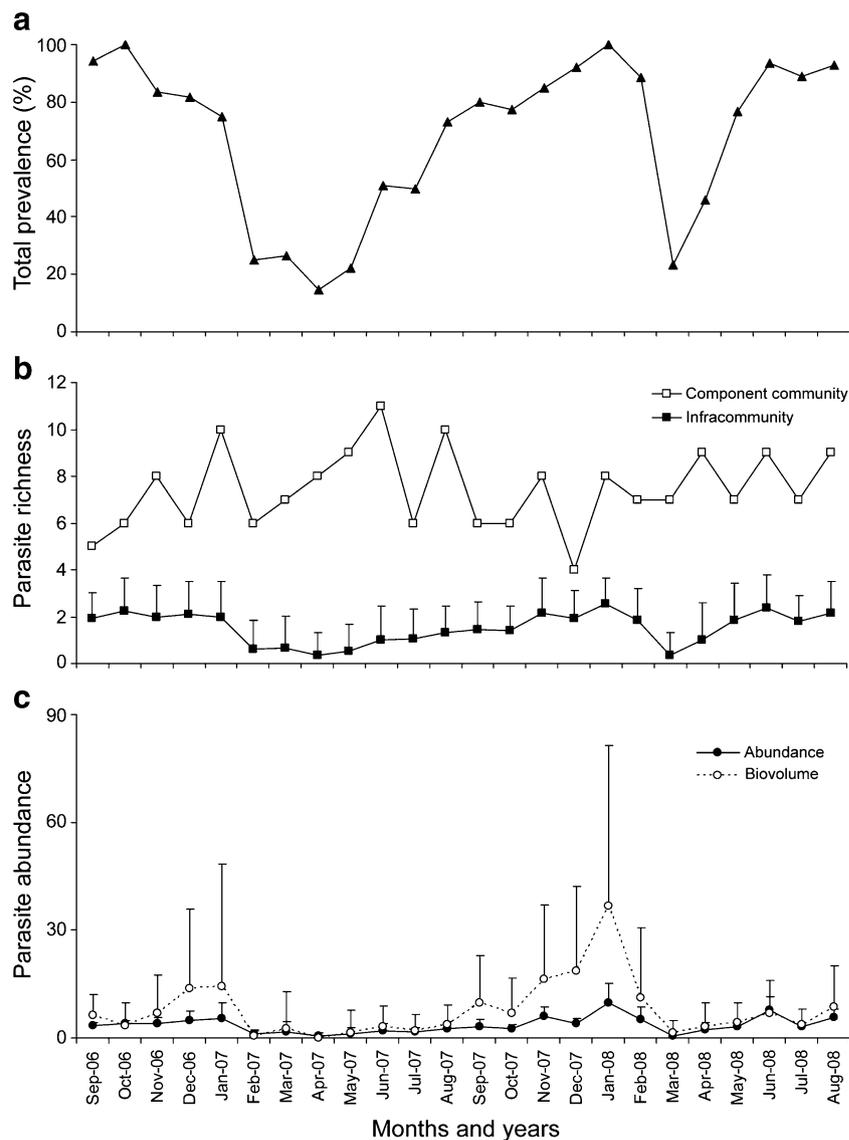
*S. viridis* TL varied between sampling months: fish were smallest between April and May (austral autumn) and largest in December and February (austral summer) (Fig. 5). There was an annual pattern in the fish TL distribution, with a steady increase in TL throughout the year beginning at recruitment of juveniles, one cycle started

in February 2007 and the other in March 2008. According to the cluster analysis, the body sizes of fish, whether measured as TL or weight, were statistically different between the two clusters, i.e. corresponding to the grouping seasons, austral autumn–winter and spring–summer (Table 2; Fig. 5).

The total prevalence and average abundance and biovolume of the 5 most common parasite species were positively correlated with monthly averages for *S. viridis* TL; Piscicolidae gen. sp. *L. zborniewi*, *Colobomatus* sp., *Microcotyle* sp., and Lecithasteridae gen. sp. ( $n=24$ ;  $r_s=0.43$ – $0.81$ ;  $P<0.001$  for all parasite species and descriptors), except for *Microcotyle* sp. abundance ( $r_s=0.36$ ;  $P=0.08$ ).

Due to differences in TL between the sampled months, five parasite community descriptors obtained for each monthly sample were regressed against the average *S. viridis* TL for

**Fig. 3** Monthly variation of parasite community descriptors in *Scartichthys viridis* over a 24 month period. **a** Total prevalence of parasites; **b** infracommunity (average parasite species/host) and component community richness of parasites (total parasite species in the sample); **c** average abundance (number of parasites/host individual) and biovolume of parasites ( $\text{mm}^3$  of parasites/host individual). Months and years as in Fig. 1



each month. The prevalence, abundance, biovolume, and species richness of parasite infra-community were positively and significantly correlated with average *S. viridis* TL, i.e. months in which small fish were found had lower parasite loads than months with large fish ( $n=24$ ,  $r_s>0.856$ ,  $P<0.01$  for monthly prevalence, infracommunity species richness, abundance and biovolume of parasites vs fish length). The major differences occurred between autumn and summer, in which the fish had different TL and, consequently, different community descriptors. The average species richness of the parasite infra-community reached a maximum of 2.5 species in fish of 10 cm TL. The component community richness showed no relationship to body size, either TL or weight, between sampling months ( $n=24$ ,  $r_s=0.126$ ,  $P>0.05$ ).

The smallest fish sampled during this study, <5 cm, were parasitized by leeches only. In larger fish (>5 cm), other ectoparasites appeared, such as *Colobomatus* sp. and *Micro-*

*cotyle* sp. In endoparasites, the trematode Lecithasteridae gen. sp. was the first species to colonize the fish, from 5.5 cm TL, and was abundant and prevalent in fish between 8 and 16 cm TL. Other endoparasites were less common and appeared in fish of varying TL, although several of them were more common in fish from 10 cm TL.

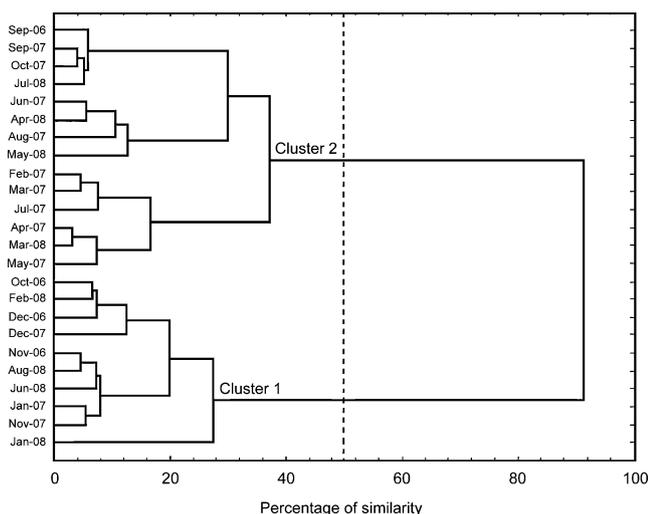
## Discussion

Parasite populations and communities in *S. viridis* vary according to the predictions proposed a priori in this study, i.e. parasitological descriptors varied monthly producing seasonal patterns; the lowest values of parasitological descriptors occurred from March to May (austral autumn), whereas the highest values were between November and January (austral summer) (Fig. 4). However, these “season-

**Table 2** Summary of the generalized linear model testing for differences in (log-transformed) abundance and species richness of parasites between sampling month, year, and fish total length (FTL)

Variable	MS	df	F	P
Log abundance				
Log FTL	69.49	1	1,515.15	0.001
Months	0.43	11	9.29	0.001
Years	0.36	1	7.74	0.005
Months×years	0.14	11	3.13	0.001
Error	0.05	944		
Log biovolume				
Log FTL	10,184.59	1	736.02	0.001
Months	54.98	11	3.97	0.001
Years	23.80	1	1.72	0.189
Months×years	28.63	11	2.07	0.020
Error	13.84	944		
Log richness				
Log FTL	25.71	1	1,103.23	0.001
Months	0.19	11	8.52	0.001
Years	0.12	1	4.98	0.025
Months×years	0.09	11	4.11	0.001
Error	0.02	944		

al patterns” were associated strongly with fish TL (Table 2). Consequently, parasite colonization in *S. viridis* begins in autumn, when fish are generally young and small, and peaks in summer, when fish are adults and reach larger body sizes. Fish cohort turnover occurs in autumn, mainly by moving to the upper subtidal zone and new recruits enter the intertidal pools becoming gradually parasitized as they grow.

**Fig. 4** Display of similarity of parasitological descriptor, through a cluster analysis, among sampling months of *Scartichthys viridis*. Broken line, 50% of similarity among months. Months and years as in Fig. 1

The coastal water temperature of central Chile changes due to seasonal upwelling and solar radiation, and is correlated also with salinity and productivity (Letelier et al. 2004). Normally, the temperature reaches 15–16°C in the summer and drops to 12–12.5°C in the winter (Letelier et al. 2004). Seasonal characteristics of the environment may somehow affect the parasite population dynamics and communities; however, this was not verified in this study. In any case, *S. viridis* descriptors of parasite communities were correlated with fish TL rather than with environmental variables known to fluctuate seasonally per se: (1) there were marked differences in fish TL during the year (Fig. 5), (2) the prevalence, abundance and richness of parasite infracommunities increased significantly with monthly TL averages. For instance, fish from February 2007 were smaller than usual for that summer, so they had fewer parasites than observed in other summer months. Conversely, fish from May 2008 were larger than usual for that autumn and, therefore, had more parasites. Thus, the average abundance and richness of parasites varies with fish TL rather than with environmental variables. In addition, despite significant variation in TL during the year, the number of parasite species is relatively constant over time, implying that the parasite component community richness showed no correlation with fish TL, nor any seasonal patterns. The common parasite species of *S. viridis* were present throughout the year and they can parasitize their hosts at any time. Larger hosts represent potential habitats with greater resources for parasites than smaller ones and are therefore more likely to become parasitized (Rohde 1993). Our results suggest that the observed parasite populations and communities would show little change even if the *S. viridis* TL remained constant throughout the year.

Historically, it has been easier to monitor and observe the effects of abiotic factors on parasite populations than in parasite communities. In fact, there are studies which concluded that temperature and salinity affect the emergence of trematode larvae (e.g. Koprivnikar and Poulin 2009) and the development of copepods and monogeneans (e.g. Voorhees and Schwartz 1979; Gannicott and Tinsley 1998; Costello 2006; Lackenby et al. 2007). Consequently, the temporal variations observed in parasite populations have been attributable, generally, to environmental factors. However, in this study, parasite populations of *S. viridis* showed seasonal variations. Yet, the effects of seasonal environmental variables could not be untangled from the biological properties of the host and parasites. More precisely, the prevalence and abundance of the leech *Piscicolidae* gen. sp. and the copepod *Colobomatus* sp. varied throughout the year and peaked during the summer. Comparable results were also associated with fish TL and were similarly observed for parasite communities.

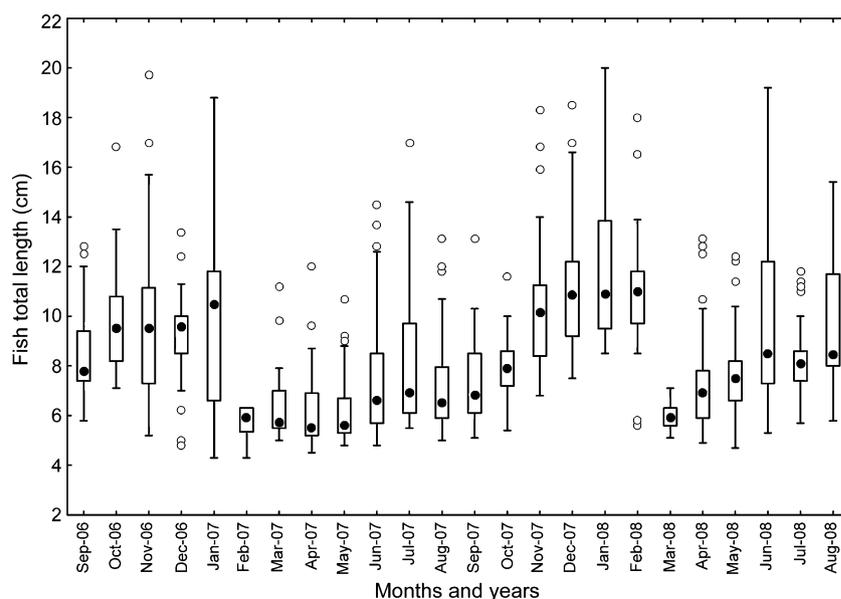
**Table 3** Summary of ANOVAs comparing the parasite community descriptors and host body sizes between the two clusters gathered from a multivariate analysis

Variable	Between SS	df	Within SS	df	F	P
Parasite communities						
Prevalence	12.42	1	10.58	22	25.82	<0.001
Average abundance	13.55	1	9.45	22	31.54	<0.001
Average biovolume	7.65	1	15.34	22	10.97	0.003
Average infra-community richness	16.64	1	6.35	22	57.59	<0.001
Component community richness	0.35	1	22.64	22	0.34	0.564
Host body size						
Total length (cm)	16.37	1	6.62	22	54.33	<0.001
Weight (g)	13.42	1	9.57	22	30.86	<0.001

The colonization of *S. viridis* by parasites begins in juveniles and parasite load increases steadily with fish TL. Generally, ectoparasites are the first to colonize this host species because of the direct life cycle involved in their transmission, i.e. no intermediate hosts are required for the completion of their life cycles. The first endoparasite species to establish infection is the trematode Lecitasteridae gen. sp. This species first appears in relatively small hosts (>5 cm) and persists throughout the year, despite exhibiting monthly and seasonal patterns in prevalence, abundance and biovolume. Other helminths (Table 1) were neither abundant nor prevalent, and, therefore, showed no seasonal pattern. Several of these endoparasites appeared in fish of medium size, mainly from 10 cm. Although *S. viridis* is mainly herbivorous, it is known to feed on invertebrates (Muñoz and Ojeda 2000). The transmission of endoparasites is likely to involve these invertebrates as intermediate hosts, although the life cycles of parasites infecting *S. viridis* are unknown. *S. viridis* consumes invertebrates in a low percentage of frequency of occurrence, about 3% of biomass in fish of between 4

and 8.5 cm in TL. However, the frequency of inclusion of invertebrates in its diet nearly doubles in larger fish (8.6–13.0 cm long) and remains constant thereafter (Muñoz and Ojeda 2000). Possibly, the greater abundance and prevalence of endoparasites in larger fish may reflect an ontogenic shift in diet: increased consumption of invertebrates at the expense of vegetation. However, it is essential to gain a better understanding of the temporal variation associated with the abundance and prevalence of parasites and host diet in order to elucidate these life cycles (see Zander and Kesting 1998).

In addition to demonstrating seasonal variations in parasite populations and communities, *S. viridis* has the most diverse parasite fauna compared with other intertidal fish species (Muñoz et al. 2002; Pardo-Gandarillas et al. 2004; Muñoz and Cortés 2009). The parasite fauna of *S. viridis* was composed of 17 parasite species (Table 1), a high parasite richness for a herbivorous fish. Nevertheless, this fish species is the most abundant among intertidal fish in Chile (Muñoz and Ojeda 1997; Muñoz and Cortés 2009), thus, it is an example of “a high fish density=a high parasite load”.

**Fig. 5** Total length of *Scartichthys viridis* along 24 months from two consecutive years (September 2006 to August 2008); median (filled circles), 25% (under median)–75% (above median), variation range (bars) and outliers (empty circles). Months and years as in Fig. 1

Seldom has parasite biovolume been considered in describing parasite communities. However, the great differences of parasite body size among the species in a community may show different temporal patterns of parasites to those estimates based solely on abundance. In this study, the largest parasite species was also the most abundant. This observation contrasts with the notion that larger parasites may be less abundant because they require more resources from the host (George-Nascimento et al. 2004). However, leeches are indeed larger, but their host use is limited to feeding events (Burreson 1995), so the resources required from the host should be less than that for other large “permanent” parasites.

In summary, parasite population and communities of *S. viridis* clearly varied with months throughout the year, thus demonstrating a seasonal pattern. This pattern was mostly associated to host body size. In turn, host body size is associated with environmental variables and is strongly correlated with seasons. These trends were observed during the 2 years of study indicating that parasite populations and communities have a variation pattern along a year. Consequently, the parasito-fauna of the recruiting cohorts of *S. viridis*, which stay in the intertidal for several months, provide insights into its population structure. So, every change in the environment that may affect the fish, such as pollution, perturbation of any nature or strong climate change, could be detected and analysed through the parasite community structure, similar that stock discrimination of fish using parasites as biological tags (e.g. MacKenzie and Abaunza 1998; Luque et al. 2010).

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